

Proceedings of
**2nd International Conference on
Research Advances in Engineering,
Technology, Science and Management**



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*Proceedings of
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on Research Advances in
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Tech Insight 2019

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Tech Insight 2019

2nd International Conference on Research Advances in Engineering, technology, science and management (TECH INSIGHT -2019) is a technical event dedicated to the advancement of the theory and practices in engineering, science, technology and management. The TECH INSIGHT promotes collaborative excellence between academicians and professionals from industry and research organisation.

This conference provides opportunities for the delegates to exchange new ideas and implicational experiences face to face, to establish business or research relations and to find international partners for future collaboration. TECH INSIGHT offers a great opportunity to bring together professors, researchers and scholars around the globe, having a great platform to deliver the latest innovative research result and the most recent development and trends in engineering and applied sciences field.

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Preface

We are honoured to bring you this collection of articles from the 2nd International Conference on Research Advances in Engineering, Technology, Science and Management organized by GRAWW Research and Education Global Network which was held in Dubai, United Arab Emirates during 29th & 30th March 2019. This book is a part of the technical articles published by GRAWW Research and Education Global Network, and is devoted to the gamut of engineering, technology, applied sciences and management issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This volume is devoted to Research and Innovations in Science, Technology and Management and the application of such research naturally complement each other. In this spirit, this issue is published with eight research manuscripts in different fields of the related conference scope. These papers provide invaluable insights into the studied problems and offer convincing case studies and experimental analysis. Each papers provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution.

Many institutions, professors and scholars have contributed to the creation of this proceedings. We are very thankful to everybody who have supported us. We look forward to bring many other such conference proceedings, reporting new developments in Research and Innovations in Science, Technology and Management. We would like to express our sincere thanks to all of our Editorial Board members and Reviewers. It is our hope that this papers will be a valuable resource for readers and will stimulate further research into the vibrant area of advances in technologies.

March 2019

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Towards a Digital Policing in Developing Nations: The Nigerian Context

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Abstract

Technology-assisted living is a growing trend in most developing nations, particularly for young-aged demographic countries, as it presents a platform for personal development and knowledge management. However, this society-scaping trend has also introduced the myriad opportunity for the formation of complex crime, which is often beyond the (immediate) capability of the policing entity in developing nations. To address this lingering and futuristic problem, particularly in Nigeria, this study developed a context-based digital policing framework for the enhancement of the Nigerian Police. This Nigerian-context framework presents the viability and relevance of the digital policing mechanism in addressing challenges ravaging society. Furthermore, it also presents a modality for improving and enhancing the policing apparatus of the Nigerian society, as a model for other developing nations. The knowledge from the Nigerian-context of digital policing has both research and societal implications. In terms of research, it opens the community of security researchers into the contextual characteristics of digital policing as well as the probable research direction required to implement digital policing in developing nations. With respect to society, knowledge

provides a substratum for the integration of the community-policing model.

Keywords: *context-based digital policing, developing nations, community-policing model, technology-assisted crime, security*

1.0 INTRODUCTION

Poor governance is often defined as the bane of economic growth in Sub-Sahara African countries, particularly in Western African states. Theories and research have established the correlation between economic growth and the rate of crime in each society. This consequential phenomenon has also been identified as a major cause of security challenges in Most African states. However, the African continent is believed to comprise a significant size of the young population with the propensity to technology-assisted living. Amalgamating technology-assisted living and the current high crime-rate presents a logical outcome of which can be termed technology-assisted criminality. In contrast, the police rely on the traditional method of policing, which is inadequate to handle a technology-assisted crime.

There is, therefore, a need to develop a technology-enhanced policing process that can be seamlessly integrated into the current policing capability. Some Countries such as Saudi Arabia, the UK, Singapore, and

Australia, have established the use of technology-assisted policing, a phenomenon, which has led to the development of digital policing. However, digital policing is a context-based policing model, which requires the comprehension of the unique context of the society and the peculiar governance model of the Country. Therefore, whilst digital policing presents an appropriate platform for the enhancement of the policing capability of a society, a contextual adaption of digital policing mechanism would be required to address the current technology-assisted criminality in most developing nations.

This paper attempted to explore this initiative. Specifically, the paper examines some of the existing policing models. It anatomizes the current state of the Nigerian police force. It further develops a framework for the digital policing model in Nigeria. Furthermore, it also presents a modality for improving and enhancing the policing apparatus of the Nigerian society, as a model for other developing nations. The knowledge from the Nigerian-context of digital policing has both research and societal implications. In terms of research, it opens the community of security researchers into the contextual characteristics of digital policing as well as the probable research direction required to implement digital policing in developing nations. With respect to society, knowledge provides a substratum for the integration of the community-policing model.

1. THE POLICING MODELS

Police and Policing are two phenomena, which are interrelated conceptually. On the one hand, Police is an agency of state saddled with the responsibilities of crime detection and prevention, law enforcement and maintaining order. On the other hand, Policing can be defined as a “measure and action taken by a variety of institutions and groups (both formal and informal) in society to regulate social relations and practices in order to secure the safety of members of community as well as conformity to the norms and values of society” [1]. Thus, policing is a highly political activity. Model of policing is a strategy or methodology adopted by a police department to perform their specialist role in enforcing Law and Order. Although, some agencies may be unaware of tested strategies that could be integrated into their traditional models in order to enhance operational efficiency.

There are different models of policing that works in different contexts of a community. These contexts may include transitional society, societal/political disagreement, economic-inequality, industrial dispute, urban and ethnic tensions, and a stable and prosperous community.[2] The various policing models are discussed in turn as follow:

2.1 Democratic policing

Democratic policing model is the most advocated policing model, which is often asserted to provide a reliable measure of the restoration of the legitimacy, stability, and peace in public administration. Generally, a policing system is such that is publicly accountable, subjective to

the constitutional law, respectful of human dignity and intrudes into citizens' life under strict adherence to the constituted process required by law. This policing model requires that citizens' inquiries and request are promptly and effectively addressed. Democratic policing is prevalent in Asian and African countries as a result of their history of colonization and military dictatorships. During those “undemocratic” periods, the notion of policing is relegated to military policing, where the policing system is deemed effective (from the rulers' perspective) and the fiercest (from the citizens' perspective) tool to control society and suppress opposition and resistance where applicable [2]. However, the problem of political bias is still a cause of disagreement in several parts and among several stakeholders.

2.2 Community-based policing

Community-based Policing (CbP) is a law enforcement philosophy and a viable organizational strategy, which promotes a partnership based on collaborative efforts between the police and the community as a way of effectively and efficiently identifying, preventing and solving societal vices such as crime, the fear of crime, physical and social disorder, as well as neighborhood decay. Consequently, a CbP aims to improve the quality of life, and a safer society for everyone. A CbP generally comprises police-community partnership, the transformation of an organizational, and problem-solving [3]. Thus, CbP extends beyond improving the relationship between police and society. However, it has the potential to effectively reduce crime, and conversely, improves citizen satisfaction and trust in the police. CbP is a policing innovation that has gained wider adoption in the 1990s after several years of unpleasant comparison with 'standard' police practices.

2.3 Problem-based policing

Problem-based policing (PbP, problem-solving, or problem-based partnerships) is a methodical approach to addressing context-specific problems; it aims to apply the rational and evidence-based analysis of problems and their solutions to a policing context. A Problem-solving approach can systematically *identify* and *analyze* crime, *develop specific responses* to individual problems. Therefore, PbP is the process of identifying context-based specific societal challenges that can lead to disorder and consequently using context-specific analysis to plan responses. This strategy often targets the underlying causes of crime and disorder and attempts to proactively combat crime before it manifests. Simply put, problem-based policing approach, in contrast to other forms of policing, posits that police should focus more attention on societal challenges, as opposed to *incidents* [4]. Such challenges can be recognized as collections of related incidents or as underlying conditions that give rise to societal disorder, and other substantive community which citizens expect the police to address. By focusing more on challenges than on incidents, preventive measures can be emphasized by the police to address crime causation, rather than mere symptoms. The police agencies that implement, organize and practice PbP

widely accepted and adopted the SARA model. The attributes of the model includes *Scanning* (the process of identifying the recurring societal challenges), *Analysis* (the process of collecting and analyzing relevant data on the societal challenges), *Response* (the process of seeking out responses that might have worked elsewhere and then selecting/implementing modalities that can address the identified societal challenge), and *Assessment* (the process of seeking out if the response reduced the challenges and to identify new probable strategies that could be deployed for efficiency[5]). In addition to the SARA model, the PAT (Problem Analysis Triangle) model is used to determine what the problem exactly is, which invites those who are looking at problems to consider three elements that all problems have: an offender, a victim, and location. These three elements can help to understand (analysis) the problem [6]. However, the effectiveness of PbP is bounded by crime specificity in contrast to blanket appropriation and administration. Therefore, the process of establishing PbP requires an acute appropriation and concentration which should align with the SARA approach [7]. Furthermore, PbP relies on reliable information, to avoid confounding information, which prompts the necessity of information verification, as well as the method of evaluation of acquired information. A depiction of problem-based policing practices is the Polar Star Project of the Hong Kong Police. With initiation in 1998, the Yuen Long police, for instance, attempted to understudy and comprehend the causation of the rampant juvenile delinquency in the district, and consequently address the underlying causation [2].

2.4 Neighbourhood policing

Traditionally, a neighborhood policing model is built on the earlier Community-based Policing (CbP) model, as it relates to crime reduction and anti-social behavioral tendency which affects local inhabitants and to provide reassurance. According to UK National Policing Improvement Agency (NPIA), "*neighborhood policing is about engaging with local communities to identify their concerns and priorities, to increase police visibility, and to work with communities to solve problems that matter to them*". Furthermore, according to Higgins [8] a "*neighborhood policing model was developed in the first decade of the twenty-first century to address local crime and disorder issues, reassure the public, and reconnect the police with communities*" [8] Similar to the community-policing model, the underlying principle of the neighborhood policing model revolves around public consent. For instance, a web-based national tool has been designed and deployed in the UK to support local policing process through engagements with local communities [2]. Typically, the foot-patrol monitoring process forms the substratum of the neighborhood policing model, as the presence of patrol officers can provide reassurance for the citizen. However, such patrol-officers would work with local community partners to adopt a problem-solving approach that can reduce the local crime rate and antisocial behavior [9].

2.5 Reassurance policing

A Reassurance policing model is a policing approach which prioritizes the importance of the relationship between the Police and the community being policed through efficient communication processes so as to maintain a positive image to the public. Consequently, ensure that the public is reassured on the effectiveness of the policing system [10]. It is closely allied to "community-based policing" and "neighborhood policing." It leverages on the signal crimes perspective developed by Martin Innes and colleagues in the early 2000s, which held that specific (but varying) types of crime and disorder – including some incidents not traditionally considered to be 'serious' – can disproportionately convey messages to individuals and communities about their security [9]. The model essentially seeks to achieve a combination of responsiveness of police forces and the signals of crime [2]. The reassurance model advocates proactive and pre-emptive crime investigation thus attempt to prevent crime escalation. It generally relies on components such as high visibility patrols (performed by police officers who are known to the public), the targeting of "signal crimes" and "signal disorders", as well as the informal social control exercised by the local communities [9]. Whilst a signal crime can be expressed as an incident that initiates behavioral change in society or in the perception of security, a signal disorder can be termed as a breach of social conventions. These "signals" implies a subjective and collective experience of insecurity as well as the process of early detection to prevent crime escalation. The reassurance policing was introduced by the British police in response to the abysmal between the rate of falling crime, the associated ignorance of the society, and the falling confidence of citizen on the police service. Simply put, the public needs to be reassured of the responsibility and effectiveness of the Police service in the event of a crime or criminal acts.

2.6 Intelligence-led policing

As asserted by Anderson [11], an intelligence-led policing is the collection, integration, analysis, and presentation of potentially incriminating information which can aid in investigative intelligence that can be used in the informed-decision-making process, both at the tactical, strategic and organizational level. In this model, intelligence is used as a guide to policing operations, in contrast to the converse. This model requires a higher level of innovation, resourcefulness, as well as robustness to the volume of available information, to perform the desired policing functions. This model of policing often provides a balance between the lack of budget and the potential to perform policing functions. Carter and Carter [12] reported that in the post 9/11 era witnessed a rapid change in the intelligence gathering capability of law enforcement agencies. The need for a re-engineering of intelligence gathering and functions was highlighted in October 2001, where the Police Investigative Operations Committee discussed the challenges militating against the state, local, and tribal law enforcement (SLTLE). Furthermore, the meeting highlighted the need for more law

enforcement agencies to develop an intelligence capacity as well as the implication of engaging national leadership to establish laws and rules for intelligence gathering, integration, and utilization process. From this meeting, an Intelligence Summit was held in March 2002, by the International Association of Chiefs of Police (IACP), with funding from the Office of Community Oriented Policing Services (COPS). The summit made a series of recommendations including the development of a criminal intelligence sharing plan. The use of the intelligence-led model of policing has gained wider adoption in settings in the UK and US, as well as Canada, China, New Zealand, and Australia [13].

2.7 Evidence-based policing

The Evidence-based policing (EbP) model leverages the intelligence-based policing model, by leveraging available researches on the outcomes of police work to implement guidelines and evaluate agencies, units, and officers [14]. In other words, an evidence-based policing uses research and research outcome to guide practices and personnel evaluation. Whilst the appropriate equipment, knowledge, rules and laws, and strategic tactics are essential for supervisors and command staffs, much is also required on the best approach to take to make informed decisions. This model thus attempts to modernized policing services such that about "what works" in crime control and prevention is implemented within the appropriate context [15]. This implies that police training is required to deviate from the traditional focus on procedures, the law, physical skills, and use of equipment, to a context-based perspective of what has been evaluated to work in recent times. In addition, the EbP centralizes the role of crime analysis in everyday policing. Therefore, a geographical and temporal profile of criminal cases, as well as an understanding of the environmental and situational factors, can attract opportunities for crime, the police apparatus can become more effective in addressing the specific crime, disorder, and traffic problems they face. However, the integration of context introduces the probability of trial by error, which could limit the potential and the implementation of the EbP. Moreover, this logic of experimental trial could lead to the development of a vibrant research-based policing which make use of trending technologies to mimic crime and provide portable solutions which can be experimented upon.

3 The Current state of the Nigerian Police Force

The 1999 Nigerian Constitution made provisions for the Nigerian Police Force (NPF), Police Council, and the Police Service Commission. Section 214(1) of the 1999 Constitution provided that: "There shall be a Police Force for Nigeria, which shall be known as the NPF, and subject to the provisions of this section, no other police force shall be established for the Federation or any part thereof." The 1999 Constitution further re-established the Nigerian Police Council (NPC), in similitude to the 1963 Constitution, which was omitted in the 1979 Constitution. Furthermore, the Third Schedule of the 1999 Constitution established the Police Service Commission (PSC). The Police Council comprises the President of the Federal

Republic of Nigeria; Executive Governor of each States of the Nigerian Federation; chairman of the Police Service Commission; and the Inspector-General of Police (IGP). Accordingly, the President of the Federal Republic of Nigeria shall be the Chairman of the Police Council. The functions of the Police Council include: "the organization and administration of the NPF and all other matters relating thereto (not being matters relating to the use and operational control of the Force or the appointment, disciplinary control and dismissal of members of the force; the general supervision of the NPF; and Advising the President on the appointment of the IGP". The 1999 Constitution, like the 1963 Constitution of the Federation, also provided for the establishment of a civilian oversight body; the Police Service Commission. The commission has members not less than seven headed by a Chairman, "as may be prescribed by an Act of the National Assembly". The Constitution further stipulates that the Commission shall have the power to "Appoint persons to police offices (other than the office of the IGP) in the NPF; and (ii) Dismiss and exercise disciplinary control over persons holding any office referred to in their jurisdiction". "Section 4 of the Police Act prescribes the functions to be performed by the NPF as (i) Prevention and detection of crime; (ii) Apprehension of offenders (iii) Preservation of law and order; (iv) Protection of life and property; (v) Enforcement of all laws and regulations with which they are charged; and (vi) Military duties within or without Nigeria as may be required of them" [1].

3.1 Structure of the Nigerian Police Force

The Nigerian Police Force (NPF) structure is provided for in section 214(2)(a) and 215(2) of the 1999 Constitution, works in a multi-divisional form, with a recent structural operation which covers the combination of many other structures. According to Section 215(2): "The *NPF shall be under the Command of the IGP and any contingents of the NPF stationed in a state shall be subject to the authority of the IGP, and under the command of Commissioner of Police of that state*". From the foregoing three different structures in the Police Force can be extracted. They include (i) a Command Structure, (ii) an Administrative structure, (iii) an Organizational structure [16]. These structures were reformed in 1986 by the Ibrahim Babangida government into 7 departments (see Table 1) and 12 zonal commands (see Table 2) to meet the constitutional expectations of the Police. The NPF uses a regimented hierarchy Command structure presented in the Chain of Command (Authority) as follows: Inspector General of Police → Deputy Inspector-general of Police (DIG) → Assistant Inspector-General of Police (AIG) → Commissioner of Police (CP) → Deputy Commissioner of Police (DCP) → Assistant Commissioner of Police (ACP) → Chief Superintendent of Police (CSP) → Superintendent of Police (SP) → Deputy Superintendent of Police (DSP) → assistant superintendent of police (ASP) → inspector of police → sergeant major → sergeant → corporal → constable. The NPF is the principal law enforcement agency in Nigeria with a staff strength of about 371,800 and plans to

increase the force to 650,000. According to section 6 of the Police Act, 1990 laws, “the NPF is commanded by the IGP, who transform inputs from the oversight bodies into programmes and guidance for police managers to implement”. The office of the IGP is located at the police headquarters in Abuja, where, administratively, there are seven deputy inspectors-general (DIGs) in charge of different departments as shown in Table 1. The Office of the Secretary to the NPF, and the Force Intelligence Bureau (FIB), both manned by assistant inspectors-general (AIGs), are also part of the Police Management Team Odeyemi and Obiyan [17].

TABLE I ADMINISTRATIVE STRUCTURE OF THE NPF

Department	Description
A	Administration and Finance
B	Operations
C	Logistics and Supply
D	General Investigation and Intelligence
E	Training and General Policy on Manpower Development
F	Research and Planning
G	Information, Communications, and Technology

The 12 zonal commands were created from the 36 states and the Federal Capital Territory (FCT). Each zone consists of 2 and 4 states (see Table 2), at the direct command of an AIG, who are directly answerable to the IGP.

TABLE II ZONAL COMMAND STRUCTURE OF THE NPF

Headquarters of Zonal Command Structure of the NPF												
Zone	States											
	Kano, Jigawa, Katsina	Lagos, Ogun	Akwa Ibom, Taraba, Gombe	Nasarawa, Benue, Plateau	Edo, Delta, Bayelsa	Cross River, Rivers, Ebonyi, Abia, Imo	FCT, Niger, Kaduna	Kogi, Kwara, Ekiti	Abia, Anambra, Enugu	Sokoto, Kebbi, Zamfara	Oyo, Ondo, Oyo	Bauchi, Borno, Yobe
Zone-One	Kano											
Zone-Two		Lagos										
Zone-Three			Yobe									
Zone-Four				Makurdi								
Zone-Five					Benin							
Zone-Six						Calabar						
Zone-Seven							Abuja					
Zone-Eight								Lokoja				
Zone-Nine									Enugu			
Zone-Ten										Sokoto		
Zone-Eleven											osogbo	
Zone-Twelve												Bauchi

The Nigerian federation operates 36-states and one federal capital territory (FCT). Each State including the FCT is headed by a commissioner of police (CP), who is assisted by a deputy commissioner. A CP oversees areas under the State commander, which comprises all the divisional police officers (DPOs), who also have the station officers and police posts under them. There are six departments within each state headquarters: administration and finance ↔ operations, logistics and

supplies ↔ investigation and intelligence ↔ training and general policy on manpower development, and research and planning [17].

The various socio-cultural and historical background of every country influences the policing systems for various countries. For example, for most countries policing works by the principle of the state law unlike in the United Kingdom where policing works based on the principle of consent by the people. Criminologists have tried to bring out common features in police structures world over because of certain features, the most prominent of them being the command architecture, and as such, police organizations are distinct across countries. It could be classified based on the legitimacy or legal backing of police function (that is policing by function or policing by law); or classified based on command structure (that is a number of forces to be commanded or type of forces) [18].

- **Number of forces to be commanded:** If the entire police force in the country is organized as a single force under a single commander (China, Saudi Arabia, and Nigeria, for example), the model is called *singular model*, and if in a single country, there are several police forces, it is called *multiple models*. Inside the multiple models, if the police forces have well-defined territories of functioning and their functions do not overlap each other, the model is called *multiple coordinated*, if the case is reversed, where many agencies can have overlapping jurisdictions, it is called *multiple uncoordinated*.
- **Type of forces:** If the police forces in a country are highly organized and having a centralized command, it is called *coordinated centralized* police force, and if the police forces in a country do not have an apparent centralized command structure, it is called *decentralized* command structure. Table 3 shows the different classification of policing systems by countries:

TABLE III CLASSIFICATION OF POLICING SYSTEMS

Model	Command	Centralized	Decentralized
Singular	Single	China, Saudi Arabia, Nigeria	Not applicable
Multiple	Coordinated	France	UK
Multiple	Uncoordinated	Spain	USA, India

3.2 The Nigerian police and community policing

In 2004, Community policing was initiated to address the growing problem of insecurity and criminality in Nigeria in collaboration with police authorities, with six states selected for the pilot scheme. The induction of people in the pilot states by the “Police covered issues of quality

service delivery, partnership, accountability, empowerment, and problem-solving". By 2007, the number of states that have adopted the model of community policing has increased from 6-states to 18-states. However, the adoption of the community policing philosophy into the Nigerian Police service and practice can be defined as introductory, as many of the police personnel are still entangled with the traditional law enforcement approaches, which negate the principle of community partnership policing [19]. Generally, the integration of community policing comprises several fundamental adjustments, which often include citizen-empowerment, Police-Citizen partnership, and context-based problem-solving approach. These are key compositions required for effectiveness.

