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Contents

A Review on Hierarchical Routing Protocol: LEACH

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Abstract
Sensor network nodes are limited with respect toenergy supply, restricted computational capacity and communication bandwidth. A review on Wireless Sensor Network (WSN) applications, characteristics and their different routing protocols is presented in first part. The second part of the paper presents the objective of the routing. In WSN there different protocols like Data Centric Protocols, Hierarchical Protocols, Location-based Protocols, AODV, and DSDV etc. In WSN biggest constraint is to employ an efficient power consumption scheme. Low Energy Adaptive Clustering Hierarchy (LEACH), Power Efficient Gathering in Sensor Information System (PEGASIS) and Virtual Grid Array (VGA) protocols were analyzed for network lifetime by changing the sensing range of sensor nodes and increasing the network size. LEACH is more suitable for networks having less than hundred numbers of nodes. In terms of energy efficiency, our protocol has been observed to outperform existing conventional sensor network protocols.

Keywords: Sensor Network, Hierarchical Protocol (Leach Protocol)

Introduction
A Wireless Sensor Network (WSN) is a wireless network of many autonomous low-power, low-cost, and small-size sensor nodes that are self-organized and use sensors to co-operatively monitor complex physical or environmental conditions, such as motion, temperature, sound etc. Such sensors are generally equipped with data processing and communication capabilities and are deployed in indoor scenarios e.g.-the home and office, or outdoor scenarios like the natural, military and embedded environments. These nodes communicate with each other, sharing data collected or other vital information to monitor a specific environment.
One or more nodes among them will serve as sink(s) that are capable of communicating with the user either directly or through the existing wired networks. The primary component of the network is the sensor, essential for monitoring real world physical conditions such as sound, temperature, humidity, intensity, vibration, pressure, motion, pollutants etc. at different locations. The tiny sensor nodes, which consist of sensing, on board processor for data processing, and communicating components, leverage the idea of sensor networks based on collaborative effort of a large number of nodes [1][2].
Figure 1 shows the structural view of a sensor network in which sensor nodes are shown as small circles. [3] Each node typically consists of the four components: sensor unit, central processing unit (CPU), power unit, and communication unit. They are assigned with different tasks. The sensor unit consists of sensor and ADC (Analog to Digital Con-

verter). The sensor unit is responsible for collecting information as the ADC requests, and returning the analog data it sensed. ADC is a translator that tells the CPU what the sensor unit has sensed, and also informs the sensor unit what to do. Communication unit is tasked to receive command or query from and transmit the data from CPU to the outside world. CPU is the most complex unit. It interprets the command or query to ADC, monitors and controls power if necessary, processes received data, computes the next hop to the sink, etc. Power unit supplies power to sensor unit, processing unit and communication unit. Each node may also consist of the two optional components namely Location finding system and Mobilizer. If the user requires the knowledge of location with high accuracy then the node should possess Location finding system and Mobilizer may be needed to move sensor nodes when it is required to carry out the assigned tasks.

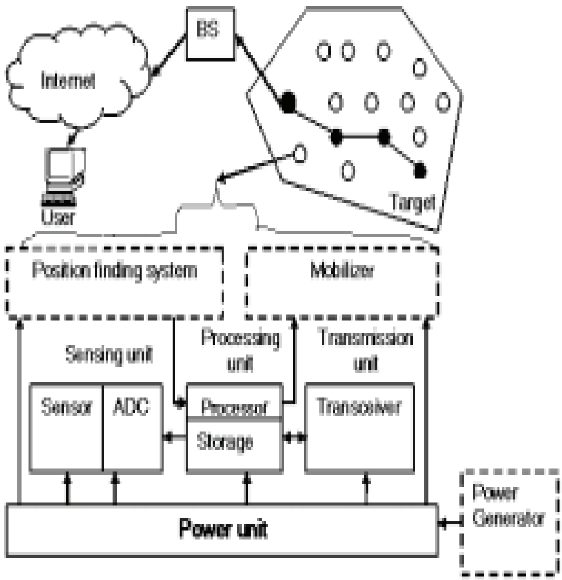

Figure 1: Structural view of sensor network [3]