3.3 The changing trend of the society: from analog to digital society

The dynamics of the current information age is contingent on the transition from the traditional narrowly linked analog society to a broader digital interconnected society. This section discusses the digital perspective of Nigeria, as it relates to the Police.

3.3.1 The demographics of the Nigerian society (age)

The total population of citizens in Nigeria was estimated to 166.2 million people in the year 2012 and over 178.5 million according to the Nigeria National Bureau of Statistics. The current population of Nigeria is estimated to be over 196million, which is equivalent to 2.57% of the total world population. The country has a relatively young population as the median age in Nigeria is estimated to be 17.9 years for both male and female [20]. Nigeria has about 98.3 million people that use the internet as at December 2017 according to the Nigerian Communications Commission (NCC) [21]. Google also ranked Nigeria to be among the top three with the highest online searches in the world early this year [22]

3.3.2 Globalization and the changing society

As a result of the growing cooperation of countries in the areas of trade, travels, finance, and the advancement in information and communication technology (ICT), more people now have the opportunity to exchange goods and services regardless of geographical barriers. Thus, making peoples' lives more comfortable as transactions can easily be made and business transaction seamlessly conducted. Globalization has reduced cost; it has made life easier; faster production of goods and services and easier to move goods, services, and people across the border. Despite all the advantages of globalization, it also has its own drawbacks. It is being exploited by international criminal organizations to perpetrate crimes easily and efficiently on a global scale. Criminals can commit a crime in one country and hide in another country where they are protected. This leads to high cost of tracking and prosecuting of these criminals because of differences in laws and policies between countries and anonymity due to lack of a single database that identifies everyone in this global word.

3.3.3 The increasing complexity of crime

Digital crime (Cybercrime) is an offense committed against computer systems and its data through modification of data and unauthorized access of the digital system. Digital crime is a rapidly growing area of crime as criminals are exploiting the strength of the digital age (convenience, speed, and anonymity) to commit different criminal activities to cause serious harm and real threat to all victims worldwide. Before the advent of the digital age, individuals or groups within a local area or country mainly committed crimes. However, the emergence of the digital age meant the introduction of a complex network of activities of organization and individual. Leveraging human and system inefficiency, complex cybercriminal networks are frequently being established. Ranging from hackers for hire, to state-organized/sponsored cyber terrorism, a complex crime such as espionage, destruction/sabotage of critical infrastructure, massive denial of service attack through distributed denial of service attack, as well as stealing of trade secret using Bots and other malicious forms of software. Thus, trotting from one sophisticated network to another, the digital societal has ushered in, increase in crime complexity both in a near real-time and zero-day attack scenario. Whilst the crimes themselves are not necessarily new – such as theft, fraud, illegal gambling, and sale of illegal items – they, however, are evolving in line tandem with available online opportunities and therefore, becoming more widespread and damaging (Mohammed, 2015). In contrast to traditional crime, a digital crime has a peculiar advantage, ranging from perceived anonymity to the exploitation of virtual complex crime opportunities. The logic of “no geographic boundaries” further introduces a complex methodology of crime perpetration. Therefore, a digital theft can be effected without leaving any physical trace, and in some cases, any digital trail. Some example of digital crimes or cybercrimes includes: Assault through Threat, Child Pornography, Cyber-laundering, Cyber theft through the use of a computer, Cyber-terrorism, Denial of service, Cyber Fraud, Online blackmailing and many more.

These rapid growths in cybercrime and the difficulty in combating these trends have created many challenges that needs need addressing. Since these challenges affect the local environment, the country, and the international community, there are needs to address the challenges from the grassroots, then the country and collaboration with the international community. These can be achieved through the combination of traditional means of policing and digital means of policing. The digital policing will use forensic evidence to address digital crimes through trails left behind by cybercriminals while traditional policing can help in tracking the traditional crimes.

The relationships between the criminals can be discovered through proper policing laws, policies and collaborations between the entities involved.

4 Digital policing model in Nigeria

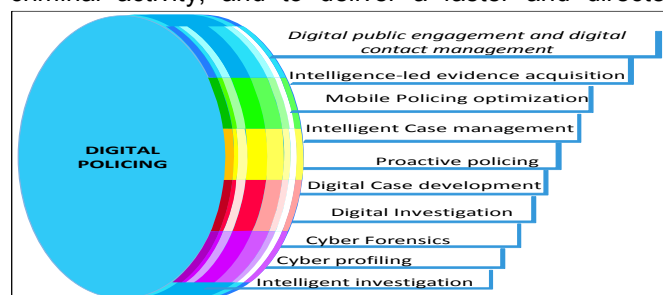
Digital policing as a model of policing is a complementary approach to existing policing model. It leverages

technological innovations and growth to expand the investigative possibilities of the police. A digital policing model in the context of Nigeria is the integration of digital component into the policing apparatus of the Nigerian Police Force. Digital component implies the transformation of the paper-based process of investigation into a digital component through which further knowledge-based process can be applied. Such knowledge-based can be leveraged to develop expert systems for the police service. A police expert system can be used to develop geographical profiling, crime hotspot mapping, enhanced police-citizen relationship through timely investigation, enhanced investigation process, as well as personnel effectiveness. Owing to the change in crime landscape over time, often in response to technological advances, there is a need for an integrated policing model which delivers services in response to technological advances. This is particularly true for developing nations, where the crime rate tends to grow astronomically in response to technological advances. This can be attributed to the tendency to adopt technology in most developing nations by the citizen, in contrast to the willingness to embrace technology revolve with technology by the Police force. Therefore, digital policing involves the use of digital technology to transform the way policing is delivered by integrating the society, virtually, with the police stations, thus bringing the Police closer to communities and crime spots. Thus, digital technologies establish the platform for police officers to be collocated within a crime scene and their respective offices, as well as when it is happening – even in a virtual [24]. There are diverse focal areas (see Figure 1) of transformation on which to apply digital technology for effective and efficient service delivery such as proactive policing, digital public engagement, mobile workforce optimization, and digital investigation.

4.1 Component of digital policing

Fig. 1. The wheel of digital policing

Applying digital technologies across policing services can enable police forces to use their resources more intelligently, proactive in identifying and addressing criminal activity, and to deliver a faster and directed



response through near real-time information-sharing and effective decision-making. The potential area of the digital policing area is presented in Fig. 1.

These areas provide a substratum for the development of digital policing. A brief description is further presented.

- *Proactive policing*: This means getting there before crime happens, thereby deterring criminal activity through proactive action, driven by data analytics and evidence-based policing. This is possible by demand forecasting to guide resourcing decisions, predictive policing analytics to model future risks and *intelligence-based evidence acquisition and analytics* to drive the deployment decisions. It can also involve the process of intelligently managing the daily operation of the Police in *enhancing case management*.
- *Digital public engagement and digital contact management*: This means to identify incidents before witnesses call through multi-channel communication with the public, online crime reporting and crowd-sourced intelligence, investigation via social media platforms, and digital channels for low-risk contact with the police. All these services can reduce demand for control rooms and Contact Centres.
- *Mobile workforce optimization*: This means getting the best out of Officer's time through Neighborhood and response officers patrolling the beat more regularly, enabled by mobile devices which they can use to receive and deliver tasking and intelligence, search internal systems, capture statements and record supporting evidence. Another component also includes the potential to profile individual in an online platform, on the motion pattern detection using CCTV camera, as well as a near-real-time recurrent anomaly detection in public domain.
- *Digital investigation*: This means accelerating the investigation through real-time information exchange using an electronic witness statement and electronic suspect image. mobile digital case file with real-time sharing and digital evidence capture, mobile ID verification and multi-system search in custody, crowd-sourced investigation through social media and digitized collaboration with CPS and court proceedings. Other related areas include cyber forensics, intelligent investigation,

However, these areas have the potential to elicit the following technological component as a modernized approach to policing:

- *Online Crime Reporting*: This is to digitize crime reporting and evidence submission procedures in order to improve the efficiency with which people can report crimes and generate significant costs savings for police forces. This will allow investigations to start immediately and save hours of police time as officers would no longer have to collect physical media.
- *Live streaming of Video Footage into Control Rooms*: The digitization of video footage allows the live streaming of CCTV and Body Worn Video (BWV) footage into control rooms and alarm-monitoring stations thereby saves police time and money, as well as improves officer safety, which further increases their situational awareness.

- **Security & Identity:** The proliferation of Digital Identity Technologies to improve online safety and reduce the impact of cyber-crime. Identity verification and management tools could significantly aid crime prevention and ease the burden on the police.
- **Police Adoption of the Cloud:** This is to address the data storage problem currently facing forces and to enable them to realize the potential of data and analytics tools.
- **Digital Skills in Policing:** A structured and comprehensive approach to address the gap in Digital Skills in Policing through enabling Digital Investigation and Intelligence (DII) programme that should further develop police capability in relation to the skills and technology required to effectively police a digital age and protect victims of digital crime. This can be achieved by adopting a three-tiered approach to digital skills for police, consisting of training to a minimum viable level for all officers; equipping frontline officers with mobile accessible digital toolkits; and establishing a Managed Service framework to allow police to access specialist capabilities from industry.
- **Smarter Procurement & Accessing Innovation:** A Smarter Approach to Procurement to ensure that Government and police forces are better able to access innovation.

5 Probable Policing-framework to adapt in Nigeria

The proposed digital policing framework to adapt for Nigeria is described as the integration of Intelligence-focused policing and community-oriented policing in a democratic setting, as shown in Figure 2. This preliminary framework requires an iterative process and continual contextual re-engineering. Given that the Country's policing apparatus is largely divided into zones as highlighted in Table 2, there will be an integration of contextual alignment of policies and digital capability amalgamation. This implies that the Police will be required to leverage expertise and knowledge from Zones with a high digital presence, to Zone with a lower digital presence, while ensuring that the required manpower for highly digitized is not shortchanged for the converse.

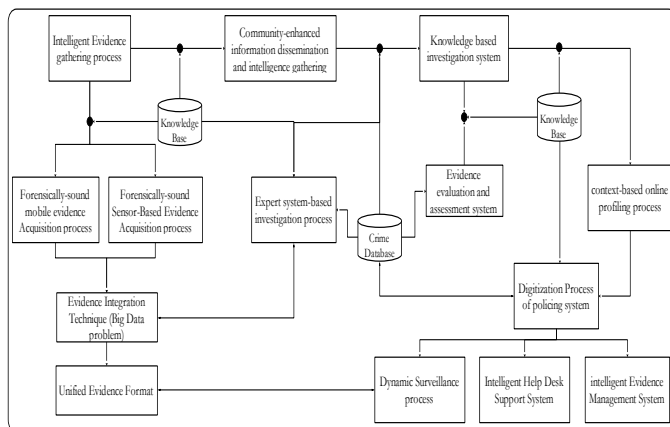


Fig. 2. Intelligence-led digital policing framework for developing nations

The framework comprises several components which leverage diverse policing models. This includes intelligence, reassurance, community policing, as well as problem-based policing models. More importantly, however, is the integration of knowledge-based component into policing. Furthermore, the framework considers the integration of evidence reliability and forensic soundness as a composition of the framework. The framework can be thematized into two interconnect asymmetric half. The first-half integrates the need for forensic soundness into evidence gathering, storage, and analysis. this implies the need for effective chain-of-custody, chain-of-evidence, and chain-of analysis. this process is expected to eventually culminate into the development of a unified evidence format which can be used to coordinate cross-regional cases. In the second phase, the need for digitization of the policing process is presented. This notion presumes that the traditional paper-based manual policing process in Nigeria can leverage the trend in technological advancement to digitize the policing process. The overall framework, therefore, presupposes that the Nigerian police force considers the contextual peculiarity of the various Zones (as categorized by the Police Force) of the Country, which may require further extrapolation and justification. One major application of the proposed framework is the development of a tacit knowledge base. Such a knowledge base involves the retention of tacit knowledge from experience and retiring/retired police personnel. Knowledge from such development can be leveraged to enhance policing. With such a knowledge base, expert systems which utilized artificial intelligence, nature-inspired heuristic algorithms, as well as metaheuristic processes, can be developed. This could also serve as a source of data for research and knowledge transference.

6 Conclusion

The notion of digital policing in a developing nation, particularly in Nigeria, is presented in this manuscript. Approaches and models of policing are identified and discussed. The need for the digitization of the various policing apparatus of developing nation is defined as a core requirement for effective policing in the current information age. This further elicited the development of a digital policing framework for developing nation with a focus on the practicality of application in tandem with infrastructural projections. The framework presented in this manuscript will be further evaluated in close collaboration with the Nigerian police force and other identified developing nations. This proposed policing framework has the potential to provide a baseline for the integration of digital competency, as an effective policing mechanism for developing nations.

7. Acknowledgement

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Response surface optimization of oil refinery wastewater treatment process

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Abstract

In this paper, a laboratory dissolved air flotation (DAF) process was employed for the removal of chemical oxidation demand (COD), soap oil and grease (SOG), total suspended solids (TSS) and turbidity from oil refinery wastewater (ORW) using polyferric sulfate. The optimization was carried out by response surface methodology Box-Behnken design to evaluate the interactive effects of three main independent process parameters (pH, coagulant dosage and flotation time) on the removal of the COD, SOG, TSS, and turbidity. The quadratic model fitted very well with the experimental data at regression coefficients (R^2) of values of 0.9986; 0.9992; 0.9847; 0.9858 for COD, SOG, TSS, and turbidity respectively. Under the optimum conditions of coagulant dose of 48 mgL^{-1} , pH (5) and flotation time (17 min), the maximum removal of COD, SOG, TSS, and turbidity were 86%, 92%, 84% and 85% respectively were obtained. The removal efficiencies showed a high significance of the model correlations at 95% confidence level. This demonstrated that the addition of the polymeric sulfate can enhance the treatability performance of the ORW.

Keywords: Box-Behnken design; coagulation; flotation; oil refinery wastewater; polymeric organic coagulant; response surface methodology

1.0 INTRODUCTION

Industrial mineral oil wastewater (IMOW) consist of wastewater from ship slops, oil leaks, oil refinery off specs and the sludge from oil storage tank, which contains a high content of about 75% oil and other organic matter such as chemical oxidation demand (COD), soap oil and grease (SOG), total suspended solids (TSS) and turbidity [1–3].

Generally, the toxicity of IMOWs is of global concerns in relations to human health and environment. According to a local South African oil refinery, they are able to recover about 25% of the oil from the wastewater per day where the rest creates a potential source of pollution [3, 4]. As such, it is essential to remove or minimize these environmental contaminants. In addition, to mitigate the environmental challenges, there is the need to recover the oil waste from the wastewater settings and reprocess it into useful products such as lubricating oil and the treated water for reuse [5].

Coagulation, flotation, sedimentation, microfiltration, ultrafiltration, and electrocoagulation techniques are widely employed for oil-water separation [1, 6]. However, to comply with the environmental regulations together with technical and managerial development, some of these conventional wastewater treatment techniques have some drawbacks [4, 5]. Consequently, separation of oil from water by merging the chemical and physical process has been proofed to be effective [1]. Whereby coagulation-dissolved air flotation (DAF) mechanism stands as an advantageous route for the removal of suspended organic solids and dissolved oils in the oil refinery industries [7, 8]. This is because of the coagulation-DAF favors easy operation, high efficiency, and fewer energy consumptions than the other conventional methods [9]. The addition of coagulant is term as coagulation (chemical treatment), whereas the DAF process (physical treatment) involves the use of microbubbles as a driving force for the separation.

To yield higher performance of process operation without increasing the cost is very essential in wastewater treatment. The termed optimization is usually employed to select and set the best levels of the operating variables to maximize a particular response [6]. Recently, researchers have reported the use of response surface methodology

(RSM), for optimizing wastewater treatment process, such as sugar refinery wastewater, landfill leachate, palm oil mill effluent, is gaining response over the tradition of one factor at time (OFAT) approach [7, 8]. OFAT approach is not only time consuming but lacks the ability to identify the interactional effects on the response [9]. Nevertheless, to the advantage of the RSM, it can resolve the relationship between multi-variables due to their complex influence on the response or outputs [8 – 10].

The common design of experiment (DOE) used for RSM analysis includes the three-level full factorial design, central composite design (CCD), the Doehlert design (DD) and the Box Behnken design (BBD) [11]. The CCD, DD, and BBD are modified forms of two-level factorial designs (2^n) by the addition of center points that generate three level designs suitable for higher degree polynomials in RSM [12, 13]. The RSM has been reported as an alternative method to optimize wastewater treatment processes. Ahmad et al., [14] also used a polymeric chloride with uniform design-RSM to evaluate and optimize the interactions of pH, coagulant dosage and basicity to improve upon biodiesel wastewater.

In this study, the application of the BBD approach is adapted from RSM for the industrial oil refinery wastewater treatment with the purpose of optimizing the coagulation – DAF process to remove the contaminants. The use of the RSM design assisted, in this study, to express and quantify the relationship between the input parameter and the corresponding response (water quality). Above all, to investigate the treatability performance of the coagulation-DAF process with polyferric sulfate (Zetag32-FS/A50), the experimental matrix was generated by the BBD and by monitoring the COD, SOG, TSS and turbidity removals, the optimum conditions are then determined.

2.0 MATERIALS AND METHODS

Wastewater sample and polymeric organic coagulant

The IMOW sample used in this study was obtained from a local South African oil refinery wastewater treatment plant located at Durban in the Kwazulu-Natal province. Physicochemical analyses were conducted in accordance with the standard methods for the examination of water and wastewater [15]. The sample characterized is depicted in Table S1. The polymeric sulfate (Zetag32-FS/A50) used was provided by a local South Africa chemical supplier (ZetagChem ZA). This contains complex ferrous ions formed by hydroxylase ferric sulfate and aluminum chloride together with a high molecular weight and charge density. It has less than 0.3% insoluble substances, a specific gravity of 1.54, weight of 12.2% w/w Fe^{3+} and 43.7% w/w $\text{Fe}_2(\text{SO}_4)_3$.

The dissolved air flotation (DAF)

The DAF jar tester (EC Engineering, Alberta, Canada) with six 1-L rectangular jars and an 8-L recycle air saturator was used for this study. In the DAF jar tester, the coagulant addition requires to form robust flocs with the oil droplets before introducing the dissolved air to the system [16]. The release of the saturated air, based on the pressure drop, causes the air bubbles to float with the oil droplet to the surface for separation. The jar test protocols were followed in accordance with the American Society for Testing and Materials [17]. The pH of the sample was adjusted from 7 according to the experiment design using 1.0 M H_3PO_4 . The amount of the Polyferric sulfate dose was added to the sample according to the design of the experiment. The sample was immediately stirred at a constant speed of 250 rpm for 2 minutes (rapid mixing), followed by slow mixing at 30 rpm for 15 minutes, with a recycle air to water ratio of 10% at a retention time of 3 seconds and air saturator pressure of 350 kPa. The mixture was allowed to stand for the oil droplet floc formation and the flotation time to elapse before sample analysis [18]. The DAF mechanism follows the principle of gravity separation, which is based on the Stokes' law [19, 20]. The Stokes law equation gives a relationship between the rise or settling velocity of a sphere in the fluid density and viscosity as mathematically expressed (Eq. 1).

$$\text{Stokes' law equation: } V = \frac{(2gr^2)(d_1-d_2)}{9\mu} \quad (1)$$

Where: V = Rise velocity (cm s^{-2})

g = Gravitational acceleration (cm s^{-2})

r = Equivalent radius of particle (cm)

d1 = Density of particle (g cm^{-3})

d2 = Density of medium (g cm^{-3})

μ = Viscosity of medium (dyne.sec cm^{-2})

The response surface methodology (RSM)

RSM is a collection of statistical and mathematical tools used for developing empirical models, optimizing process systems with curvatures that represents the response surfaces. As the aim of this study is to evaluate the interactional effects of the factors, and also to determine the combined factors that would yield the optimal response. The experimental design, desirability, statistical analysis, and the regression were done using Design expert software

Version 10.0.3 (Stat-Ease Inc., Minneapolis, Minnesota, USA). This provided the Box-Behnken design (BBD) for the response surface design. Thus the BBD was responsible for the experimental design evaluating the desirability and evaluating the correlation between the response (COD, SOG, TSS, and turbidity) and the experimental variables (pH, coagulant dosage and flotation time). This was able to fit first-order (linear) and second-degree models with the aid of the axial and center points.

Ideally, to identify the response variable of interest (Y) in equations (2) to (4) with sets of predictor variables (X_1, X_2, \dots, X_k) requires an empirical model for the approximation of the unknown function.

$$Y = f(X_1, X_2, \dots, X_k) + \varepsilon \tag{2}$$

Where the term ε represents errors in the system. In addition, the function f is in the form of first-order or second-order polynomials. The first-order model always includes the main effects of the input variables in (3) as follows;

$$Y = \beta_0 + \sum_{i=1}^n \beta_i X_i + \varepsilon \tag{3}$$

Where the terms $Y, \beta_0, \beta_i X_i$ and ε represents the response, constant, coefficient of the input variable, predictors and the residual error from the treatment process respectively. At critical points RSM-BBD generates a second-order polynomial model in (4) as follows:

$$Y = \beta_0 + \sum_{i=1}^n \beta_i X_i + \sum_{i=1}^n \beta_{ii} X_i^2 + \sum_{i<j}^n \beta_{ij} X_i X_j + \varepsilon \tag{4}$$

Where $X_i X_j$ represent the interaction terms β_{ii} and β_{ij} represent the coefficients of the interaction factors respectively. To employ the RSM as an optimization technique the following steps were considered; (a) the selection of independent variables of major effects on the system through screening studies and the delimitation of the experimental region (Table 2), according to the objective of the study; (b) the choice of the experimental design and carrying out the experiments according to the selected experimental matrix; (c) the mathematic-statistical treatment of the obtained experimental data through the fit of a polynomial function; (d) the evaluation of the model's fitness; (e) the verification of the necessity and possibility of performing a displacement in direction to the optimal region; and (f) obtaining the optimum values for each studied variable [21,22].

The design properties as orthogonality, curvature and rotatability were estimated via the BBD matrix. Consequently, a series of 17 experimental runs were derived

with three factors and levels conditions shown in Table 1. The input variables were coded using (5) and the response percentage removal viz COD (Y_1), SOG (Y_2), TSS (Y_3) and turbidity (Y_4) were calculated using (6) below.

$$X = \left(\frac{x_i - x_0}{\Delta X} \right), (i = 1, 2 \dots k) \tag{5}$$

$$Y_n = \left(\frac{y_0 - y_1}{y_0} \right) \times 100\% \tag{6}$$

Where Y_n, y_0 , and y_1 respectively, represent the response variable, initial and final values for the coagulation flotation process

Table 1. The levels and ranges for the BBD experimental design

Variables (factors)	Values			Reference
Levels	-1	0	1	
A: pH	4	5	6	[5]
B: Coagulant dosage (mg L-1)	30	40	50	[5]
C: Flotation time (min)	10	15	20	[5]

3.0 RESULTS AND DISCUSSION

Effects of the operating conditions

This study employed RSM to address a problem in relating to an oil refinery wastewater treatment facility by integrating modeling and optimization to evaluate the interactions effects of the factors on the response. Also, to consider the application of polyferric sulfate as an alternative coagulant for reuse. Where the addition of the coagulant destabilized, neutralized and coalesce the oil droplets to form larger flocs. This occurred through the compression of the double layer, charge neutralization, entrapping and interparticle bridging [12]. It was also observed that pH played a major role in the oil droplet floc size formation, by neutralizing and making the oil droplet charge unstable. Thereby exciting the ionic charge of the oil droplets to easily adhere to the coagulant. The optimum coagulant dosage was defined as the highest value at which there is no significant increase in percentage removal with any further increase in the coagulant dosage.

The results obtained from the runs actual design matrix and the analyzed models predicted values are depicted in Table 2. The difference between the models predicted values and experiment data of each run is shown in Fig 1. The

experimental values were determined for a particular run and the predicted values were calculated from the approximating function used for the model. The oscillation that is seen (Figure 1), is due to the chemical reaction and the holdup time that occurred between the coagulant and the oil droplet, in reference to their specified coagulant dosage and flotation time at each run. In accordance with the design matrix conditions for the runs, there was a low difference from run 1 to 6; using 0 as the center point or benchmark. Follow up was from run 6 to 14; which was very close to the center point. From runs 14 to 17; whose difference was further away from the center point, suggesting that the conditions of those runs far off from precision and accuracy of the models.

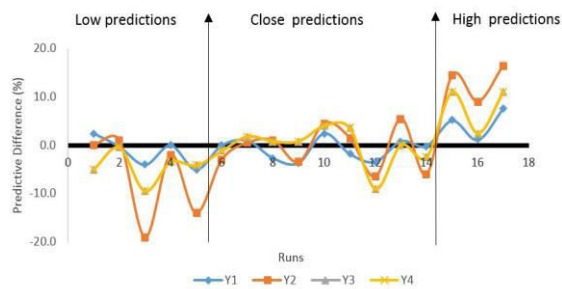


Figure 1. The difference between the predictive model and the experimental results values at each run

Polynomial models and analysis of variance (ANOVA)

After performing 17 runs of the BBD, the results of the statistical experiment were analyzed with regard to the actual design matrix. Four quadratic regression equations were developed (7 – 10), expressed as the percentage removal of contaminants as a function of the input variables in their actual units. These are expressed in terms of Y_1 , Y_2 , Y_3 , and Y_4 for COD, SOG, TSS and turbidity removal respectively. Whereas the input variables terms are also expressed as A, B, and C for pH, coagulant dosage and flotation time respectively.

$$Y_1 = -79.125 + 47.25A + 1.2375B + 2.025C - 0.15AB - (2.8713 \times 10^{-16})AC + (5 \times 10^{-3})BC - 4.125A^2 - (3.75 \times 10^{-3})B^2 - 0.075C^2 \quad (7)$$

$$Y_2 = -66.5 + 37A + 3.1B - 1.3C - 0.05AB - 0.5AC + 0.5BC - 4.75A^2 - 0.0425B^2 - 0.11C^2 \quad (8)$$

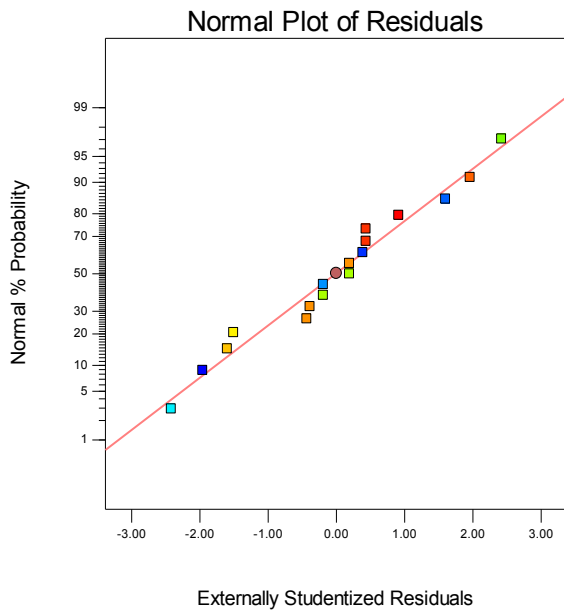
$$Y_3 = -17.8 + 12.5A + 3.43B - 1.68C + 0.075AB + 0.15AC + (5 \times 10^{-3})BC - 1.7255A^2 - 0.04225B^2 + 0.031C^2 \quad (9)$$

$$Y_4 = -16.8 + 12.5A + 3.43B - 1.68C + 0.075AB + 0.15AC + (5 \times 10^{-3})BC - 1.7255A^2 - 0.04225B^2 + 0.031 \quad (10)$$

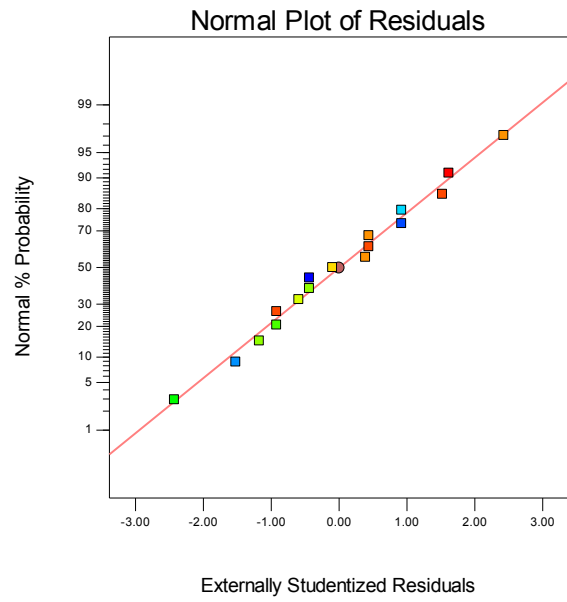
The regression equations and determination coefficients (R^2) were determined to test the fit of the models. The ANOVA shows that all the models developed (7 – 10) were highly significant. Thus the fitted models were considered adequate if the F-test were also significant ($p < 0.05$). Such that the very low probability ($p < 0.05$) of the F-test and the insignificant result from the Lack of Fit (LOF). The LOF test was applied to determine whether the selected models were adequate to describe the observed data or whether a more complicated model should be used.

The coefficient determination (R^2) values of 0.9986; 0.9992; 0.9847; 0.9858 are the measures of goodness of fits for the models Y_1 , Y_2 , Y_3 , and Y_4 respectively, enumerating a high degree of correlation between the observed value and predicted values. The determination coefficient suggested that more than 99.5% of the variance is attributable to the variables and indicated a high significance of the model. Thus, less than 0.5% of the total variance cannot be defined by the model. The predicted R^2 values were in good agreement with the adjusted R^2 values with a desirable $< 2\%$. The adequate precision measures the signal-to-noise ratio, where a ratio > 4 was suitable for the models to navigate the design space. The coefficient of variation (CV) value which is not $> 10\%$ obtained indicated a high precision and reliability of the experiments with an observed standard deviation of < 4 . The P -values of the regression coefficients suggest that among the test variables, linear, quadratic and interaction effects of pH, coagulant dosage and flotation time level are highly significant. The insignificant effects (factors and interactions) with P -values higher than 0.05 were ignored.

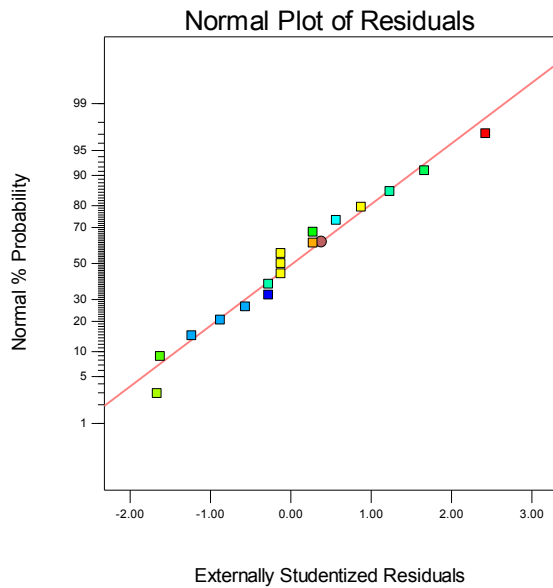
Furthermore, the statistical and diagnostics studies were also used to evaluate the significance and interaction effects of the models' terms on the response. Figure 2 shows the externally studentized residuals and normal percentage probability plot. Where the residual is the representation of the difference between the observed value of the response measurement and the value that is fitted under the empirical model. In all the plots, the residual points are close to the diagonal lines that the models' prediction were accurate.



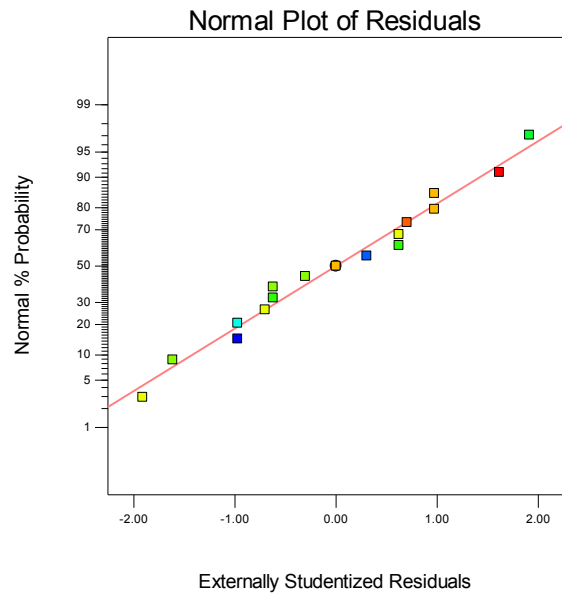
(a)



(c)



(b)



(d)

Figure 2. Normality plots for (a) COD, (b) SOG, (c) TSS and (d) turbidity

Interaction and optimization of the factors

The interaction between factors affecting the coagulation-DAF process is shown in Figure 3. The 3D representation facilitated in visualizing the interaction effects levels of the factors in respect to the percentage removal of the contaminants. Consequently, the interaction between the

coagulant dosage (45-48 mg L⁻¹) and pH (4.5- 5.5) was found to be the most influential factors. The maximum removal of COD, SOG, TSS and turbidity obtained at a flotation time of 15 min, were 86%; 92%; 84% and 85% respectively as depicted in Figure 3.

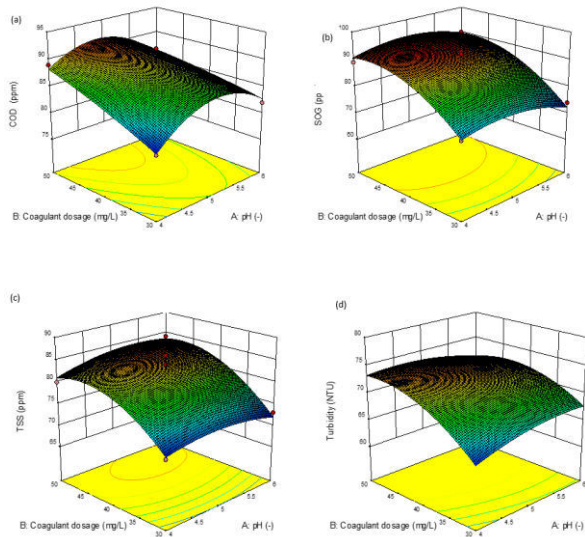


Figure 3. Response surface 3D plot indicating the interaction effects of pH and coagulant dosage for the percentage removal of (a) COD, (b) SOG, (c) TSS and (d) turbidity at flotation time of 15 min.

The numerical optimization technique based on the overlay plot was carried out to determine the optimum conditions at maximum efficiency. The input variables were set within the range of the design space and contaminants removal were set on maximize. The optimum conditions obtained were coagulant dosage of 48 mg L⁻¹, with a pH and flotation time of 5 and 17 min respectively at desirability performance of COD (81-89%), SOG (85-99 %), TSS (79-89 %) and turbidity (80-90 %) as shown in Figure 4.

A comparative study was done between the models predicted values and the experimental results at pH of 5, coagulant dosage of 48 mg L⁻¹ and flotation time of 17 min. As shown in Fig 5, the models predicted values were 94%, 97%, 88% and 87% as against the experimental results of 90%, 93%, 82% and 80% for COD, SOG, TSS and turbidity removal respectively. The result indicated a reasonable agreement between the model predictions and the experimental results. The standard error margin was less than 5%, which proves the accuracy and consistency of the models.

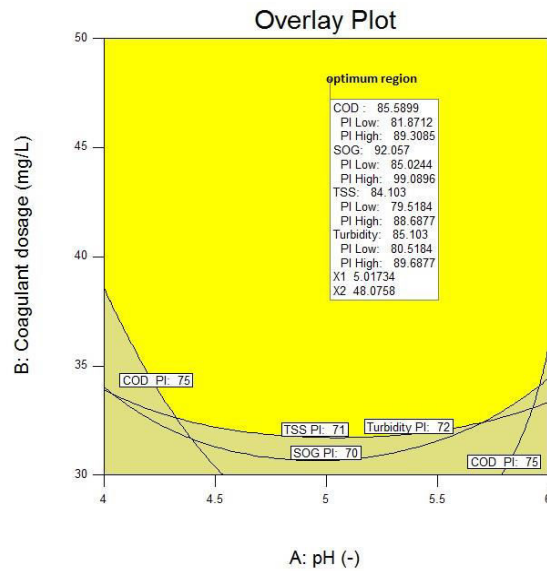


Figure 4. Overlay graphical plots coagulant dosage (mgL⁻¹) vs pH showing the low and high percentage indicator (PI) of the responses

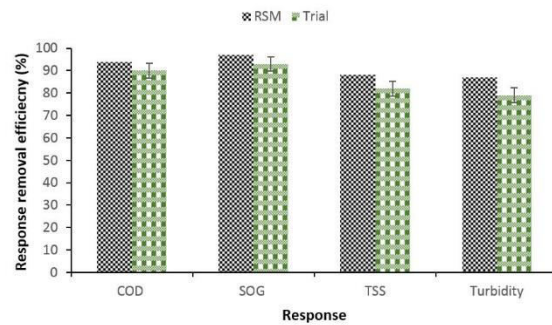


Figure 5. The relationship between the response models and the experimental trial data; pH at 5, coagulant dosage at 48 mgL⁻¹ and flotation time at 17 min.

4.0 CONCLUSIONS

This study was intended to evaluate the treatment performance of coagulation DAF process and its optimization using RSM. The RSM-BBD and the ANOVA results showed that coagulant dosage is the most significant and influential variable to control in order to enhance. The optimized condition for the treatment of the oil refinery wastewater was pH at 5, coagulant dosage at 48 mg L⁻¹ and flotation time at 17 min. Above 80% treatability performance of the oil refinery wastewater treatment facility was obtained when the Polyferric sulfate dosage was increased. The second order quadratic regression models developed were all significant with a coefficient of determination (R²) greater than 0.95, obtained at a statistically significant probability (p < 0.05). The models' prediction were consistent with the trend of the experimental result obtained from the confirmation test. RSM with BBD is seen to be an economically viable, reliable and controlling tool for modeling and optimization.

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The Effect of Water in Diesel Emulsion with its Nano Additives on Diesel Engine: A Review

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Abstract

The harmful air pollution which is caused due to diesel engines has revealed more focus on the use of eco-friendly alternative fuels. With a view to intensify the performance and lessen the exhaust emissions in existing diesel engines, continuous attempts are being made for the adoption of water-in –diesel (W/D) emulsified fuels, as they acquire certain characteristics which scales down the nitrogen oxides (NO_x) and soot particles emissions simultaneously. The present review targets the specified study related to the principle of W/D emulsion fuel and the effect of W/D emulsion fuel on performance and emission characteristics of diesel engines. Also, the consequences of nanoparticles in W/D emulsion fuel for enhancing engine performance and compressing exhaust emissions are considered. Most of the earlier researchers disclosed a positive effect of nanoparticles in diesel fuel for enhancing various parameters and lowering down the emission levels.

Keywords: Diesel engine; emission characteristics; nano additives; performance parameters; emulsion fuel

1.0 INTRODUCTION

The diesel engines rule the power production in vehicles and even they are majorly used in the transit sector, as compared to petrol engines. However, more perilous emissions are emitted out by combustion of diesel fuel (DF) such as nitrogen oxides (NO_x) and particulate matter (PM) which have generated deliberating results regarding environmental pollution [1-2]. Therefore, some rigid adjustments are to be pursued in order to command the levels of emissions from diesel engines. Nowadays much focus has been on reducing the coexistence of NO_x and PM emissions. But, it is a difficult task to reduce these emissions together [3]. Many emission control approaches are being used by researchers which include the use of alternative fuels, diesel particulate filters, diesel oxidation

catalyst and water-in-diesel (W/D) emulsion fuel [4]. Among these listed techniques, W/D emulsion technique has progressed out to be the most effective strategy which can be presented in diesel engines with no need of engine alterations. It is generally considered a strategy to diminish both NO_x and PM discharges simultaneously. The accelerated and severe vaporization of water known as a micro explosion phenomenon enhances the rate of mixing of air and fuel particles by generating tiny droplets of fuel. The soot formation rate decreases due to the presence of water in the core spray area. But, the considerable difficulty with W/D fuel is a higher rate of emissions of carbon monoxide (CO), unburnt hydrocarbons (HC) due to longer ignition delay [5]. Some current investigations demonstrated that nano-additives have attractive qualities to enhance the characteristics of better combustion Nano-additives enhances the proportion of surface area over volume which will thus boost the fuel dispersion [6].

Vellaiyan et al. [4] concluded that with the inclusion of nano-particles in W/D emulsion fuel results in upgraded the main attributes such as combustion and performance along with reduced ignition delay period. Hasannuddin et al. [7] disclosed that the application of emulsified nature fuel stands out to be an excellent approach in a diesel engine for reducing NO_x and soot particles together. However, it hikes CO emissions due to low exhaust temperature. Jiaqiang et al. [8] examined the consequences of the addition of water and cerium oxide nanoparticle in the biodiesel-diesel blend fuel. They claimed that brake specific fuel consumption (BSFC) diminished by 4.5% as compared to that of B5 fuel and brake thermal efficiency (BTE) got increased along with a decrease in emissions because of upgraded combustion quality generated by the catalytic behavior all along the combustion process. Karthikeyan et al. [9] considered the effect of (Zinc oxide)

ZnO nanoparticles on the performance parameters and emissions with Grape Seed Oil Methyl Ester (GSOME) in a diesel engine. They reported that BTE increases with an increase in the fraction of ZnO in the blended fuel. It was observed that there is an increase in NO_x and CO₂ emissions when ZnO nanoparticle blended fuel is used. But CO, HC, and smoke emissions are lower for ZnO nanoparticles mixed fuels.

This study focuses on the importance of emulsified fuel in small quantity in diesel fuel which can be used in diesel engines along with the inclusion of nanoparticles in W/D emulsified fuel and notifies the future involvement of nanoparticles as additives in water diesel emulsified fuel.

2.0 WATER-IN-DIESEL EMULSION FUEL

Basically, there exist two different types of emulsified fuels, particularly; two-phase emulsified fuel and three phases emulsified fuel. The two-phase emulsified fuel as shown in Fig. 1 consists of a single continuous phase and single dispersed phase while in three-phase emulsion there exists one continuous phase and two dispersed phases as shown in Fig.2. The two-phase emulsified fuels are further classified into two varieties i.e. water-in-oil (W/O) and Oil-in-water (O/W) whereas three phases emulsified fuels are further classified as oil-in-water-in-oil (O/W/O) and water-in-oil-in-water (W/O/W). A water-in-oil emulsion is considered better in comparison to oil-in-water emulsion due to the micro explosion process of a small amount of water droplets as well as fewer viscosity changes are appreciable characteristics. Also in oil-in-water emulsified fuel, a large quantity of water participates in the combustion system, which has a diverse effect on engine operation and leads to incomplete combustion [11-12]. Lin et al. [13] concluded that three phases emulsified fuel possess certain unwanted characteristics such as low BSFC and enhanced exhaust temperature as compared to two-phase emulsified fuel. Moreover, they reported that there exists complexity in examining the behavior of three-phase emulsified fuel.