WSN Applications

WSNs have a wide variety of applications such as environmental monitoring and tracking. The particular applications are tracking of object, monitoring of health, fire detection and control of nuclear reactor. Deployment of sensor nodes in an area for collection of data is a typical application of WSN.

a) Monitoring of Area:

The common application of WSNs is monitoring of area. The events occurring in the environment are monitored by the sensor nodes deployed in the region. Monitoring of area involves detecting enemy intrusion by a large number of sensor nodes deployed over a battlefield. The detected events are then reported to base station for some action [4].

b) Monitoring of Environment:

A large scale wireless sensor networks are deployed for environmental monitoring including forest fire/flood detection, monitoring of the condition of soil and space exploration [4].

c) Applications in Commercial Area:

Wireless Sensor Networks have a lot of applications concerning commercial are such as office/home smart environments, health applications, controlling of environment in buildings, monitoring of industrial plants.

d) Tracking Applications:

In tracking area, WSN applications include targeting in intelligent ammunition and tracing of doctors and patients inside a hospital. A search and rescue system is designed using connectionless sensor based tracking system using witness (CenWits) [5]. Sensors with different radio frequencies and processing devices are used. This rescue system consists of mobile sensors, access points and GPS receivers. The search and rescue efforts are concentrated on an approximate small area with the help of Cen Wits.

The characteristics of the sensor networks as:

- The number of sensor nodes in a sensor network can be several orders of magnitude higher than the nodes in an ad hoc network
- Sensor nodes are densely deployed.
- Sensor nodes are prone to failures.
- The topology of a sensor network changes very frequently.
- Sensor nodes mainly use broadcast communication paradigm
- Sensor nodes are limited in power, computational capacities, and memory.
- Sensor nodes may not have global identification (ID) because of the large amount of overhead and large number of sensors.

Routing Objectives

Sensor networks have emerged as a promising tool for monitoring and actuating the physical worlds, utilizing self-organizing networks of battery-powered wireless sensors that can sense, practice and correspond. In sensor networks, energy is a critical resource, while applications exhibit a limited set of characteristics. Thus, there is both a need and an opportunity to optimize the network architecture for the applications in order to minimize resource consumed.

Some sensor network applications only require the successful delivery of messages between a source and a destination. However, there are applications that need even moreassurance.

a. **Non-real time delivery:** The assurance of message delivery is indispensable for all routing protocols. It means that the protocol should always find the route between the communicating nodes, if it really exists. This correctness property can be proven in a formal way, while the averagecase performance can be evaluated by measuring the message delivery ratio.

b. **Real-time delivery:** Some applications require that a message must be delivered within a specified time, otherwise the message becomes useless or its information content is decreasing after the time bound. Therefore, the main objective of these protocols is to completely control the network delay. The average-case performance of these protocols can be evaluated by measuring the message delivery ratio with time constraints.

c. **Network lifetime:** This protocol objective is crucial for those networks, where the application must run on sensor nodes as long as possible. The protocols aiming this concern try to balance the energy consumption equally among nodes considering their residual energy levels. However, the metric used to determine the network lifetime is also application dependent. Most protocols assume that every node is equally important and they use the time until the first node dies as a metric, or the average energy consumption of the nodes as another metric. If nodes are not equally important, then the time until the last or high priority nodes die can be a reasonable metric.

There are various routing protocols used in WSN like Data Centric Protocols,Hierarchical Protocols, Location-based Protocols, AODV [Ad-hoc on-demand distance vector], DSDV [Destination-sequenced distance vector] etc. Main Emphasis remains on particularly LEACH protocol.