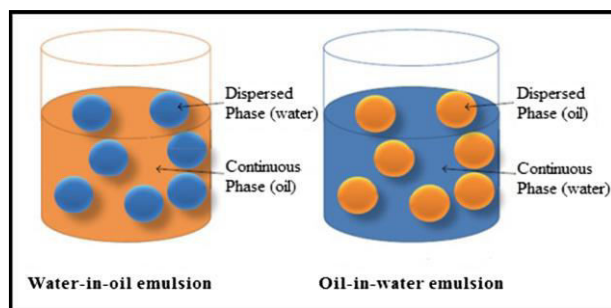


Fig.1 Illustration of Two-Phase Emulsions [10]

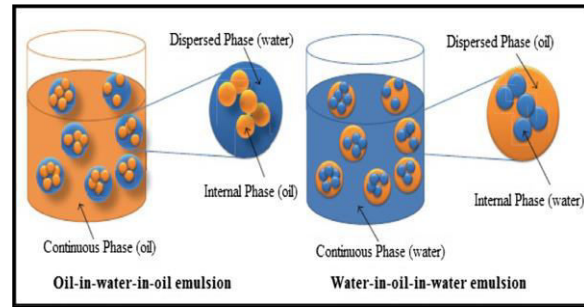


Fig.2 Illustration of Three-Phase Emulsions [10]

3.0 CONSEQUENCES OF W/D EMULSIFIED FUEL ON COMBUSTION PROCESS: MICRO-EXPLOSION PHENOMENON

Diesel engine combustion process is greatly influenced by the micro-explosion event of W/D emulsified fuel. The comprehensive focus on the essentials of micro explosion and its commanding factors are detailed below.

Basics of Micro Explosion Phenomenon

Inanov et al. [14] were the first to report a micro explosion phenomenon. They noticed that due to the presence of water particles in emulsified fuel the level of superheating is achieved quicker as compared to diesel. Due to this, they developed spontaneous explosion during combustion phenomenon, which results in the formation of very fine particles. Sheng et al. [15] through their flame angle study supported the act of microexplosion in emulsified fuel. Tanaka et al. [16] and Mura et al. [17] selected a hot plate procedure in order to examine the development of microexplosion. Watanabe et al. [18] studied break up phenomenon related to secondary atomization. Fu et al. [19] studied numerical methods of microexplosion and analyzed the data in contrast to their experimental findings. Fig.3 shows microexplosion and secondary atomization phenomenon in diesel engines.

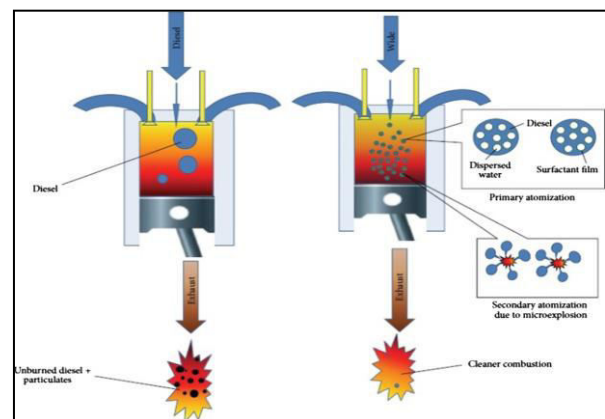


Fig.3 Micro Explosion Phenomenon [10]

Factors affecting Micro Explosion Behaviour

Fu et al. [19] reported that for better results of the explosion and lessened burn out timings the optimal amount of water in emulsion fuels is necessary. Jeong and Lee [20] stated that with enhancement in the percentage of water in emulsified fuel enhances the micro explosion intensity. However, an excess amount of water leads to the breakdown of the fuel injection system and causes rough engine operation. Marrone et al. [21] observed that water particle size of the emulsion is directly proportional to the ability of dispersion of emulsified water in oil droplets. Many studies have been conducted for finding out the optimal amount of water which is to be added in emulsified fuel. Tanaka et al. [22] found that the intensity of microexplosion is enhanced by increasing ambient temperature and pressure conditions. Ignition delay is also one of the main factors which influence the combustion process. Ghajel et al. [23] stated that because of lower flame temperature ignition delay increases with the use of emulsified fuel. Subramanian [24] also reported similar observations regarding ignition delay. Therefore, it is crucial for curbing the variations in ignition delay along with emulsified fuel for smooth engine operations and desired combustion features.

4.0 CONSEQUENCES OF W/D EMULSIFIED FUEL ON PERFORMANCE AND EMISSION ASPECTS OF DIESEL ENGINE

Brake Power and Torque

Alahmer et al. [25] reported that with an increase in the amount of water particles in emulsified fuel, engine torque and power enhances. They stated that because of extra forces acting on the topmost part of the piston due to steam pressure results in increased engine torque and power. Also, some of the researchers reported that due to longer ignition delay with the use of emulsion fuel the net output of the work cycle is reduced. But, the diversifications in power and torque attributes are comparatively insignificant and can be ignored when compared to noticeable emissions reduction.

Major Performance Parameters: Brake Thermal Efficiency (BTE) and Brake Specific Fuel consumption (BSFC)

Most of the researchers reported that with the increase in water concentrations BTE is enhanced. Basha et al. [26] investigated that an increase in 3.5% BTE is noticed with the addition of 20% amount of water in emulsified fuel. Alahmer et al. [25] and Wang et al. [27] revealed that the

increase in BTE is because of longer ignition delay as well as micro-explosion phenomena of emulsified fuel. Complete combustion is due to better air-fuel mixture [4]. Reduction in BSFC with an increase in water dosage is because of many reasons. Some of them could be due to the micro explosion, enhanced premixed combustion characteristics and decreased combustion temperature [4].

Emission Characteristics:

NO_x Emissions

Reduction of NO_x takes place due to a fall in local high temperature. Many of the studies reported that NO_x formation reduces with W/D emulsified fuel. Suresh et al. [28] investigated 35% contraction in NO_x emissions. Attia et al. [29] and Park et al. [30] recorded 25% and 20% fall in NO_x emissions respectively. Farfaletti et al. [31] reported that due to the presence of water in emulsified fuel, hydroxyl (OH) group increases which in turn leads to a lower level of NO_x emissions. Samec et al. [32] investigated that with the addition of 10% water in the emulsion, the NO_x emissions get reduced by 20%. The fall in NO_x percentage for emulsified fuel is because of the lower temperature of flame during the occurrence of combustion phenomenon.

Particulate Matter and Soot Particles

It has been reported by many studies that soot and particulate matter drop downs when the concentration of water particles is increased. Ochoterena et al. [33] reported 81% reduction in the formation of PM when W/D emulsified fuel is applied. Fu et al. [19] revealed that due to improved mixing and better atomization because of microexplosion activity of emulsified fuel soot particles got reduced. Fast water evaporation, increased oxidation, and reduced flame temperature is some of the other reasons for the reduction of soot particles if diesel fuel containing water particles [4].

Carbon monoxide and Unburnt Hydrocarbons

Many studies reported an increase in HC and CO emissions by the use of W/D emulsified fuel [24, 34] because of reduced combustion temperature which is insufficient for the conversion process of carbon monoxide into carbon dioxide. Koc et al. [34] revealed that the main reason for enhancement in CO and HC emissions is because of the presence of a large quantity of OH ions. Attia et al. [29] reported that in order to achieve complete combustion and reduction in emissions, the micro explosion could play a major role. However, there exists disagreement in the various studies in the field of W/D emulsified fuel regarding BSFC, BTE, HC and CO emissions due to complications in the analysis of the combustion process. Whereas, for NO_x and PM emissions, almost all the analysis revealed low level of emissions from diesel engines.

5.0 ROLE OF NANOPARTICLES AS AN ADDITIVES FOR DIESEL ENGINES WITH EMULSIFIED FUELS

Some of the recent considerations revealed that the addition of nanoparticles acquires certain characteristics which improve combustion features [35]. Addition of nano-additives increases surface area to volume proportion which in turn enhances fuel dispersion [36]. Hassannudin et al. [6] concluded that nano additives act as a promising additive for diesel engines for reduction of CO,HC and PM emissions altogether.

Nanoparticles in Combustion

Tyagi et al. [37] reported improvement in ignition temperature and delay period with the use of nanoparticles in diesel fuel. Due to immense reactivity and potential of nanoparticles ignition delay reduces and also the formation of soot particles [38]. Basha and Anand [39-40] investigated combustion, performance and emissions characteristics with CNT and Alumina nanoparticle. They observed significant improvement in these properties. Selvan et al. [41] and Sajith et al. [42] reported marginal improvement in BTE with the use of cerium oxide nanoparticle as an additive in biodiesel. Marquis et al. [43] recorded an increase in surface to volume in the proportion which leads to enhancement in combustion properties when W/D emulsified fuel along with CNT nanoparticle fuel is used.

Engine Brake Power and Torque

The nanoparticles react with water present in emulsified fuel during the combustion process at higher temperatures which in turn yield hydrogen and as a result enhance the combustion process inside the engine cylinder [44]. However, torque variations differ with a variety of nanoparticles, where higher torque represents complete combustion. Overall, with an increase in surface to volume ratio of nanoparticles, heat transfer coefficient increases, which confirms brake power and combustion efficiency enhancement by the introduction of W/D emulsified fuel incorporated with nanoparticle [45].

Brake Specific Fuel Consumption

Better engine performance is greatly dependent on low BSFC. It is a characteristic that determines the engine's efficiency along with the measure of fuel utilization by the engine for generating brake power [6]. It is generally observed that BSFC gets reduced with a rise in mean effective pressure. It is reported that BSFC slightly increases with nanoparticle W/D emulsified fuel because of a fall in calorific value and lower losses related to the heat of W/D emulsified fuel [46]. But, this is not the case

with all types of nano-additives. Hassannuddin et al. [4] reported a decrease in BSFC value for copper oxide and aluminum oxide nanoparticle along with 10% of water addition in diesel fuel. 5.5% of BSFC gets reduced in case of aluminum oxide nanoparticle as compared to only W/D emulsified fuel in which 10% of water is added along with diesel only. This could be because of the combined effects of microexplosion behavior, shorter ignition delay, and secondary atomization.

NO_x Emissions

The nanoparticle increases the cetane number by 1.2% [4] and as a result, they affect the emission characteristics. Due to the increase in cetane number lower quantity of premixed fuel portions are allowed. Presence of some nanoparticles also behaves as NO_x Emissions reducing agents which converts NO_x into oxygen and nitrogen and as a result lowers NO_x Emission. Majorly, nanoparticle addition to W/D emulsified fuel results in shorter ignition delay as well as higher catalytic reactions. Due to this, complete combustion takes place. Whereas, by the addition of some nanoparticles the oxidation process speeds up and thus results in higher NO_x emissions. So, NO_x emissions completely depend on the type and characteristics associated with particular nanoparticle [47].

Particulate Matter (PM) Emissions

Lower PM emissions with the adoption of W/D emulsified fuel are because of the presence of hydroxyl radicals, soot precursor consumption by oxygen and the reduced temperature of the combustion process [48-49]. Furthermore, nano-additives incorporated W/D emulsified fuel has a promising future for diesel engines in order to reduce brake specific PM emissions at elevated mean effective pressures due to improved speed of evaporation and shorter ignition delay. Due to shorter ignition delay, the surplus volume of fuel gets accumulated in the combustion zone before the beginning of ignition process which decreased premixed burn interval [4].

Carbon Monoxide (CO) Emissions

The nano additives incorporated W/D emulsified fuel has the potential to reduce CO emissions to a great extent. Due to the potential of release of oxygen, the nano-additives function as oxygen-rich particles and produce a greater amount of oxygen for carbon atoms to convert into carbon dioxide emission [4]. The creation of a fuel rich zone is reduced due to the presence of nano-additives in W/D emulsified fuel, which in turn reduces the chances of formation of CO. The shorter ignition delay and increase in important cetane number of the emulsified fuel by the

nano-additives could be the reason for contraction in carbon monoxide emissions [49-50].

Carbon Dioxide (CO₂) Emissions

The consumption of fuel, as well as fuel, enriched burning zone gets increased with the increase in torque, but lowering down of equivalence ratio had a great influence on increasing CO₂ emissions with the rise in mean effective pressure.

Hydrocarbon (HC) Emissions

Higher HC emissions results are due to the preheating stage at lower loads and poor distribution of atomized air-fuel mixture. Microexplosion behavior also sometimes leads to elevated cylinder pressure and temperature. HC emissions are more or less similar when only W/D fuel is used in diesel engines when compared to nanoparticles incorporated W/D emulsified fuel [4]. However, sometimes due to the activation energy of nano additive, carbon particles get burned inside the combustion chamber which results in reduced unburned HC emissions.

6.0 CONCLUSIONS

It can be deduced from this study that the nano-additives incorporated water-in-diesel emulsified fuel possess ample prospective to enhance diesel engine performance parameters and lessen the harmful emissions. Furthermore, many detailed studies are required to study and analyze the stability aspects of nanoparticle incorporated W/D emulsified fuel for its use in a diesel engine as a fuel.

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Vehicle suspension response due to road unevenness

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Abstract

Recent studies have shown that, a quarter-car model is used to study ride response due to road unevenness. Starting with the simplest mathematical representation (single degree-of-freedom) of a quarter-car model, response due to road surface variations are computed analytically. The objective of this paper is to find the dynamics effect of rubber-tired highway vehicles with a view of evaluating ride response due to road surface roughness/variations. To improve understanding of response, additional details are included in the mathematical model. Effect of dynamic system parameters in the quarter-car model, namely vehicle (sprung) mass, stiffness and damping coefficient of suspension, stiffness of tire, and mass of sub-systems below suspension (un-sprung mass) on ride response is studied.

Keywords: *vehicle dynamics, ride comfort, quarter car*

1.0 INTRODUCTION

Automobiles travel at a very high speed and as a consequence experience a broad spectrum of vibrations. These are transmitted to the passenger either through tactile, visual, or aural paths. The term ride is commonly used in reference to tactile and visual vibrations, while the aural vibrations are categorized as noise. Alternatively, spectrum of vibration may be divided according to frequency and classified as ride (0-25Hz) and noise (25-20,000) Hz. The 25Hz boundary point is approximately the lower frequency

threshold of hearing, as well as the upper frequency limit of the simple vibrations common to all motor vehicles. [1]

The definition of ride quality in a motor vehicle is at once complex and subjective, changing not only with time but also from user to user. Ride quality remains an increasingly important parameter in customer choice and strongly competitive factor among manufacturers. In order to provide better realization of ride behaviour, it is useful to show the ride dynamic system which is shown in figure 1.

Gillespie, T. D., 1992 [1] deals with ride quality and the parameters influencing it. Road roughness as an external source of input is considered and PSD for the road roughness is plotted. Other excitation sources such as tire/wheel assembly, driveline and engine have been considered and their influence on ride quality is shown. additional degrees of freedom like Bounce/pitch motions have been considered and analytical approach to tuning of bounce and pitch frequencies has been shown. Ride vibration assessment is done by dealing with how ride is perceived. A master thesis by Kailash Vijay Inamdar have presented a numerical method for optimization of vehicle suspension system for stochastic inputs from random road surface profiles. Road surfaces are classified based upon the power spectral density functions.

Time domain responses of the output of the suspension system are obtained using transfer function techniques. Optimum values of the damper constant are computed by simulation of the Quarter Car Model for generated stochastic inputs for good road holding and passenger ride comfort. A performance index minimization procedure is developed to find optimum damper constant value considering mutually conflicting requirements of ride comfort and road holding. The objective of this paper is to

use a quarter-car model to study ride response due to road unevenness beginning with a SDOF model for vertical motion only.

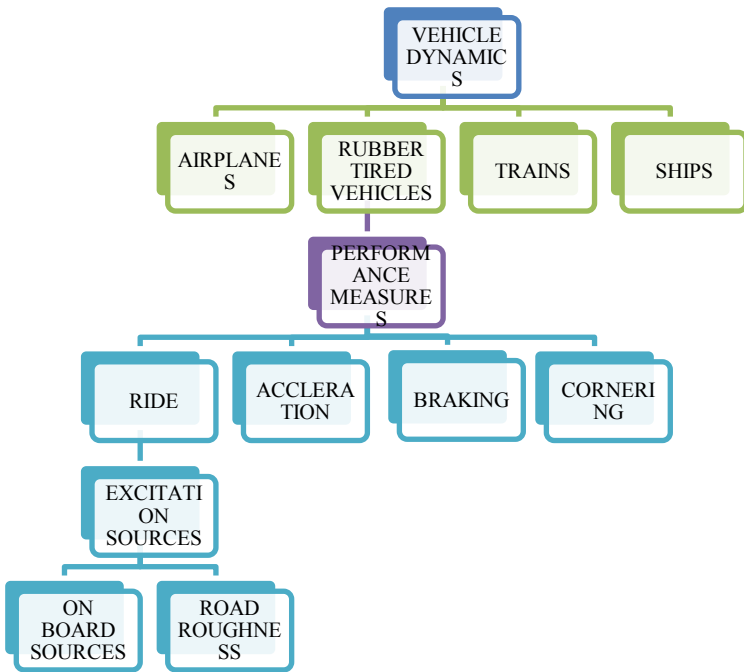


Fig. 1. The ride dynamic system Source: ref[1]

2.0 Formulation of quarter car model with single degree of freedom

Consider the simplest quarter-car model shown in Fig (2). The equation of motion of the system is simple. Using the symbols shown in the figure it is

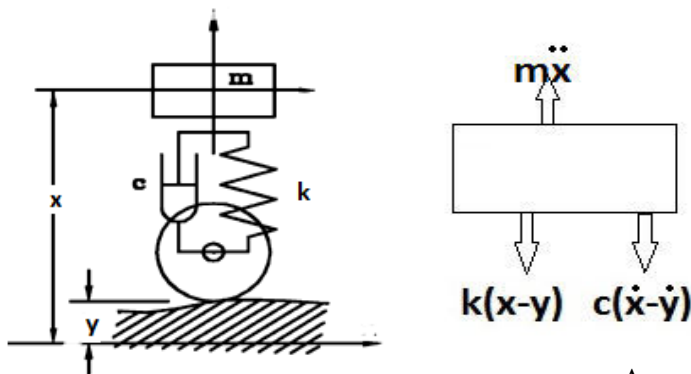


Fig. 2. SDOF quarter car model, free body diagram

$$m\ddot{x} + c\dot{x} + kx = c\dot{y} + ky \dots \dots \dots (1)$$

Where, $x(t)$ is the displacement from static equilibrium position, $y(t)$ is the vertical displacement of supporting point.

Let us consider $y = Y_0 e^{i\omega t} \dots \dots \dots (2)$

The output can be expressed as $x = X_0 e^{i\omega t} \dots \dots \dots (3)$

Substituting the equation(2) and (3) in equation (1), we get

$$(-\omega^2 m + i\omega c + k)X_0 = (i\omega c + k)Y_0 \dots \dots \dots (4)$$

$$X_0 = \frac{Y_0(i\omega c + k)}{(-\omega^2 m + i\omega c + k)} \dots \dots \dots (5)$$

$$\frac{X_0}{Y_0} = \frac{(i\omega c + k)}{(k - \omega^2 m) + i\omega c} \times \frac{(k - \omega^2 m) - i\omega c}{(k - \omega^2 m) - i\omega c} \dots \dots \dots (6)$$

Separating real and imaginary parts,

$$\frac{Re(X_0)}{Y_0} = \frac{k(k - m\omega^2) + c^2\omega^2}{(k - m\omega^2) + c^2\omega^2} \dots \dots \dots (7)$$

$$\frac{Im(X_0)}{Y_0} = \frac{-c m \omega^3}{(k - m\omega^2) + c^2\omega^2} \dots \dots \dots (8)$$

Amplification factor =

$$\left| \frac{X_0}{Y_0} \right| = \sqrt{\frac{k^2 + c^2\omega^2}{(k - m\omega^2)^2 + c^2\omega^2}} \dots \dots \dots (9)$$

3.0 RESULTS AND DISCUSSION

A quarter car model is considered with the following characteristics

- spring mass $m = 250 \text{ kg}$;
- Stiffness $k = 25 \text{ kN/m}$;
- Damping coefficient $c = 2150 \text{ Ns/m}$.

Assuming that the vehicle is traveling at 30m/s ,

The natural frequency is,

$$\omega = \sqrt{\frac{k}{m}} = 10 \text{ rad/sec or } 1.59 \text{ Hz}$$

Optimum damping constant is,

$$c_{opt} = \sqrt{\frac{km}{2}} = 1770 \text{ Ns/m}$$

The suspension has a damping higher than the optimum value.

The dynamic compliance, that is the ratio between the displacement of the sprung mass and that of the supporting point,

$$|H(\omega)| = \left| \frac{X_0}{Y_0} \right| = \sqrt{\frac{k^2 + c^2\omega^2}{(k - m\omega^2)^2 + c^2\omega^2}} \dots \dots (10)$$

is plotted in Fig(3), and the inertance that is the ratio between the acceleration of the sprung mass and the displacement of the supporting point is plotted in fig (4).

Power spectral density,

$$s = c' \omega^n$$

Expressing ω in Hz and s in m^2/Hz ,

Where,

$$c = 1.28 \times 10^{-6} m$$

$$n = -2$$

$$c' = \frac{c}{v^{n+1}} = 3.84 \times 10^{-5} m^3/s^2$$

The power spectral density of the acceleration of the sprung mass can thus be immediately computed by multiplying the square of the iterance by the power spectral density of the road profile

$$PSD_{accln} = [\omega^2 H(\omega)]^2 \times S_r$$

$$S_r(\omega) = \frac{\omega^4 (k^2 + c^2 \omega^2)}{(k - m\omega^2)^2 + c^2 \omega^2} \times 3.84 \times 10^{-5} \times \omega^{-2}$$

The RMS value of the acceleration can be computed by integrating the power spectral density. The limits of integration referred to the space frequency are 0.01 and 10

cycles/m. By referring them to time, the frequency range extends from 0.3Hz to 300 Hz.

$$a_{rms} = \sqrt{\int_{\omega_1}^{\omega_2} S_r(\omega) d\omega}$$

Thus from literature survey [2], we find the RMS value of acceleration to be,

$$a_{rms} = 5.84 \text{ m/s}^2$$

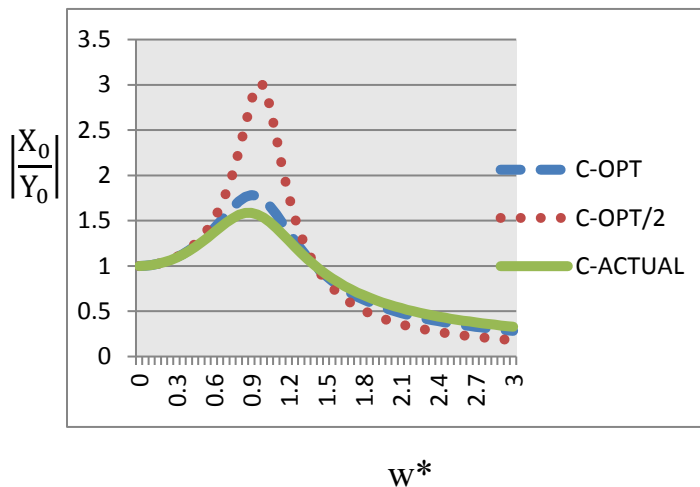


Fig 3. Ratios between the amplitudes of the displacement and ground displacement v/s w*

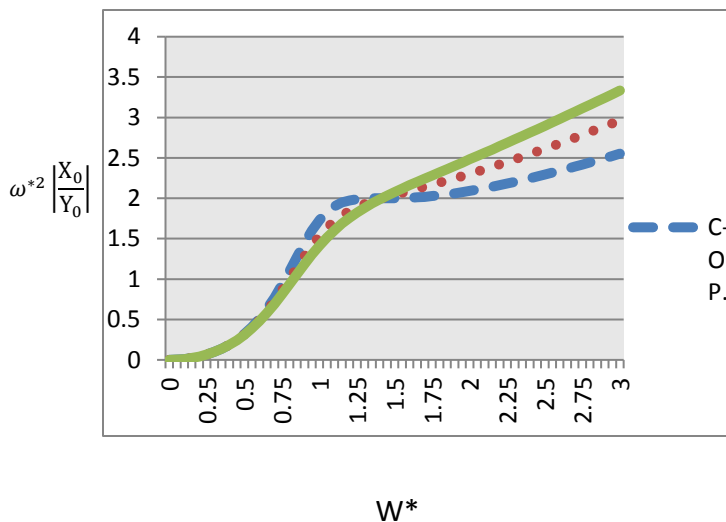


Fig 4. Ratios between the amplitude of the acceleration and ground displacement v/s w*

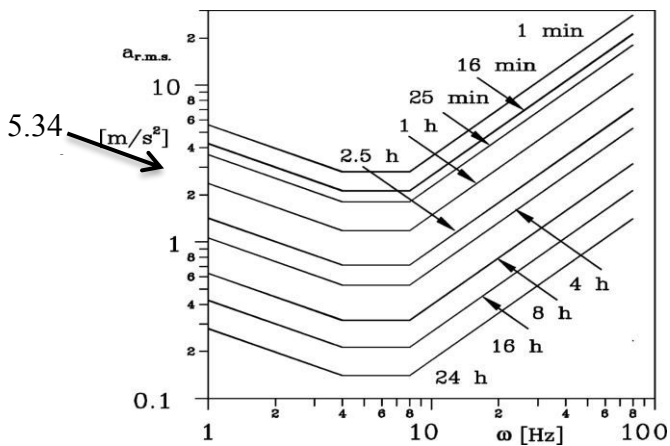


Fig 5. RMS value of the vertical acceleration causing reduced physical efficiency to a sitting subject as a function of the frequency (source: ref [2])

The RMS value of acceleration is found to be $5.84 m/s^2$ which causes reduced physical efficiency in less than 1 s at a frequency between 1 and 2 Hz, where the resonance of the sprung mass is located from fig (5). For the quarter car model has only one degree of freedom and no tire. From the power spectral density it is clear that the largest contribution to the integral is due to the range between 10 and 300 Hz, because the response is still quite high even with increasing frequency. The computation, performed by neglecting the ability of the tire to filter out the excitation at medium-high frequency, has little meaning.

Response curves (using simulink)

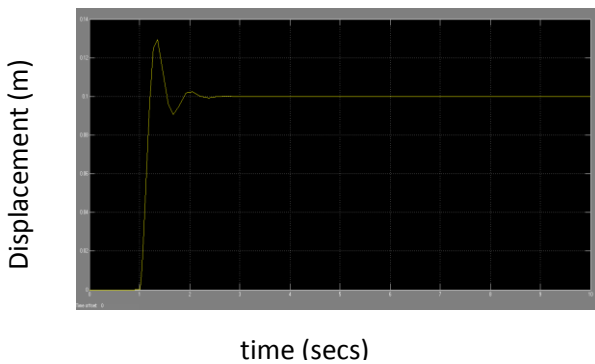


Fig 6 (a) response curve for optimum value($c=c_{opt}$)

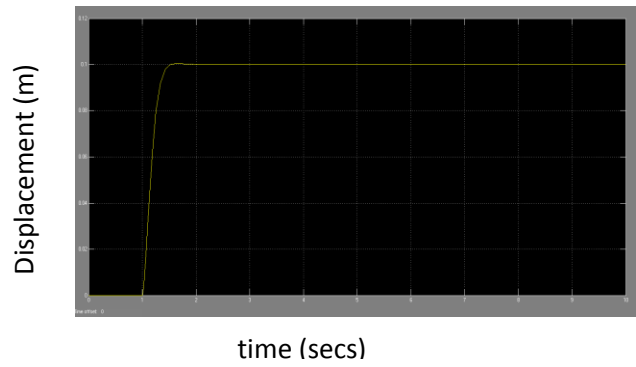


Fig 6 (b) response curve for half the optimum value($c=1/2 c_{opt}$)

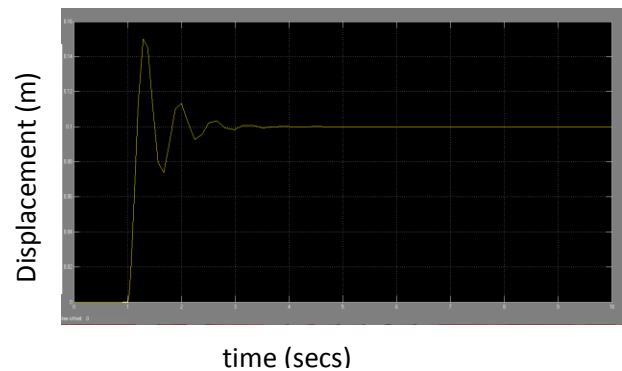


Fig 6 (c) response curve for twice the optimum value($c=2 c_{opt}$)

4.0 CONCLUSIONS

SDOF model holds well for motions taking place at low frequency, in the range of the natural frequency of the sprung mass (up to 3 – 5 Hz). One might hypothesize that ride engineers goal is to eliminate all the vibrations on the vehicle. Even though this will never be possible, but it does give direction to development of effort. There are two contradictory phenomena to deal with; first elimination of one vibration always exposes another less annoyance. This has been illustrated in the past stories of cars being made so good that the sound of clock ticking becomes annoying. Secondly, elimination of all vibrations is also undesirable as vibrations are the source of road feel considered to be essential feedback to driver of a motor vehicle.

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Improvement in overall equipment effectiveness in manufacturing process of engine element through six sigma approach

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Abstract- An engine bracket manufacturing process has been analysed. Quality tools like R & R study, Pareto chart, FMEA analysis has been implemented successfully on the processes. Number of defective parts has already been reduced by this method. Major area of study is to improve yield of the manufacturing process of engine bracket. This problem was solved by Six Sigma methodology and its applications. The main approach of Six Sigma handles with the functional form of $Y=f(X)$, Y is the dependent variable or output of the whole process and X, a set of independent variable or possible causes due to output get affected. In this case, Y is the hole dimension in bending and piercing process for bracket elements. A DMAIC approach is used to solve the problem and identifies the possible causes to affect the quality of product. Applying desired changes improve the loss incurred in rejection of the product.

Keywords- Overall equipment effectiveness, Six sigma, FMEA analysis, R & R study, Pareto Chart

I. INTRODUCTION

Sebastian Koziółek [1] presents the methodology for assessing the process of designing and constructing vehicles and machines, which implements Design for Six Sigma tools. How defects affect the quality of the structure, based on the criteria of its conformance is the main motive of his study. The paper also presents the requirements needed to implement the method and the benefits arising from the use of quality assessment tools. According to Sharma O. P. [2] Six sigma as a problem solving approach has been used in various fields to provide the fundamentals of variation management and reduction in order to assist in transforming established methodologies in to new and efficient techniques. Ying-Chin Ho [3] study determines critical factors for aircraft maintenance, repair, and overhaul companies during the initial incorporation stage of Six Sigma programs. R.Rohini [4] proposes the DMAIC Six Sigma approach of Define, Measure, Analyse, Improve/Implement and Control (DMAIC) to improve the process in the Operation theatre of a corporate multi-specialty hospital in Bangalore India. The DMAIC approach showed a wider application and how the healthcare organization can achieve competitive advantages efficient decision-making and problem-solving capabilities within a business context. The paper develops a Design DMAIC Model that can be used as a template for improving the Operation Theatre Process in hospitals. Six Sigma is complimentary to other initiatives such as ISO, JACHO, TQM, NABH etc. The study recommends many OT related solutions for framing policies, for consultants and for supportive staff, engineering and IT services.

From the past case studies and literature review it appears that Six Sigma has been widely applied in large manufacturing industries and it is very rare and very inconsistent in small manufacturing industries. In India where there is so much scope of service sector, application of Six Sigma is also very rare. The application of Six Sigma in large manufacturing companies has

shown tremendous financial gains based on the literature. Little evidence also exists in literature on Six Sigma implementation in small scale industries. So, an attempt has been made to analyze the impact of Six Sigma in service organizations and small scale industries. Hence, an initiative has been taken to apply Six Sigma to Sheet metal manufacturing industry.

II. PROBLEM STATEMENT

The company in the present problem is a manufacturing company in India, manufacturing engine mount brackets. These brackets were used in various vehicles. These items are precise and the organization has good accuracy machines and a highly skilled manpower of around 350 people. Problem was the assembly of bracket elements for the engine block. Each element consists of Series of holes and curves in which engine main bracket mounts with the help of nut and bolts. The element hole diameter is not match with the standard engineered specified diameter then in the final assembly of engine problem arises, same is for centre to centre distance. Hence the dimensions like hole and C to C distance is a 'critical to quality' characteristic (CTQ). A bending and piercing operation before the project, in starting of the process the quality was as low as 85%. There were on also an average 34 customer complaints per month from the customer regarding mis fitment of bracket supplied by the company. This problem was solved by Six Sigma methodology and its applications. The main approach of Six Sigma handles with the functional form of $Y=f(X)$, Y is the dependent variable or output of the whole process and X, a set of independent variable or possible causes due to output get affected. In this case, Y is the hole dimension in bending and piercing process for bracket elements.

III. PROBLEM DETAILS

Table 1 Last four month's production data

Particulars	Formula	Sept'12	Oct'12	Nov'12	Dec'12
Production Schedule Adherence	Actual Production/Planned Production	34%	39%	60%	54%
Rejection	Total parts rejected	546	456	378	657
Rework	Total parts in Rework	410	550	480	754
Availability (A)	Operating Time/Planned Production Time	0.54	0.56	0.617	0.33
Performance (P)	Net Operating Time/Operating time	0.97	1.1	0.98	0.98

Quality (Q)	Productive time/Net Operating time	0.49	0.67	0.76	0.59
OEE (A*P*Q)	A X P X Q	0.257	0.413	0.46	0.191
Die change/Shift	No. of Die changes/Shift	2.47	3.63	2.84	2.51
No. of times Breakdown in a Month	No. of times Breakdown in a Month	32	37	40	7
Mean Time to Repair (MTR)	Average time taken from problem identification to repair	0.2	0.45	0.41	1.38
Mean Time between Failures (MTBF)	Average time between failures	100	140.15	168.9	23.47

Losses:

The losses occurring in company due to defective and non-availability is estimated as follows:

Cost per unit = Rs 1250 / per unit

Average Incurred rework cost = Rs 250 /per unit

Above cost doesn't include Servicing, investments and life span of the machine. On an average monthly schedule for company in these six months are 50000 components. So according to above data average loss bear by the company is:

Average part rejected = 513

Average part reworked = 602

Loss to the company = (cost of 1-unit x rejected) + (Rework Cost X Reworked units)

Loss to the company per month = Rs 791750

Annual losses bear by company 95 lacs

Component Details:

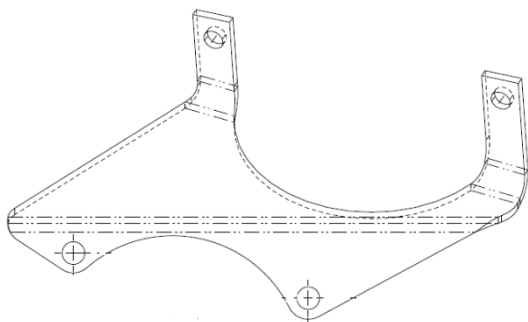


Figure 1 a, b Drawings of component

Table 2 Dimensions of component

Sl.No.	Parameter	Specification	Tolerance	Mode of Checking
1	Dia	13mm	±0.2	Vernier
2	CD	26mm	±0.3	Vernier&Height Gauge
3	CD	135mm	±0.5do.....
4	Bending to CD	14mm	±0.2do.....
5	Dia	12mm	±0.2	Vernier
6	CD	15mm	±0.2	Vernier
7	CD to CD	152mm	±0.5	Vernier&Height Gauge
8	Dim	41mm	±0.3	Vernier&Height Gauge
9	Dim	84mm	±0.3	Height Gauge
10	CD to CD	117mm	±0.5	Vernier&Height Gauge
11	Thk	5mm	Fe410	Micrometer
12	BlackEpoxy	30 to 50		Alcometer
13	Angle	132		Combination Set
14	Angle	86		Combination Set
15	CD	180mm	±0.5	Vernier
16	Dim	10mm	±0.2	Vernier&Height Gauge
17	Dim	53mm	±0.3	Vernier&Height Gauge
19	Final Check			Checking With Fixture

CD = Centre Distance

Dia = Diameter

Dim = Dimensions end to end

IV. METHODOLOGY

Table 3 Six Sigma implementation process

Phases	Phase Methodology	Tools
Define	Identify the CTQ, and develop a measurement System for the CTQs	No tools associated, as the methodology is straight forward.
	Develop a list of quality issues in the plant	structured/unstructured Brainstorming
	Map the process outputting substandard quality	Process Flow Chart
Measure	Characterize the variable that could cause the quality issue	FMEA
	Characterize the CTQs, as to how many defectives are produced by the current setup	Histograms
Analyze	Do Process Capability Study based on the data from the measure phase.	Process Capability Study

	Based on the characterized CTQ's theorize on the possible areas of improvement.	No tools associated, as the methodology is very much dependent on qualitative judgment.
	Eliminate the causes by streamlining all aspects of the process by mechanizing, automating and organizing the work place.	5S
	Automate the manufacturing system, which means autonomous control of both quality and quantity.	No tools associated, as the methodology is straight forward.
Improve	A detailed analysis of the costs, benefits, potential problems, and impact on other areas should be developed.	No tools associated, as this is not considered within the scope of the research.
	Identify the driving and restraining forces	Field Force Analysis
	Plan a strategy for the removal of restraining forces and the subtle promotions of driving forces.	No tools associated, as the methodology is straight forward.
	Develop an action plan as to how the activities that needs to be done for eliminating the quality issue.	
Control	Keeping in mind the causes of the potential problems that could, monitor the variations.	Control Charts
	Do process capability study for the integrated QC system.	Process Capability Study
	Train the operators to run the integrated QC system effectively and give them authority to make decisions pertinent to the cell.	

A. The define phase

A basic flow chart of the total process was prepared and a supplier–input–process–output–customer (SIPOC) mapping has been carried out to have a better understanding about the process. The process mapping along with SIPOC provides a picture of the steps needed to create the output of the process.

Table 4 SIPOC Table

Supplier	Input	Process	Output	Customer
Raw Material cold rolled steel Fe 150	Sheets	Shearing	Width, Corner angles	Blanking Press shop
Plate after shearing	Surface ok	Blanking	Blank Profile	Bending Shop
Blanking shop after notching	Notching Profile	Bending	Bending Height	Piercing shop
Bending shop after notching	Bending Profile	Piercing	Centre Distance, Hole Diameter	Painting
Piercing Shop	Surface free from Burrs	Painting	Painting Thickness	Company's Customer for Bracket

B. The Measure Phase

The total GR&R value was found to be 12.43%. The measurement system may be acceptable when the measurement system variability is between 10% and 30%; at above 30% variability, a measurement system is not considered acceptable

[5] Since the GR&R value in this case was within the acceptable limit of 30%, it was concluded that the measurement system was acceptable for further data collection.

Table 5 R&R Gauge calculation

Measurement Unit Analysis	% Process Variation						
Repeatability - Equipment Variation (EV) $EV = \frac{R^*}{K_1}$ 0.04 <table border="1"> <tr> <td>Trials</td> <td>K₁</td> </tr> <tr> <td>2</td> <td>4.56</td> </tr> <tr> <td>3</td> <td>3.05</td> </tr> </table>	Trials	K ₁	2	4.56	3	3.05	$\% EV = \frac{100}{EV/TV}$ 10.16 %
Trials	K ₁						
2	4.56						
3	3.05						
Reproducibility - Appraiser Variation (AV) $AV = \frac{SQRT[(X_{diff} * K_2)^2 - (EV^2/nr)]}{n}$ 0.03 n = no of parts & r = no of trials <table border="1"> <tr> <td>Operators</td> <td>2</td> <td>3</td> </tr> <tr> <td>K₂</td> <td>3.65</td> <td>2.7</td> </tr> </table>	Operators	2	3	K ₂	3.65	2.7	$\% AV = \frac{100}{AV/TV}$ 7.17 %
Operators	2	3					
K ₂	3.65	2.7					
Repeatability & Reproducibility (R&R) $R \& R = SQRT (EV^2 + AV^2)$ 0.04	$\% R \& R = \frac{100}{R\&R/TV}$ 12.43 %						
Part Variation (PV) $PV = \frac{R_p}{K_3}$ 0.36 K ₃ = 1.62 for 10 Parts	$\% PV = \frac{100}{PV/TV}$ 99.22 %						
Total Variation (TV) $TV = SQRT (R\&R^2 + PV^2)$ 0.36							

Guidelines for Acceptance of Gauge are :

If Gauge R&R

- a) Under 10% error Gauge system Ok
- b) 10% to 30% error may be acceptable based upon importance of application, cost of gauge, cost of repairs etc
- c) Over 30 % error Gauge system needs improvement. Make every effort to identify the problems and have them corrected

C. The Analyse phase

In analyze phase it has to identify the root cause(s) that creates the problem for the process.

Table 6 FMEA reasons for defects

DEFECTS	REASON FOR DEFECT	RPN	OCCURANCE
---------	-------------------	-----	-----------

D.F.T	Parameter not Maintained Properly	48	4
Hole Dia. Under Size	Punch wear	72	2
Center Dist. Less	Stopper shifting	96	6
Notch Profile Not ok	Die & Punch Profile Worn out	96	3
Blank Profile Not O.K	Die profile not ok	96	3
Width oversize	Stopper shifting	96	3

The major causes or types of defects were identified through Pareto Chart (MINI TAB). Major defects identify from pareto chart

- 1) Centre Distance Less
- 2) DFT (Paint thickness) and from FMEA analysis reason for above defects is

1. Stopper Shifting
2. Incoming material and parameter not maintained properly

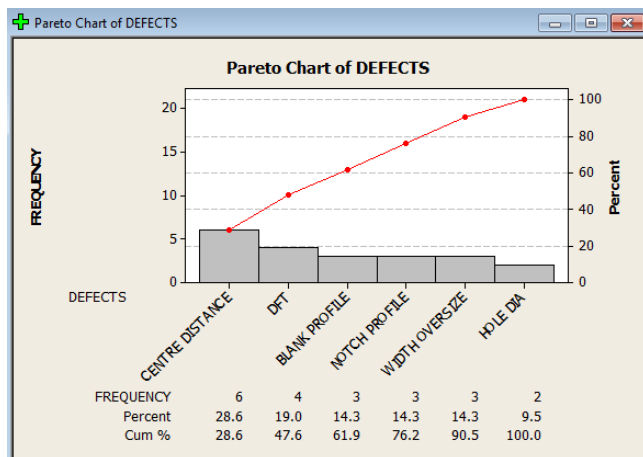


Figure 2 Pareto Chart

Defects	Improvement
Centre Distance Less	Proper check of Stopper shift (gauge shift) regularly and tightening of the Allen Key .
Paint Thickness not proper	Due to improper temperature in oven paint does not adhere to material, proper cleaning of component before applying powder.

D. The improve phase

E. The control phase

Control Plan: The following are the mandatory actions that have to be taken by the management to sustain the results after lean six sigma implementation.

- The operators of industry must be given training on a continuous basis on the issue of quality.
- The drawings of the product must be made available at all the machines. The final component pattern should be referred by all the operators.
- The management should give incentives for high quality performance.

- The focus should be on preventing defects rather than correcting defects.
- Tight quality controls should be enforced on those products coming from subcontractors.
- Training the subcontractors on the importance of quality on continuous basis.