Hierarchical Protocol:

A hierarchical protocol is an approach to the balance between scalability and performance. In hierarchical routing, energy consumption of sensor nodes is drastically minimized when the sensor nodes are involved in multi-hop communication in an area of cluster and performing data aggregation and fusion so as to reduce the number of transmitted information to the sink. The clusters formation is based on the energy reserve of sensor nodes and its proximity to the cluster head (Akkaya and Younis, 2005; Lin and Gerla, 1997). In hierarchical routing, data moves from a lower clustered layer to higher region, hopping from one node to another which covers larger distances, hence moving the data faster to the sink faster. Clustering provides inherent optimization capability at the cluster heads

Following are the hierarchical routing protocols:

1. LEACH.
2. PEGASIS and Hierarchical-PEG ASIS.
3. TEEN and APTEEN.
4. Energy-aware routing for cluster-based sensor networks.
5. Self-organizing protocol

A view of the architecture of hierarchical network is as shown in Figure 2:

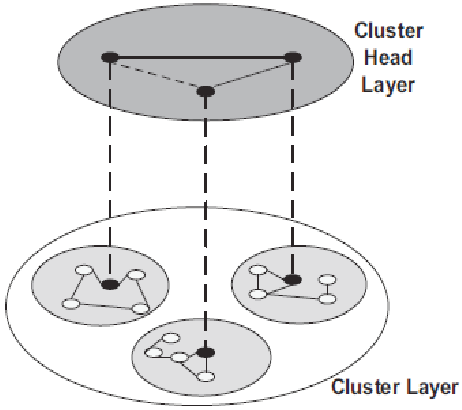

Figure 2: Hierarchical network architecture [6]

Related work to LEACH:-

W. R. Heinzelman, A. Chandrakasan, H.Balakrishnan[7] proposed LEACH, a clustering-based routing protocol that minimizes global energy usage by distributing the load to all the nodes at different points in time. LEACH outperforms static clustering algorithms by requiring nodes to volunteer to be high-energy cluster-heads and adapting the corresponding clusters based on the nodes that choose to be cluster-heads at a given time. A.Joshi, L. Priya,[8] examined the current state of proposed hierarchical routing protocols, specifically with respect to their power and reliability requirements. In wireless sensor networks, the energy limitations of nodes play a crucial role in designing any protocol for implementation. In addition, Quality of Service metrics such as delay, data loss tolerance, and network lifetime expose reliability issues when designing recovery mechanisms for clustering schemes. However there is still much work to be done.

R. V. Biradar , V.C .Patil , Dr. S. R. Sawant, Dr. R. R. Mudholkar ,[9] identified some of the important design issues of routing protocols for sensor networks and also compared and contrasted the existing routing protocols. Although many routing protocols have been proposed for sensor networks, many issues still remain to be addressed. P. Kansal, D. Kansal, A. Balodi[10] focused on the routing problem in wireless sensor networks. SO presented an extensive simulation study to compare three on-demand protocols (AODV, DSDV and LEACH), using a variety of workloads such as packet delivery ratio, routing over head, throughput and average delay. According to practical results, the routing protocol AODV gives the better performance for both MANETs and WSNs. Our results indicate that AODV and LEACH both perform better but AODV is less reliable than LEACH because the result of AODV is fluctuated compare to LEACH.

Intanagonwiwatet.al [11] have introduced a data dissemination paradigm called directed diffusion for sensor net-works. It is a data-centric paradigm and its application to query dissemination and processing has been demonstrated.Estrinet.al [12] discussed a hierarchical clustering method with emphasis on localized behavior and the need for asymmetric communication and energy conservation in sensor networks. A cluster based routing protocol (CBRP)has been pro-posed by Jiang et. al in [13] for mobile ad-hoc networks. It divides the network nodes into a number of overlapping or disjoint two-hop-diameter clusters in a distributed manner. However, this protocol is not suitable for energy constrained sensor networks in this form.

MdEnamulHaque et al [15] proposed an energy efficient routing protocol, Context-Aware Clustering Hierarchy (CACH) where cluster formation is entirely based on the context of the environment. Moreover, an efficient technique has been utilized to avoid similar data traffic across the network and cluster head role has been equally distributed among the nodes. In future, the protocol will include the implementation of multi-hop communication between the cluster head and the base station, which can contribute more in energy efficiency. The super clustering technique which is efficient method for large number of sensor nodes will also be included in future work.