V. RESULTS AND DISCUSSION

Following figure 3,4 and 5 shows the availability, oee and quality improvement between two years.



Figure 3: Availability improvement

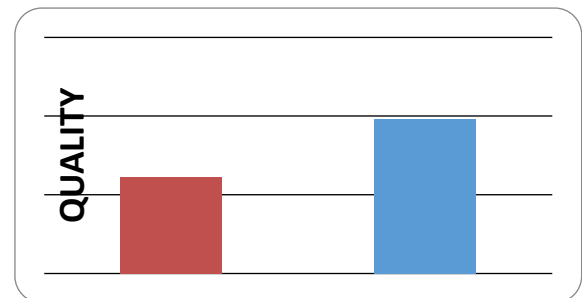


Figure 4: No of approved parts improvement

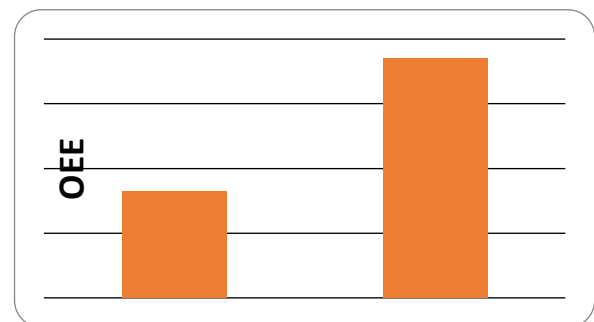


Figure 5: OEE improvement

Cost Saving:

Average parts rejected reduced to 150 per month
 Average parts reworked reduced to 200 per month
 Cost will be saved by company = 93 lacs

- Availability increased by 200 min by implementing a new fork lift which saves 216000 Rs per month.
- Process comes in its limit.

% Defective comes at its lowest level 1.95

There are so many constraints in the process which has not been considered in this work. Training and education (towards six sigma) to workers and employees is not a rapid fast task. Significant and less tools of six sigma has been applied in this work, otherwise more refined results would have been come. It can also be referred as future scope. Application of Six Sigma in Indian small scale Industries has large scope, but due to lack of knowledge and awareness on latest quality tools and statistical techniques among the management, its implementation is very limited. In this context, application of Six Sigma methodology on one of the chronic problems uncovered the scope of following further study and research in Indian industries.

1. Six Sigma can also be implemented over other SME industries such as foundries, power looms, rolling mills etc. to improve the productivity level.
2. Application of DMAIC methodology at other areas such as, accounts receivable, shortening development time of the new products, reducing customer complaints etc. and ultimately deploying Six Sigma company-wide.
3. Six Sigma implications can be studied and explored over different service organizations like healthcare, safety care, transportation, traffic management etc.

VI. CONCLUSIONS

Cost saved after suggestion is considerably more. From this study, it is evident that applied tools detect a greater number of possible failure causes, so the failures in the production process can be prevented. With the application of the SIX SIGMA method more time is spent in the new than in the old process flow. Furthermore, the new process design and development is more costly then the old one. Hence, due to better production preparation the machining and material scrap will be decreased to such a level as to cover all the additional costs in the preparation stage and, furthermore, to produce savings that are several times greater than the initial cost increase.

1. Cost saving estimation by the plant is 93 lacs.
2. Availability improved considerably.
3. Customer complaints reduced to 2 in a month.

In conclusion, even the application of some isolate tools from Six Sigma methodology provides benefits in process improvement. These results could be improved with more widespread use of Six Sigma tools and methodology.

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Efficient Detouring of Vehicles after Accident

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Abstract

This paper considers the detouring of vehicles after accident. Detouring is necessary to mitigate traffic congestion around the accident area. This work is the continuation of our previous work in which we proposed an effective way of processing and dissemination of accident information to the vehicles moving towards the accident area. The work in this paper shows the efficiency of detouring of vehicles after receiving information about the accident. The results show that receiving information on-time will help in improving the efficiency of detouring of vehicles from the accident area and minimizing the traffic congestion.

Keywords: VANET, detouring, efficiency

1.0 INTRODUCTION

Vehicular Ad-hoc Networks (VANET) have been considered to provide communication services using Dedicated Short Range Communication (DSRC) at a very low-cost. DSRC is a standardized service for VANET by IEEE [1]. VANET usually consists of on-board units on vehicles and road side unit (RSU), on-board unit may contain tens of sensors. Vehicles sense data and send it to the RSU for further process. VANET help drivers to cooperate and exchange information about road conditions. Two types of information are exchanged in VANET i.e., delay-tolerant and delay-intolerant. Delay-intolerant is usually used for safety-based information such as accidents, hurdles, etc. and delay-tolerant is used for non-safety information such as infotainment.

Some efficient routing protocols have been proposed for delay-tolerant data dissemination [2, 3, 4]. These papers propose important ways of selecting appropriate vehicle that forwards the packet towards destination such that the packet delivery delay is minimized. Much research has also

been done on delay-intolerant data dissemination [5, 6, 7]. The purpose of delay-intolerant data dissemination is to promptly send the information to other vehicles that might be affected by the accident.

For both delay-tolerant and delay-intolerant data dissemination, clustering is considered to be an efficient way for reliable driving. Clustering algorithms based on speed [8], traffic flow [9], trajectory [10] and many more have been proposed in VANET.

Vehicles are getting smarter day by day. These smarter vehicles share traffic statistics via vehicle-to-infrastructure (V2I) communication or vehicle-to-vehicle (V2V) communication with road side unit (RSU) or among vehicles for smoother traffic flow. Vehicles periodically send their information such as trajectories, current position, and speed and so on to the traffic control system (TCC). Vehicles that encounter an accident send the information towards the vehicles that are going to use the same route in near future. This paper shows the efficiency of rerouting after data dissemination to overcome the traffic congestion problem after accident.

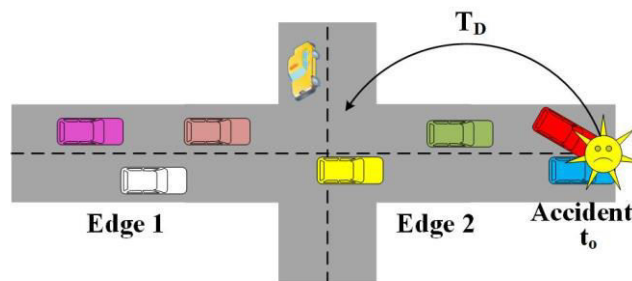


Fig. 1. System model showing accident scenario.

Rest of the paper is organized as follows: Section II summarizes related works on delay-tolerant and delay intolerant data dissemination. Section III explains our

proposed system model. Section IV shows the performance evaluation. In Section V, the paper is concluded along with future work.

2.0 RELATED WORK

Many delay-intolerant protocols have been proposed for the safe traffic flow. Accidents can be prevented by timely informing the drivers. Mostly accidents occur due to speed, lane change or traffic signal violation. For all these situations some prior information is needed to be send such that speed warning, traffic signal violation warning, lane change warning [11].

Authors in [5] propose a mechanism to use path diversity to provide reliability where a message is disseminated by two different paths and by their cooperation this message is disseminated in short delay. In their mechanism a sender node selects one auxiliary node for each relay node then both relay node and auxiliary node resend the received packet without any acknowledgement which shortens the number of overheads. Relay node has the responsibility to select the next relay node and auxiliary node.

Authors in [12] propose a collision warning safety message dissemination via V2V communication. This paper promises to achieve low-latency in delivering emergency warning messages by designing an effective protocol. Authors introduce a new category of vehicles i.e., abnormal vehicles (AV), vehicles applying brakes suddenly or moving in abnormal way may generate an emergency warning message and send it to other vehicles. Vehicles become alert by getting such warning messages and help in preventing further accident and overall congestion control. A new routing protocol proposed by [7], called intersection based delay sensitive routing using ant colony optimization. Authors use ant colony optimization to find some optimal and robust route to disseminate the data with minimum delay. The ants at the front are in charge of routes survey that consists of a succession of intersections, which are selected considering local and global delay from current intersection to the destination. The ants at the back take charge of collecting global delay and updating ant pheromone along the explored routes. Next intersection is dynamically chosen and then data packets are forwarded by utilizing updated ant pheromone.

Delay-tolerant and infotainment data dissemination is used for the comfort of drivers and passengers, such as locating some attraction point, mall, coffee shop etc. User applications such as video-conferencing, weather information or Internet access such as data transfer, Web

browsing, music download and interactive games, to roadside service applications, such as location and price lists of restaurants or gas-stations are presented in [13]. Authors in [14] propose infotainment traffic flow dissemination in an urban VANET, using some algorithms to extend the coverage area of RSU. Algorithms allow the data to cross the road junctions and propagate towards multiple directions, without using beacon or hello message.

3.0 SYSTEM MODEL

Timely rerouting of vehicles is much important to avoid further accident and traffic congestion around the accident area. Assumptions of our paper are as follows:

- We assume that the vehicles are equipped with GPS devices.
- Vehicles share their trajectories, position, speed and other necessary information to infrastructure (RSU).

In Fig.1 we can see an accident happened at some point at time ' t_o ' and the information of accident is sent toward the junction in time ' T_D ' following the concept of our previous work [15]. In [15], we proposed that the information is sent to the junction by selecting an appropriate position for processing and disseminating information among cluster head, RSU, and cloud.

$$X = \min [CLD, RSU, CH] \quad (1)$$

$$\min \sum T_{CH} \cdot X_{CH} + T_{RSU} \cdot X_{RSU} + T_{CLD} \cdot X_{CLD} \quad (2)$$

where CLD, RSU and CH represent cloud, road side unit and cluster head respectively. $X_{CH} + X_{RSU} + X_{CLD} = 1$, showing that among the three only one is selected for processing data. T_{CH} , T_{RSU} , and T_{CLD} are the total delivery time when processing position selected is CH, RSU or cloud respectively. Equations (1) and (2) showing the selection of appropriate processing position to disseminate the information on time. From (1) we can select one among three on estimated cost and delivery time and from (2) we get the actual delivery time. Once the vehicles receive information about accident at junction they will start detouring to avoid the accident edge.

We calculate the efficiency of detouring with and without dissemination of information. We denote number of vehicles as ' $N_{i,j,k}$ ', N is the number of vehicles, where ' i ' shows edge number, ' j ' shows time, and ' k ' shows that the data is disseminated or not. Efficiency of detouring without dissemination is given by E_1 as follows:

$$E_1 = \frac{N_{1,1,1}}{(N_{1,1,1}) + (N_{2,2,1} - N_{2,1,1})} \times 100 \quad (3)$$

Efficiency of detouring with dissemination is given by E_2 as follows:

$$E_2 = \frac{N_{1,1,2}}{(N_{1,1,2}) + (N_{2,2,2} - N_{2,1,2})} \times 100 \quad (4)$$

Where ' $i=1$ ' shows edge 1 and ' $i=2$ ' shows edge 2, ' $j=1$ ' shows the time at which the accident happened and ' $j=2$ ' shows the time at which the vehicle at junction starts rerouting, and ' $k=1$ ' shows without data dissemination and ' $k=2$ ' shows with data dissemination.

Algorithm 1. Rerouting efficiency
Input: Accident position (P_A), Accident time (t_0), Speed (s), Period (V), Dissemination time (T_D)
Output: Efficiencies (E_1, E_2)
begin
While Accident happened do
read accident position and time
calculate E_1, E_2
end
end

Algorithm 1 explains the concept of our work, it explains that when accident happens, the position of accident and time are noted and the delivery time to the junction is calculated. In the end efficiency is calculated.

4.0 PERFORMANCE EVALUATION

In this section, we evaluate the performance of our proposed efficient way of rerouting of vehicles in time of accident. Our performance shows the efficiency of with and without data dissemination towards the vehicle around the junction. Our work is focusing on the delay-intolerant data dissemination, and we need to disseminate the data as soon as possible to the junction, so that the vehicles having the accident edge in their trajectories can detour on-time and avoid being part of traffic congestion. In Fig.2 we can see the efficiency of rerouting of vehicles when the data is disseminated and when data is not disseminated. Efficiency decreases with speed of vehicles because the vehicles enter the accident edge before getting the information. For without dissemination of data,

performance is not so good because vehicles enter the edge until the end of the junction, and then the other vehicles detour from that edge. Same is the case with Fig.3 that shows efficiency with respect to delivery time of data. For without dissemination we can see efficiency remains constant. In Fig.4 efficiency is shown with respect to number of vehicles but here the number of vehicle is not taken directly instead it is taken as a period that explains the insertion of vehicles with time. Simulation done in MATLAB and the parameters are shown in Table I.

TABLE I. SIMULATION PARAMETERS

No	Parameter	Value
1	Length of vehicle	2.5m
2	Edge Length	500m
3	Min-gap between vehicles	2.5m
4	Vehicles insertion period	1, 1.5, 2, 2.5
5	T_D	3, 5, 7, 9 (sec)
6	Speed of vehicles	10, 14, 18, 22 (m/sec)

5.0 CONCLUSION

This paper proposed the detouring of vehicles after accident. This work was a continuation of our previous work in which we proposed an effective way of processing and dissemination of accident information to the vehicles moving towards the accident area. The work in this paper showed the efficiency of detouring of vehicles after receiving information about the accident. We have shown that on time data dissemination helps improving the efficiency of detouring of vehicles and minimizing traffic congestion. For future work we will try to calculate End-to-End delay of vehicles using the same idea in a more complex scenario.

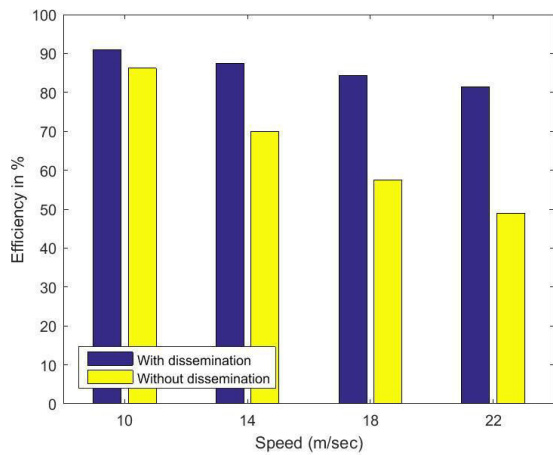


Fig. 2. Efficiency of with and without dissemination with respect to speed of vehicles.

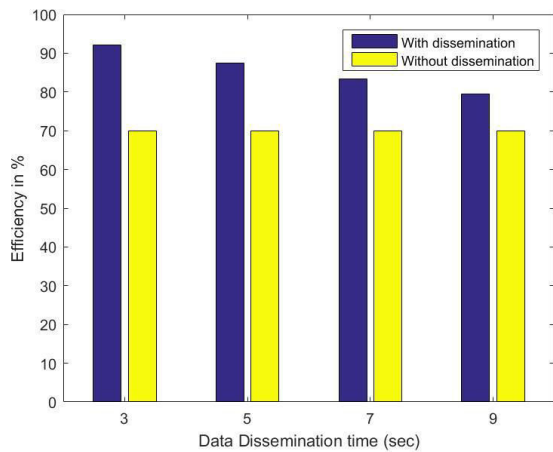


Fig. 3. Efficiency of with and without dissemination with respect to dissemination time.

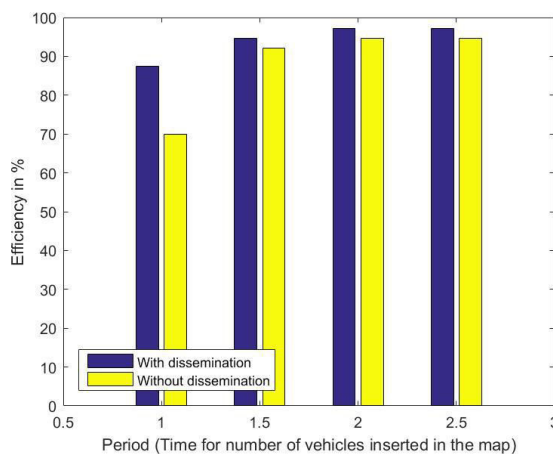


Fig. 4. Efficiency of with and without dissemination with respect to number of vehicles inserted.

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Awareness Case Study for Understanding and Preventing Social Engineering Threats using Kali Linux Penetration Testing Toolkit

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Abstract

In today's world of the Internet of Things, cybercrime activities are increasing at exponential rates. Despite abundant security software tools rendering security services we are exposed to daily cyber threats such as phishing and malware attacks. Security over the internet can be considered only an illusion of which if we have basic knowledge on such malicious activities and tools used by hackers we can have a better understanding to prevent and mitigate such attacks in the future without the use of any advanced security software. Most of today cyber-attacks are concentrating on human error to manipulate users to gain access to secured networks which result in sensitive information falling into wrong hands. This paper discusses in-depth how these social engineering attacks are launched by attackers using Kali Linux penetration testing toolkit. In this case study, we will discuss phishing attacks techniques used to harvest login credentials to gain access secured information bypassing security technology measures. Furthermore, basic defence measures for individuals as well as for organizations are discussed to assist to prevent and mitigate such attacks in the future.

Keywords: *Spyware, Malware, Social Engineering, Cyber security, Phishing, Human Vulnerability*

1.0 INTRODUCTION

We are now living in the digital world whereby everything can be done by just a few clicks on the internet. Despite the good things the internet has brought to us we keep hearing of new cyber-attacks such as the recent notorious WannaCry ransomware attack occurred May 2017 targeting various organizations and users running Microsoft Windows operating system. According to Symantec report, this attacked was by far one of the complex attack encrypting data in the victim machine and demand ransom payment in the form of digital cryptocurrency.

This attack was launched through EternalBlue exploit developed by US National Security Agency (NSA) for outdated windows platforms that were released by The Shadow Broker a few months before the worldwide attack. However, Microsoft previously released patches to secure the older versions of windows systems much of WannaCry attacks took advantage of organizations or individuals who failed to apply the update of their systems to patch the exploit which left most systems vulnerable to backdoor attacks.

The attack was identified and further damage was prevented a few days after various reports about its existence using new emergence patch developed by Microsoft to avoid further spread of WannaCry through infected computers. More than 200,000 computers across 150 countries were estimated affected leading to total damaged of hundreds of millions of dollars. As we are now living in the connected world such cyber-attacks will continue to grow with new technology despite new security innovations to combat against cybercrime. The weak links in any organization big data security breach are usually its employees. It is by far impossible to achieve secure networks through prevention of attacks only on a technical level forgetting human vulnerability factor. The ignorance of this critical vulnerability element provides hackers with easy methods to gain access to secure and sensitive data compromising the well-being of businesses to some extent of failing to survive in competitive digital markets.

In cybersecurity, the term social engineering is defined as a type of cyber-attack which involve manipulation of individuals with the aim of gaining access to sensitive information Atkins et al (2013). Social engineering attack is a social-technical intrusion attacking depending on human error vulnerability to trick users into breaking of certain security rules to bypass advanced security technologies such as firewalls, Intrusion Detection Systems, and anti-viruses software. There are two category types in social engineered namely technology-based and human-based attack. According to Manske (2000), in technology-based attack,

hackers gain access by tricking users into bogus websites and application which appears legitimate leading to divulging confidential information allowing attackers to compromise organizations network. However, the human-based attacks fully depend on taking advantage of human predictable psychological behavior to gain access to secured computer systems.

Most of the cyber-attacks today are taking advantage of social engineering techniques to gather and collect data for malicious objectives. The success factor behind social engineering attack solely depends on intense information gathering about the victim without any suspicion before launching the attack Twitchell, (2006). Although social engineering attacks vary with its objective there are common pattern attackers follow to ensure successfully attack. This pattern usually follows various phases therefore named as social engineering attack lifecycle as shown below.

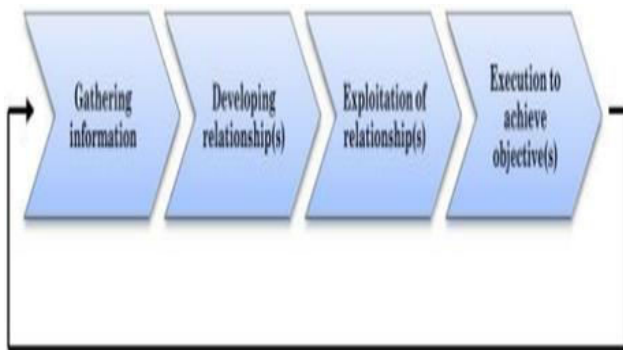


Fig. 1. Life Cycle of a Social Engineering Attack

The first phase entails footprinting which also referred to as information gathering process performed by the attacker prior to launching the intended attack to the victim. Once enough information about the victim has gathered the attacker proceeds to the second phase. In this stage, the attacker build trust with the victim to enable easy manipulation of the target. In the third phase, the attacker exploits the human vulnerability of the trust gained in the previous phase and begin to harvest sensitive data for their objective gain. In the final stage, the attacker covers their digital footprints to ensure that no evidence is left behind to discover their malicious objective thus fulfilling the cycle.

2.0 COMMON SOCIAL ENGINEERING ATTACKS TECHNIQUES

Social engineered attacks are launched in various ways and fully depend on human interaction for successful execution.

These attacks can either be technical or non-technical in nature with their uniqueness and complexity solely depends on the creativity of the attacker. This section provides insight into common forms of social engineering attack techniques used by hackers in today digitalized connected world as shown in (Fig 2).

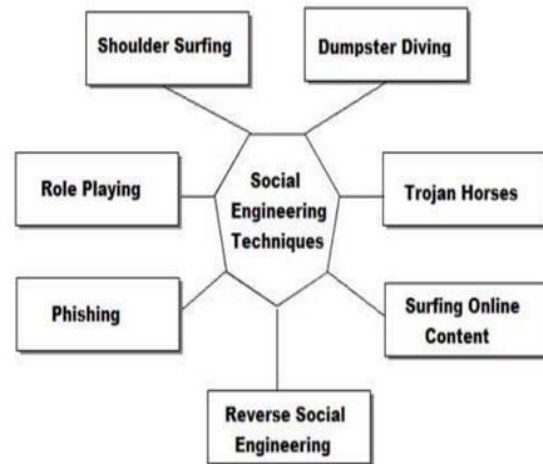


Fig.2. Some Common Social Engineering Attacks

2.0.1 Phishing: This is by far is one of the most dangerous forms of social engineered attack which is increasing at exponential rates targeting victims in unique attack vectors. The ability to clone websites and spoof emails to make them appear legitimate is one of the problems that make phishing attacks complex by nature because by using bogus sites which resemble the original one trick users into trusting this website and reveal sensitive information to attackers. While email phishing remains as the most commonly used attack medium, there are new emerging phishing attacks which can also be carried out through phone calls, text messages or even social media. One of the recent phishing attempts involves phishing emails targeting Android smartphones users to installing malicious APK files from Google Play Store. Once users download these infected APK files they trigger auto execution of malicious files into the phone without the user's knowledge.

The Anti-Phishing Working group reported an increase of 250 percent in the number of different phishing attacks website they blocked from October 2015 to March 2016. With the advantage of new technology, attackers are finding it easy to develop sophisticated attacks to effectively exploit targeted individuals.

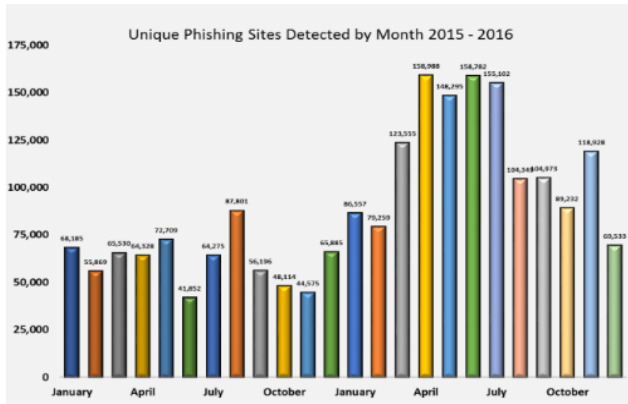


Fig. 3. Unique Phishing sites detected - Source: APWG Phishing Activity Trends Report

As technology rapidly advancing with new innovations humans are becoming reliant on the usage of the internet for their daily tasks. Human vulnerability extends to rise with users not aware of security measures to take while interacting with social websites and emails attachments while online. Phishing attacks also keeping evolving with unique attack vectors making human exploitation easier. Spear phishing or whaling is a new type of phishing by far considered as the most sophisticated attack targeting employees through the usage of spoofed emails from high profile individuals within organizations. In this form of attack, users are lured into a trick to click on bogus links or attachments carrying malicious files to enable attackers to gain access to the targeted network using the backdoor. Spear phishing usually have a higher success rate because the attacker usually performs intense information gathering on the targeted organizations or individuals to access the human vulnerability to exploit at ease.

For example, the new Business Email Compromise (BEC) scams take advantage of spear phishing whereby attacker gather information about senior personnel usually CEO to find out their weak entry point and customize the email that will exploit CEO into revealing secure sensitive information that can compromise the whole organization. Once the CEO email is compromised now attackers are in the position to trick employees impersonating to be senior staffs to perform business transactions, reveal of employee records and even sensitive cooperate credentials. According to a survey by Cloudmark, spear phishing is by far sophisticated attack vector which is continuing to be an expensive business challenge for many organizations worldwide. Some of the previous well-known spear phishing attacks are on JPMorgan Chase&Co, PayPal, eBay, Target, Anthem, Sony and various USA government departments.



Fig.4. Spear phishing survey - Source: Cloudmark

2.0.2 Baiting/Trojan Horse: This attack is somehow similar to phishing, the difference is more rooted in the fact that this form of attack is more human-based rather than electronic means of launching the attack Twitchell (2006). Baiting usually takes advantage of human curiosity and to some extent exploit even greedy victims. For this form of attack to be a success a piece of portable electronic storage devices such as USB Flash Drives, CD-ROM is intentionally placed in public common areas such as parking lots, bathrooms, front desks with the intention to tempt victims to insert such devices into their computers and launch malware attacks without the users knowledge. In most cases, attackers bind malicious files with other legitimate files such as music, photos to mask the malware to avoid suspicion by the user. Once the users open this bogus files, access is granted to the hackers to gain control of the entire internal cooperate network.

2.0.3 Dumpster Diving: This attack technique is considered low-tech attack with severe implications. In this form of attack the hacker examining thrown away company waste such as discarded papers with useful information. The sensitive information in this form of attacks ‘can be recovered from items such as company hardware manuals, manually achieved passwords, classified documents or business reports. In most cases gathered information here is usefully to hackers to perform more sophisticated fraud attempts using identity theft.

2.0.4 Tailgating: Aforementioned is another low technical mode of attack also known as piggybacking. In this attack, the intruder tries to gain access to a restricted area such as server rooms by targeting opened doors. In some instances, attackers develop trust with the front desk

and later exploit this relationship by accessing restricted areas within the building. The ultimate motive for this type of attack is to gain access to certain restricted areas within the organization building.

2.0.5 Pretexting: This is one of the complex social engineering attacks which makes use of scenarios to perform information gathering process with the awareness of the victims. In this attack, information gathering is carefully performed so as to collect information that is sufficient enough to manipulate users to reveal sensitive information. The success of this attack depends on intense footprinting to gather information that could be used to plan customized email which will trick users into fake websites. One example of pretexting could be a scenario whereby the company front desk receive a call from an internet service provider requiring for the type of model of the router used and its mac address. In this case, the attacker imitates to be service provider technical team trying to provide solutions thus exploiting the human vulnerability factor to trust the attacker to provide the service.

2.0.6 Reverse Social Engineering: This is one of the unique attack social engineering which impose threat by pushing victims to approach attackers for assistance. In most cases reverse engineering involves three stages sabotage, advertising and assisting. The reverse engineering technique relies on the idea of starving network resources to sabotage victim. The attacker will then promotes himself portraying to trusted legitimate technical support provider and as it is humanistic tendency to trust the user will allow the attacker to interact with the system or company network hoping to receive a solution. Most of these attacks are widely used to target online social media services such as Facebook, Twitter & LinkedIn with attack increasing each and every day.

2.0.7 Shoulder Surfing: This is usually an internal form of attack in which users with organization spy over another employed by watching their computers over the shoulder with raising any suspicion. This technique observes sensitive information such as passwords by following the key patterns as entered by the victim. This form of attack is usually considered passive human based but it can go to extent of been technical when done remotely throw cameras and keyboard monitoring software.

3.0 IMPACT OF SOCIAL ENGINEERING ATTACKS

Cybercriminals have several attack motives and the threats they impose also varies with their objective. According to Wisecrackers (2008), hacking threats usually target financial gain or personal revenge whereas backdoor attacks using spyware can be a social or personal motive. Cyber-attacks have various types of threats they oppose such as:

- Personal Threat / Organizational Threat
- National Security Threat
- Economical Threat

According to a report by Symantec December 2009, most of the phishing attempts targeted mostly banking sector hence exposing the organization to an economic threat which is continuing to rise with more complex social engineered attacks. Furthermore in their December 2009 Symantec report that e-commerce websites in China are mainly targeted with various social engineering attacks. One of the most devastating cyber-attack occurred in 2015 when the telecom giant TalkTalk had consumer data compromised leading to big financial loss after being fined £400,000 for the security failings. Similarly, Three Mobile was also victim to a cyber-attack which saw more than 200,000 people's information exposed. However, is not only big organizations to worry of rising cyber-attacks individuals and the government need to also realize that in today digitalized world device are connected together leaving us at risk of any cyber-attack in the wild.

The impact of these attack range from personal to national threats with no business secure anymore as technology continue to grow hackers no longer depend on technical skills to gain access to sensitive data with social engineering attacks making it easy to bypass secure networks. The economic threat comes along with the fact that no business is no longer in today cyberspace the concern for an organization is no longer how much they invest in security but when will they get attacked. SME Boomerang Video was fined £60,000 for leaving itself vulnerable to hack attacks, and other SMEs, such as software company PCA Predict, have experienced cyber-attacks in recent years. These examples are the tip of the iceberg and emphasize the need for businesses to protect virtual interests from malicious attacks with strong security.

4.0 CASE STUDY USING KALI LINUX

As Social Engineered attacks are continuing to become complex with the attack vector they use, this section will demonstrate how effective these attacks can be using Kali Linux penetration toolkit. Kali Linux is a Debian Linux operating system platform mainly used by cybersecurity experts to test and understand various attack vectors used by

cybercriminals. There are many vulnerabilities that can be exploited using Kali Linux platform shown in (Fig 5). The following case study demonstrates phishing attack attempts using fake website through social engineer toolkit (SET) to harvest credentials.

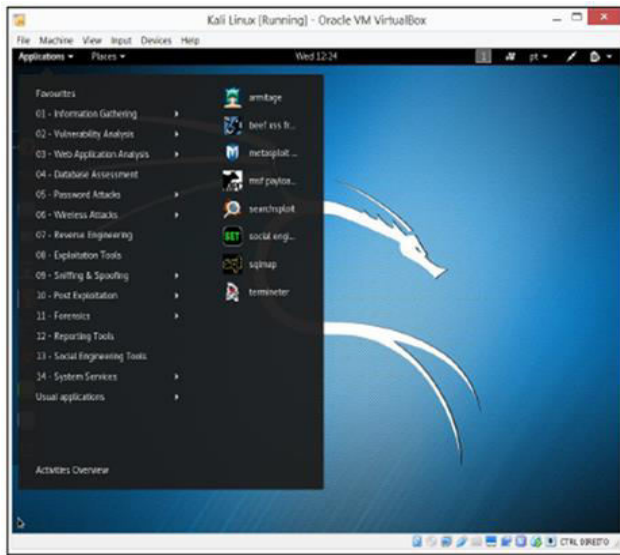


Fig.5. A few exploitation tools in Kali Linux including the Social-Engineer Toolkit

4.0.1 Implementing Phishing Attack Case Study

In this case, we have created a fake phishing website to harvest user credentials and also launch of remote administration tool malware which enables the attacker to take full control of remote computer system. As this research is only for the academic purpose the malware will not be spread in wild but rather launched in a controlled virtual hacking environment to get an insight into how hackers deploy their social engineering attacks. To achieve phishing attack social engineer toolkit (SET) will be used to demonstrate the attack vectors used in phishing attempts. By typing the simple command “setoolkit” in Kali Linux will present us with the main menu to select the type of attack to be used as shown in (Fig 6). Since this study paper mainly focuses on social engineering, therefore, we proceed to select the first option which is the type of attack to demonstrate in this case.

```
[---] Follow me on Twitter: @HackingDave [---]
[---] Homepage: https://www.trustedsec.com [---]
Welcome to the Social-Engineer Toolkit (SET).
The one stop shop for all of your SE needs.

Join us on irc.freenode.net in channel #setoolkit

The Social-Engineer Toolkit is a product of TrustedSec.

Visit: https://www.trustedsec.com

It's easy to update using the PenTesters Framework! (PTF)
Visit https://github.com/trustedsec/ptf to update all your tools!

Select from the menu:

1) Social-Engineering Attacks
2) Penetration Testing (Fast-Track)
3) Third Party Modules
4) Update the Social-Engineer Toolkit
5) Update SET configuration
6) Help, Credits, and About
```

Fig. 6. Social Engineering Toolkit Menu

Once the first option is selected which is social engineering attacks, Kali Linux will present us with a set of various attack vectors that attackers can launch to exploit users to harvest secured sensitive information such as passwords. In this case, we will make use of website attack vector which is a website cloning phishing attempt. This attack vector is widely adopted by hackers due to its efficiency to trick users to trust clone websites and reveal login credentials.

```
Visit: https://www.trustedsec.com

It's easy to update using the PenTesters Framework! (PTF)
Visit https://github.com/trustedsec/ptf to update all your tools!

Select from the menu:

1) Spear-Phishing Attack Vectors
2) Website Attack Vectors
3) Infectious Media Generator
4) Create a Payload and Listener
5) Mass Mailer Attack
6) Arduino-Based Attack Vector
7) Wireless Access Point Attack Vector
8) QRCode Generator Attack Vector
9) Powershell Attack Vectors
10) SMS Spoofing Attack Vector
11) Third Party Modules

99) Return back to the main menu.

set>
```

Fig.7. Social Engineering Attacks Menu

As in most phishing attacks the attacker’s main objective to dupe users to reveal sensitive personal information such as passwords, credit card numbers, Kali Linux social engineer toolkit (SET) comes along with “Credential Harvest Attack Method” option which enables hackers to breach secured website as shown in (Fig 5). By using this method attacker find it easy to harvest sensitive data by manipulating users to reveal this information using fake emails claiming from trusted parties such as banks commence websites and even social media accounts. The success of phishing attacks usually relies on human factor vulnerability therefore for attackers to win the trust of victims they make use of the

fake cloned website to convenience users to reveal sensitive information.

```

ate however when clicked a window pops up then is replaced with the malicious link. You can edit the link replacement settings in the set_config if its too slow/fast.

The Multi-Attack method will add a combination of attacks through the web attack menu. For example you can utilize the Java Applet, Metasploit Browser, Credential Harvester/Tabnabbing all at once to see which is successful.

The HTA Attack method will allow you to clone a site and perform powershell injection through HTA files which can be used for Windows-based powershell exploitation through the browser.

1) Java Applet Attack Method
2) Metasploit Browser Exploit Method
3) Credential Harvester Attack Method
4) Tabnabbing Attack Method
5) Web Jacking Attack Method
6) Multi-Attack Web Method
7) Full Screen Attack Method
8) HTA Attack Method

99) Return to Main Menu

set:webattack>
    
```

Fig.8. Website Attack Vectors Menu

Moreover by making use of credential harvester attack method in Kali Linux enables hackers to execute intended social engineered attacks with ease as shown in (Fig 8). The credential harvester attack method allow attackers to collect login reports from any desired fake website designed to trick users to reveal credentials bypassing security measure software such as antiviruses.

```

8) HTA Attack Method
99) Return to Main Menu

set:webattack>3

The first method will allow SET to import a list of pre-defined web applications that it can utilize within the attack.

The second method will completely clone a website of your choosing and allow you to utilize the attack vectors within the completely same web application you were attempting to clone.

The third method allows you to import your own website, note that you should only have an index.html when using the import website functionality.

1) Web Templates
2) Site Cloner
3) Custom Import

99) Return to Webattack Menu

set:webattack>
    
```

Fig.9. Website Site Cloner Attack Vector Menu

To enable attackers to get link reports of harvested credentials a web panel should be active. To demonstrate how attackers end up with credential reports in Kali Linux as shown in (Fig 10) we need to configure the localhost IP address of the virtual hacking environment like the web server to receive harvested credential reports. Once the web panel is configured hackers simple enter the URL of the website they wish to clone and harvest credentials from in this case we will use popular social media website www.facebook.com.

```

need to do port forwarding to your NAT IP address from your external IP address. A browser doesn't know how to communicate with a private IP address, so if you don't specify an external IP address if you are using this from an external perspective, it will not work. This isn't a SET issue this is how networking works.

set:webattack> IP address for the POST back in Harvester/Tabnabbing [192.168.150.136]:192.168.150.136
[-] SET supports both HTTP and HTTPS
[-] Example: http://www.thisisafakesite.com
set:webattack> Enter the url to clone:www.facebook.com

[*] Cloning the website: https://login.facebook.com/login.php
[*] This could take a little bit...

The best way to use this attack is if username and password form fields are available. Regardless, this captures all POSTs on a website.
[*] You may need to copy /var/www/* into /var/www/html depending on where your directory structure is.
Press (return) if you understand what we're saying here.
[*] The Social-Engineer Toolkit Credential Harvester Attack
[*] Credential Harvester is running on port 80
[*] Information will be displayed to you as it arrives below:
    
```

Fig.10. Site Cloner Vector Attack Configuration

Once the configuration of phishing attack vectors is done and attacker have an active cloned website the next stage is to generate a persuasive legitimate email that will gain the trust of users to reveal sensitive information targeted to be harvested by the attacker. Email is the most adopted communication medium used by hackers to deliver malicious files to targeted victims. In this case, as shown in (Fig 11) spoofed email from Facebook Technical Support team was sent to one of the users in the virtual hacking environment to test the efficiency of phishing attack. As is the tendency of humans to trust and due to lack of awareness the user opens the link in the fake email sent using a trusted party in this case Facebook support team. Once the user clicks the link, in this case, Go To Facebook as shown in (Fig 11) the user will be redirected to fake Facebook login web form which will harvest the targeted credentials.

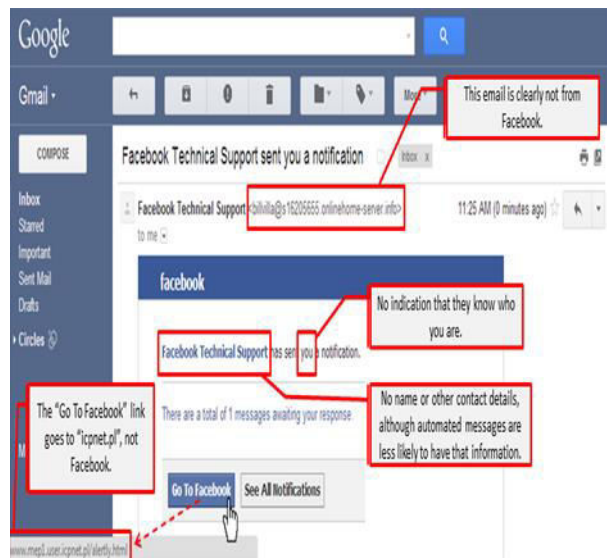


Fig.11. Customized Phishing Email

The last stage of phishing attack is to harvest sensitive data, in this case, once the user opens the bogus email link they will be directed to Facebook login home page as shown in (Fig 12) below. Once the user submits the required

credentials the attacker will successfully receive the reports without the victim's knowledge.

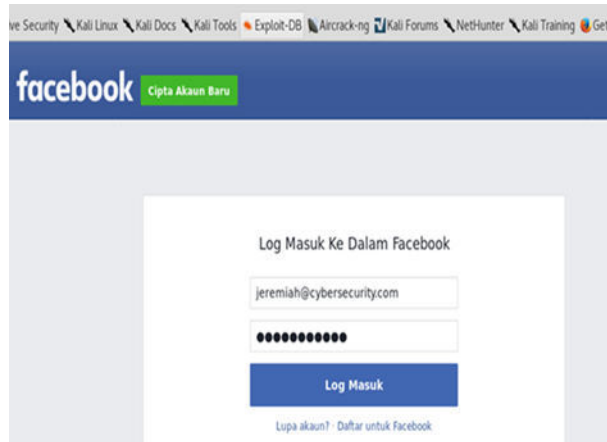


Fig.12. Cloned bogus Facebook page

As the local host IP address was configured to be the web panel server to receive the reports, once the users click submit to login into their Facebook account the harvested credentials will auto reports into the Kali Linux terminal as shown in (Fig 13).

```
POSSIBLE USERNAME FIELD FOUND: email=jeremiah@cybersecurity.com
POSSIBLE PASSWORD FIELD FOUND: pass=password123
```

Fig.13. Harvested victim credentials on the terminal

The growth of phishing attacks will continue with the new innovative technology in the connected world of the internet. The complexity of phishing attacks relies on the fact that hackers are coming up with new forms of attack vector which not only harvest data but have the capability to invade security parameters to further spread malware within cooperate network. According to McFarland (2015), phishing attack is considered as an advanced persistent threat (APT). The only best practice to combat against phishing threats is through educating users to make them aware of any potential phishing attempts that could be targeting them while online. In this case, as highlighted in fig it is significant for users to be observant of the email sender at all times while surfing the internet. Most phishing attacks use fake website templates which resembles the original ones making it easy for users to trust and believe the websites. However, this issue can only be addressed through the creation of a human firewall by training and make users aware of basic methods they can deploy to identify any potential phishing attempts Kee (2008). As much as hackers are smart enough to trick users with the fake website it is by far impossible to create same exact existing domain name making it one of the weakness to easily identify phishing attempts by observing the sender's domain as we interact with various emails while online. Hackers are usually technical people making them bad with

grammar, therefore, identifying for spelling errors and improper salutation could be one of the good practices to prevent phishing threats.

5.0 PREVENTION AGAINST SOCIAL ENGINEERING ATTACKS

The previous section provides insight into various attack techniques used by attackers to perform social engineering attacks. In this section prevention techniques to combat against social engineering will be discussed despite the complexity of attacks prevention can be considered as the only best way to ensure secure networks. It is only when people are well educated and aware they can be more vigilant to monitor any social engineering attempts as they are online. According to Boateng et al (2014), educating users is the most effective defence mechanism against social engineered attacks. Furthermore strong clear policies to govern user's conduct while online can also back up as a defence mechanism against social engineering attacks. Password management alongside with implementation of second-factor authentication can be a great way to thwart the rising numbers of social engineering threats. Even though the attacker can successfully harvest credentials without the second authentication factor it is impossible to breach security Ken (2008). A successful defence against the social engineering depends on having good policies in place ensuring that all employees follow them Social engineering attacks are most powerful attacks as the defence mechanism against it is not the software system but human who are in most time the people quite unpredictable. By using a few countermeasures we can prevent some of the attacks to succeed.

5.0.1 PERSONAL DEFENCE TECHNIQUES AGAINST SOCIAL ENGINEERING ATTACKS

As we depend on the internet in today connected world email is widely used communication medium by hackers, therefore, is a good practice for users to verify suspicious emails requesting for sensitive information. It is hard to verify digitally signed email it wasn't forged or "spoofed" because hackers can send faking email using any trusted name to win the trust of users. To avoid this attack attempts is best to view the full header of the email to get information about the sender domain name and sender email address.