Antoine B. Bagula et al [16] proposed the energy-constrained multi-path routing in wireless sensor network (ECMP). The main idea driving the ECMP model is that in the context of wireless sensor networks, efficient resource usage should reflect not only efficient bandwidth utilization but also a minimal usage of energy in its strict term. While, the MCMP model routes the information over a minimum number of hops, the strength of the ECMP model lies in the fact that it trades between minimum number of hops and minimum energy by selecting a path with minimum number of hops only when it is the path with minimum energy or a longer path with minimum energy satisfying the constraints.

Author P. Huruialăproposed[17] and analyzed the efficiency of a hierarchical routing protocol designed to extend the life of the network by minimizing energy consumption and latency by choosing the best nodes to become cluster-heads. Minimization is realized with a multi-objective genetic algorithm executed on a central BS and the results send to the network nodes. Author Ying-Hong[18] presents a Hierarchy-Based Multipath Routing Protocol(HMRP) for wireless sensor networks. According to HMRP, the wireless sensor network is initially constructed as a layered network. Based on the layered network, sensor nodes have multipath routes to the sink node through candidate parent nodes. The simulation results indicate that the proposed HMRP can increase the lifetime of sensor networks better than other clustering or tree-based protocols.AuthorFeneybao[19] proposed a highly scalable cluster-based hierarchical trust management protocol for wireless sensor networks to effectively deal with selfish or malicious nodes. They developed a probability model using stochastic Petri net techniques to analyze the performance of the proposed trust management protocol.

Leach

In wireless Sensor Networks, Cluster is formed by collection of nodes. Each cluster has a cluster head to communicate with Base Station. The cluster heads are selected on rotation bases to balance the load of energy in the way that most of the nodes get small distances to transmit and only cluster heads are responsible for long transmission to the BS. Besides, LEACH allows data fusion and aggregation in order to minimize the amount of data to be transmitted. Because for energy concerns local computations require less energy than transmitting signals to BS [20] [21].

Each round of LEACH protocol is composed of 'setup phase' and 'steady-state phase'. In setup phase the cluster heads broadcasts an advertisement message to all the nodes to elect cluster head. And the cluster heads are elected depending upon the predefined specified percentage of cluster heads and how many times the node has been elected as cluster head. On receiving the advertisement messages from cluster heads, the non-cluster head nodes decides to which cluster head it will belong depending upon the energy required for transmission to the cluster head. Thus nodes become the members of the cluster requiring low energy transmission for the cluster head [20] [22]. Each non-cluster head node sends a message to the cluster head declaring that it belongs to its cluster after the selection of that cluster head. The cluster head then generates a TDMA schedule for communication with the nodes within its cluster.

In steady state phase non-clusterhead nodes transmit their data only when their allocated time slots arrive. The radio of each non-cluster head node is kept off all the time except when it is ready to transmit data to BS (when its time slot arrive), reducing the battery power consumption. Furthermore, as the cluster head receives all the data from all the nodes it aggregates and fuses the data to minimize the amount of long distanced transmission with the base station. Thus again reducing the energy consumption.When a node decides to become a cluster head, it also chooses a CDMA code from the available list of spreading codes and informs all the non-cluster head nodes within its cluster about the details of the chosen code. The reason for this is that, the radio transmission of a node with cluster head in a cluster usually affects the transmission in the neighboring clusters. By CDMA, the cluster head filters the received signal using the specific spreading code [20] [22].

PEGASIS

This protocol is presented to improve LEACH protocol [17]. In this protocol just one node has direct connection to the Sink and the other nodes should be connected to the most nearest node to receive required data. Then it aggregates this information with its own data and extracts a packet and it is sent to the nearest node on the path. The path selection is done using Greedy algorithm and is started from Sink. Generally, data fusion reduces the transmitted data from source to destination. When 1% to 100% of nodes are dead, this protocol has 100% to 300% improvement in comparison with LEACH.