Most phishing attempts to trick users to reveal personal information such as usernames, passwords, credit card numbers, social security numbers, therefore users need to be aware that is not common for genuine origination request such information. Phishing threats have the weakness that

can be easily identified through monitoring if emails received are personalized or not, because authentic emails from an organization such as banks usually are personalized accordingly. For instance, if the email is coming from your bank and start with a salutation such as “Dear Customer” it is a bogus email because in most cases banks will address the customers using their full names as they already have their details in the record. However, in some cases of spear phishing whereby information gathering about the victim is done prior to the attack, emails are customized in advance way they use personal information to make the attack more legitimate.

Since most social engineering attacks usually are targeted for financial gains it is important to always use verifying communication channels when contacting financial institution. It is not good practice to only rely on email links even if the website looks legitimate making use of information on bank cards, monthly account statement can play a significant role in reducing bank phishing attacks.

It is a good practice to always confirm if the website in use is secured while interacting the web forms requiring submission of credit card details or other sensitive personal information. By checking the address bar it is easy to identify if the URL is valid and secured. For example, if the website is not secured it will always start with HTTP:// whereas secured site will always have HTTPS:// within the URL.

Password management is also one major factor to keep checking and changing regularly because some phishing attempts are complex in nature leading tricking users without any suspicion. According to it is a best practice to change entire cooperate network password every three months since some phishing attempts are not easy to identify.

5.0.2 ORGANISATION DEFENCE TECHNIQUES AGAINST SOCIAL ENGINEERING ATTACKS

Well Defined Policies: With increasing numbers of cyber-attacks organizations are investing heavily on security technologies to combat against attacks in today cyberspace. Humans as the weak within the organization are usually ignored or deemed challenging factor to deal with as humans are unpredictable. Well defined security policies should be implemented, it is in these process companies set policy standards to govern and guide employees activities while using cooperate network.

Acceptable Usage Policy: Policies to guide users to accept the terms and conditions to use business emails, computer

system, telephone and internal network, as well as other hardware like pen-drive, should be stated clearly. It is common for users these days to access their personal emails using cooperate devices while connected to internal organization secured network, therefore, policies should be set to control such activities.

Personnel Security: Individual screening of each employee should be done to identify those who impose a threat to the organization.

Access Control: Clear guideline on generating strong passwords and access authorization should be highlighted from all levels in the organizational hierarchy.

Protection from Malware: Malware is common threats which are widely delivered through phishing attempts using emails to bypass security software by manipulating users to perform malicious activities to give hackers access to secured networks. By using new security technology such as Intrusion Detection Systems (IDS), firewalls, anti-malware, and anti-virus software could by far reduce cyber threats if monitored well for its efficiency and regularly updated to patch outdated applications that could result in the data breach.

Awareness and Education: To create an effective human firewall to combat against social engineering attacks educating users on the common attack vectors deployed by hackers can be considered as effective security countermeasure. For instance, an aware user can easily identify any potential social engineering attempt if they know what to check on any suspicious email. Implementing various training strategies and effective awareness programs it is undoubtedly a good security measure that can change the certain type of employee behaviour while online.

Audits and compliance: To ensure successful implementation of policies and standards it is only can be achieved when everyone within the organization conforms to the policies. Security Incident Management: Any cyber-attacks that occurs within an organization should be reported to the IT service desk as soon as they occur. As each socially engineered attack differs in its attack vector mode if all incidents are well reported new threats can be easily identified and prevented in the future.

6.0 CONCLUSION

Social engineering attacks pose a huge real threat which needs to be addressed rather ignored or deemed challenging. Even though these attacks continue to rise in various attack vectors they follow similar attack life cycle which make

easier for aware use to identify potential threats easily. The main contributing drawback in the increase of these attacks is due to a lack of basic cybersecurity training and awareness programs available to employees with organizations. Despite advance security technologies designed to ensure secure network infrastructures it is impossible to stop social engineering attacks because of human vulnerability factor. A well-defined security measure could only be achieved through the creation of human firewall prioritizing security awareness programs as work culture, which assist employees to be alert for to identify and report threat incident to IT personnel to prevent such attacks to occur in the future. Educating employees on various attacks and tools used by hackers such as the Social-Engineer Toolkit (SET) in Kali Linux could be the only answer to reduce exponential rising social engineering attacks. Organizations are investing on digital security technology with humans still unpredicted factor to cause major data breaches due to lack of awareness and ability to be manipulated to trust without the concern of the consequences, an organization could be faced with a new version of attack that could result in the major data breach. The complexity of social engineering attacks does not only rely on humans as the weak within the security chain, but also the best security measure tool to ever exist to combat social engineering attacks through the creation of human firewall. Regular training to make employees aware on latest attack incidents is necessary to ensure secure network at all times with policies established to ensure proper security procedures are performed and considered responsibility of each user not only IT security department.

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Enhancement of Estidama Pearl Rating of a retail store and energy centre using sustainable solutions

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Abstract

The main concept of environmentally sustainable buildings is its design that offers minimal environmental impact with maximum human comfort. This paper presents a more green and sustainable retail store and energy centre of an arena by changing its Estidama Pearl Rating from 2 to Estidama Pearl Rating 3 in its design stage, thereby increasing its points from the already existing 75 points to 85 points. The points are achieved by modifying and improving the design, materials, efficiency, facilities and thermal comfort under credit sections of the Estidama Pearl Rating System such as Integrated Development Process, Livable Outdoors and Stewarding Materials of the structure. Furthermore, the cost analysis for each credit point is also provided.

Keywords: Pearl Rating, Sustainable, Building, Material, Cost

Nomenclature

PBRS	Pearl Building Rate System
GFA	Gross Floor Area

1.0 INTRODUCTION

Rick Fedrizzi once said, “Green Buildings are a hallmark in economic sound business decisions, thoughtful environmental decisions and smart human impact decisions”. ‘Sustainability/ Sustainable development’ is one of the most discussed and talked about everyday challenge yet very few understand and act on it. It has been estimated that the daily operation of buildings accounts for up to 40% of the total energy usage worldwide. Buildings and construction together account for 36% of global final energy use and 39% of energy-related carbon dioxide (CO₂) emissions. “Green Building” is now a global revolution and as a part of its initiatives around the world is the launch of a series of green building rating systems,

standards, guidelines, and certifications, one of which is ‘Estidama Pearl Building Rating System’ which is specifically tailored to middle eastern regions. ‘Estidama’ means ‘Sustainability’ in Arabic and this green building concept is based on a life cycle perspective during a building’s design, construction, and operation, so that its negative impact on the natural environment and human health reduced.

Estidama Pearl Building Rating System

The current pressing demand for sustainable infrastructure is on the rise as it is no longer a personal choice but an urgent need that we preserve our finite resources and look for wider and greener options.

Table 1. Pearl Building Rating Levels

Requirement	Pearl Rating Achieved
All mandatory credits	1 Pearl
All mandatory credits + 60 credit points	2 Pearl
All mandatory credits + 85 credit points	3 Pearl
All mandatory credits + 115 credit points	4 Pearl
All mandatory credits + 140 credit points	5 Pearl

The Pearl Rating System provides design guidance and detailed requirements for rating a project’s potential performance in relation to the four pillars of Estidama - Environmental, Social, Cultural and Economic. Integrated Development Process, Natural System, Livable Buildings, Precious Water, Resourceful Energy, Stewarding Materials, Innovating Practice are the seven credit sections that Pearl Building Rating system (PBRS) focuses on.

Table 2. Maximum credit points available for each section

Credit Section	Maximum Credit Points
IDP - Integrated Development Process	13
NS - Natural Systems	12
LB - Livable Buildings	37*
PW - Precious Water	43*
RE - Resourceful Energy	44
SM - Stewarding Materials	28
IP - Innovating Practice	3
TOTAL	177*

2.0 Methodology

This paper's scope of work is the Retail Store and Energy Centre of the main Arena project. The two larger retail buildings are steel framed, with steel columns in the perimeter supporting steel roof trusses and beams. The roof structure of these buildings is of composite metal deck construction, with shear studs connecting the metal deck to the supporting steel structure. The Energy Centre is a single storey structure located to the west of the Arena building and contains primary centralized MEP plant and equipment. A mezzanine level is included at level +9.500 NADD. The building includes a basement over the majority of its footprint which extends approximately 4.5metres below existing ground level.

The buildings were awarded a Pearl Rating of 2- a common rating achieved by all retail and commercial buildings in Abu Dhabi - after scoring a total of 75 points in the Estidama Design Rating Assessment. This paper aims to take the buildings' sustainability a level higher by proposing a plan and design to change its Pearl Rating from 2 to 3 by achieving additional credit points of '10' to get the total of 85 points.

The PBRS was taken as the baseline for creating the objectives. The solution and outcome for each credit point were assessed based on the list design credit requirements given under each point. The following are the credit sections and credits which are targeted to be achieved to successfully fulfil the additional '10' required points:

- **IDP: Integrated Development Process**
 - IDP-2: Guest Worker Accommodation
- **LB: Livable Buildings**
 - LBo-1: Improved Outdoor Thermal Comfort
 - Lbo-4: Active Urban Environments
 - Lbo-7: Bicycle Facilities
 - Lbo-9: Travel Plan
- **SM: Stewarding Materials**
 - SM-2: Design for Materials Reduction
 - SM-8: Material Reuse
 - SM-11: Rapidly Renewable Materials

The originally designed Retail store and Energy Center i.e: Pearl Rating 2 is first modelled in Revit 2017 with its structural and architectural components by linking the 2D plan in AutoCAD 2017. The BIM Model is shown in Fig.1.

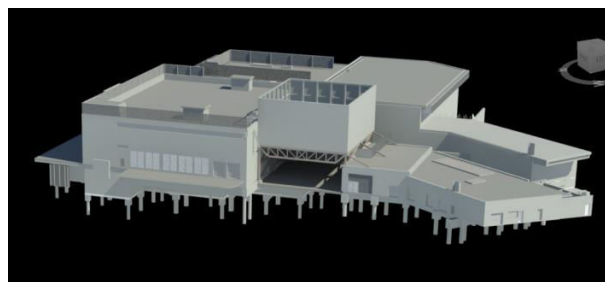


Fig. 1. BIM Modelling of the Retail Store and Energy Centre

Note: The targeted credit points are selected based on whether they are not attempted by the client or attempted and not accepted after the Estidama Design Rating Assessment.

3.0 IDP- INTERGRATED DEVELOPMENT PROCESS

As per PBRS- This credit encourages construction activities that value workers welfare, quality and sound environmental management.

3.1 IDP-2: Guest Worker Accommodation

Intent: To promote fair labour practices in building construction.

Total Credit Points: 2

Already Achieved credit points: 0 (Reason: Not Attempted)

Targeted credit points 2

Newly Achieved credit points: 2

Calculations and Methodology: This credit requires all the laws and regulations of Abu Dhabi Cabinet Decision No. (13) of 2009 to be met or exceeded.

The manual set up by the main contractor for the labour camps, the existing plan, design, facilities, health and safety, Utility and emergency systems of existing labour camp for the Arena Project are cross checked with the Abu Dhabi Cabinet Decision No. (13) of 2009 and seems to fulfil all the requirements.

4.0 LIVABLE OUTDOORS

This credit focuses on those elements that influences the quality of human life and are in the direct and deliberate control of the design and development team.

4.1 LBo-1: Improved Outdoor Thermal Comfort

Intent: To improve outdoor thermal comfort during transition months and further reduce thermal discomfort during summer months in public spaces and walkways.

Total Credit Points: 1

Already Achieved credit points: 0 (Reason: Not Attempted)

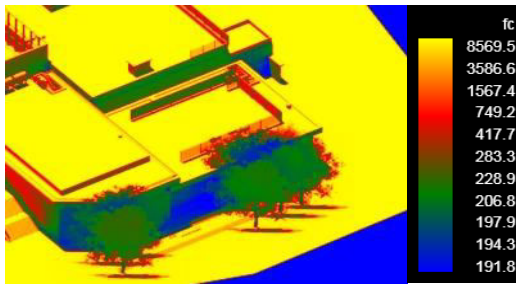
Targeted credit points 1

Newly Achieved credit points: 1

Methodology and Calculations: Primary pedestrian corridors as defined in the Abu Dhabi Urban Streen design Manual with 1m frontage zone which is provided adjacent

to the building line for door openings, pedestrian movement, 2m thoroughway that is kept in the same level and material as that of the frontage zone, 0.7m of furnishing zone with street furniture, trees and transit stops and a 2m cycle track with an edge of 0.5m.

The SRI is a composite measure of a material's reflectance and emittance. It is calculated as set out in ASTM E 1980.1. Shading primarily with shading trees of varying height (7-18.5m) such as Lombardy Poplar(12.2m), Red Oak(18.2m) and Red Ash(7.6m). SRI values range from 29 to 37(SRI value of 29 being minimum requirement). These natural canopies which must be in place at the time of occupancy.



(a)



(b)

Fig. 2 Illuminance Analysis and Solar Shading in Revit 2017 in cloud on March 21,2019(Equinox)

Some additional benefits include increasing cooling energy savings and reduced heat island effect. Shaded surfaces, for example, may be 20–45°F (11–25°C) cooler than the peak temperatures of unshaded materials. The above illuminance analysis shows that providing trees attenuates light up to 85-96%. A wooden canopy with metal frame is provided for the bicycle racks.

Cost Analysis: Oak trees come in the range of Dhs3600 to Dhs5700 with elm trees ranging from Dhs580 to Dhs1200. The cost of tree installation and labour costs is therefore much less than the cost of installation of steel framed wooden canopies which ranges from Dhs30,000- Dhs100,000 for primary pedestrian walkways.

4.2 LBo-4: Active Urban Environment

Intent: To encourage active lifestyles by providing building occupants and users with recreational public open spaces.

Total Credit Points: 1

Already Achieved credit points: 0 (Reason: Not Attempted)
Targeted credit points 1

Newly Achieved credit points: 1

Calculation and Methodology: None mentioned in PBRS
Since the project is of an arena, it satisfies the condition of 'sports field areas' which is also provided with accessible shower and changing room facilities.

4.3 LBo-7: Bicycle Facilities

Intent: To minimize greenhouse gas emissions, improve connectivity and encourage bicycle use (particularly during the cooler winter months).

Total Credit Points: 2

Already Achieved credit points: 0 (Reason: Not Accepted)

Targeted credit points 2

Newly Achieved credit points: 2

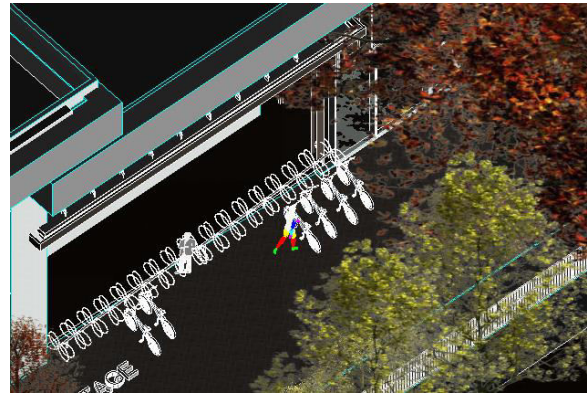


Fig.4 Bicycle Facilities with wooden canopy shading.

Calculations and Methodology:1 credit: The bicycle facilities were not accepted in the previous design rating due to inadequate bicycle racks.

Each bicycle rack allows both the wheel and the frame of the cycle to be locked safely and each space is provided with dimensions of 2 x 0.75m. The number of bicycle racks and spaces is provided as per the requirement of a minimum of 1 space per 500m² of GFA, which amounts up to a total of 6 spaces for the retail store (short term and long-term commuter parking) and 4 spaces for the energy centre (long term commuter parking, provided less than 30m from the entrance of the retail store. A minimum space of 15m² is to be provided.

1 credit: Another credit is awarded on providing a maximum of one shower per gender for every 5000m²

The total GFA of the retail store and the energy centre is 5215.54m². Since the project is an arena the shower and changing facilities provided for arena can be utilised by the cycle users.

Cost Analysis: Bicycle rack costs can range from approximately Dhs180 to Dhs10,800, depending on design and materials used. On an average the cost is approximately Dhs1980. Bicycle lockers costs range from Dhs3840 to Dhs8040, and bicycle stations are approximately Dhs750,000.

4.4 LBo-9: Travel Plan

Intent: To reduce single occupancy vehicle use by managing the demand for travel and by maximizing the availability of alternatives to travel by car.

Total Credit Points: 1

Already Achieved credit points: 0 (Reason: Not Accepted)

Targeted credit points 1

Newly Achieved credit points: 1

Calculations and Methodology: Out of the 1900 parking spaces provided for the project, 5% can be allotted for green vehicles (95 spaces) and electric vehicle supply equipment (EVSE) in 2% of all the parking spaces used by the project (38 spaces) with level 2 charging capacity (208-240 volts) or greater. Car park management systems such as providing discounted rate of a minimum of 20% for the green vehicle parking spaces can encourage citizens to go for greener options. Offering staff the option to work from home or other flexible working options whenever possible, getting company pool cars so that staff can have access to vehicles, providing electronic barriers with number plate recognition to car parks to control who comes in, are a few pointers that can be included in a Travel Plan. Bicycle facilities, public transport, shuttles etc offer cheaper options to citizens with an added advantage to enjoy the scenic beauty of the surrounding landscape elements provided in the vicinity thus improving air quality, reducing noise pollution, dirt and fumes.

Cost Analysis: The average cost of operating an electric vehicle is Dhs1455 as compared to gasoline powered vehicle which is Dhs3351. Maintenance costs for conventional vehicles increase with age such as changing engine oil, coolant, transmission fluid etc, however in the case of electric powered vehicles the largest possible cost is the change of battery pack which again is covered if the vehicle is under warranty.

5.0 STEWARDING MATERIALS

5.1 SM-2: Design for Material Reduction

Intent: To reduce the overall amount of material used in the development of buildings.

Total Credit Points: 2

Already Achieved credit points: 0 (Reason: Not Accepted)

Targeted credit points 2

Newly Achieved credit points: 2

Calculations and Methodology:

Providing building with integrated photovoltaics on 12% of the building envelop, replacing traditional building materials for powering the retail store would offer the traditional advantage of uses such as unlimited energy and lower electricity bills. Vegetated or green roofs for (52% of the building envelop) are thin living layers of vegetation installed on conventional roofing system. They are provided with layers of substrate, waterproofing membrane, roof barrier, filter fabric and growing media.

Cost Analysis:

Though the initial cost of solar panels are high (Dhs75,000 per panel for 5kw system). Cost of vegetative roofing is Dhs34,134 per sqft per year but as compared to conventional roofing they provide a 30% savings in terms of cool building strategies and heat island effects.

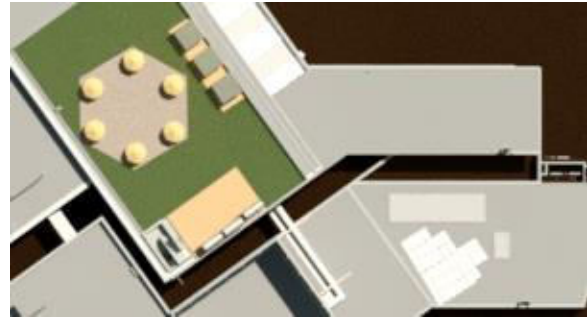


Fig.5 Vegetated roof(green) flooring with wooden decks and cafés and gazebos installed on tile flooring with solar panels(white) on the subsequent roof

5.2 SM-8: Material Reuse

Intent: To promote the selection of previously used or salvaged materials to reduce demand on natural resources and reduce waste

Total Credit Points: 1

Already Achieved credit points: 0 (Reason: Not Accepted)

Targeted credit points 1

Newly Achieved credit points: 1

Calculations and Methodology: Reuse of plastic (polypropylene pellets with 2% SBF) in asphalt or plasphalt pavements is a viable alternative to conventional pavement not only provides better physical and chemical performance but also is a more sustainable option of disposing off such non-bio-degradable wastes. Use of flax fibre reinforced concrete (FFRC) provides an increase in the toughness and shear strength of reinforced concrete which ultimately results in the savings in reinforcements. Using green concrete such as FFRC reduces carbon footprint by 30%

Cost Analysis: Although plasphalt costs 10% more than the conventional asphalt pavement, it lasts 25% longer and diverts 27% of wastes from landfill. FFRC can cost Dhs325 per cubic meter as compared to Dhs285 per cubic meter for conventional C40 concrete.

5.3 SM-11: Rapidly Renewable Materials

Intent: To increase the use of fast-growing materials as an alternative to slow growing materials and finite resources.

Total Credit Points: 1

Already Achieved credit points: 0 (Reason: Not Accepted)

Targeted credit points 1

Newly Achieved credit points: 1

Calculations and Methodology: Linoleum, a natural floor covering made of 98% of mineral based raw material and 80% renewable: materials like Linseed oil, natural resins, wood and cork powder and jute can be used for the floor finishes. Naturally occurring material that 'breathes' such as wool maintains the acoustic and thermal insulation for the lifespan of the structure. Its high integrity eliminates the need for glue and other bonding agents.

Cost Analysis: Linoleum and Wool Insulations costs as low as Dhs12 and Dhs25 per square meter respectively.

CONCLUSIONS:

The above improve improvements in the design of the structural and architectural aspects of the Retail store and Energy Center by providing sustainable solutions in its design stage ensures that the building once constructed does not stop its commitment to sustainability and energy efficiency. The intent and credit requirements as per the PBRS and its subsequent points are successfully met. When cost analysis is performed the costs under each section for may be higher for some credit sections and its benefits cannot be compensated by any conventional means. The community of ‘green buildings’ are once again awakening our planet and aiding in replenishing finite resources one step at a time without compromising the basic human comforts and requirements and the possibility of more sustainable solution remains endless.

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