TEEN and APTEEN:

TEEN protocol is designed to prevent unexpected alterations in environmental parameters. This capability is so important in time sensitive applications, especially in reaction operation networks. TEEN follows data centered model and after clusters creation, Cluster heads send two soft and hard threshold levels to their member nodes which are used to receive data. These threshold levels are used to activate nodes in different conditions and will change node status to transfer state.

Energy-Aware routingforcluster-basedsensor networks (EAR-CSN):

The algorithm was based on three tier architecture. In this sensor node in the cluster could be in any of sensing only, relaying only or inactive state. The algorithm suffers in transmission range, and as the algorithm uses many cluster heads, it introduces more overheads and hence consumes much energy.

Self-organizing protocol (SOP):

It involves basically the self-organization of the router nodes and creation of routing tables based on four phases: discovery phase,organizing phase, self-reorganizing phase and maintenance phase.The algorithm is cost effective in routing table maintenance, and consumes less energy in broadcasting messages than SPIN protocol, due to broadcast trees used in the algorithm. Due to the organization phase of the algorithm which is not on-demand, it introduces extra overhead.

Conclusion:

This paper reviews WSN and its application. This paper also discuss various routing objective and protocols .For WSN the main constraint is the efficient power consumption which is the great obstacle for performing tasks continuously. The use of efficient protocol which can reduce the power consumption during communication to prolong the network life time. We have seen that clustering architecture of LEACH makes it possible to reduce the transmission by data aggregation which minimizes the number of packets to be transmitted. So, LEACH can be used to produce energy efficient results in WSN.

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Defect Analysis by Failure Mode and Effect Analysis (FMEA) in Manufacturing Process of Streering Nut

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ABSTRACT
In India, most of the small and medium enterprises are an unorganized sector because of investment, manpower, organizational sector, space, plant and machinery etc. are limited, whereas this sector fulfills the need of many large scale units by supplying low cost components as per their specifications and their requirements (within finished as well as semi-finished). In the era of globalization, more and more competition has to face by this sector. At present, micro small and medium enterprises are facing difficulties because input cost (like raw material cost, electricity cost, fuel cost and transportation cost) has increased but final product price are not increasing accordingly. There is no space for rejection/reworking because it is a non-value added activity of the company. No customer will pay cost for this. So customer wants defect free product with economical price. The Statistical Quality Control (SQC) helps in findings problems, stating them in meaningful terms and solving them. The SQC provides a plan or roadmap that leads to a better competitive position. Attempts to improve individual performance are useless when the problem lies in the system itself. But use of statistical tools by all employees provides a common method of identifying the critical problems and managing their solutions by the facts.

1 INTRODUCTION
In India, most of the small and medium enterprises are an unorganized sector because of investment, manpower, organizational sector, space, plant and machinery etc. are limited, whereas this sector fulfills the need of many large scale units by supplying low cost components as per their specifications and their requirements (within finished as well as semi-finished). In the era of globalization, more and more competition has to face by this sector. At present, micro small and medium enterprises are facing difficulties because input cost (like raw material cost, electricity cost, fuel cost and transportation cost) has increased but final product price are not increasing accordingly. There is no space for rejection/reworking because it is a non value added activity of the company. No customer will pay cost for this. So customer wants defect free product with economical price.

1.1 Defect Analysis by SQC Technique
An item is considered to be defective if it fails to confirm the specifications in any of the characteristics **[1]**. Each characteristic that does not meet the specification is a defect. An item is defective if it contains at least one defect.

The Statistical Quality Control (SQC) helps in findings problems, stating them in meaningful terms and solving them. The SQC provides a plan or roadmap that leads to a better competitive position. Attempts to improve individual performance are useless when the problem lies in the system itself. But use of statistical tools by all employees provides a common method of identifying the critical problems and managing their solutions by the facts. The seven most commonly used statistical tools for quality controls are:

i. Cause and Effect Diagram
ii. Check Sheet
iii. Control Chart
iv. Histogram
v. Pareto Chart
vi. Scatter Diagram
vii. Stratification

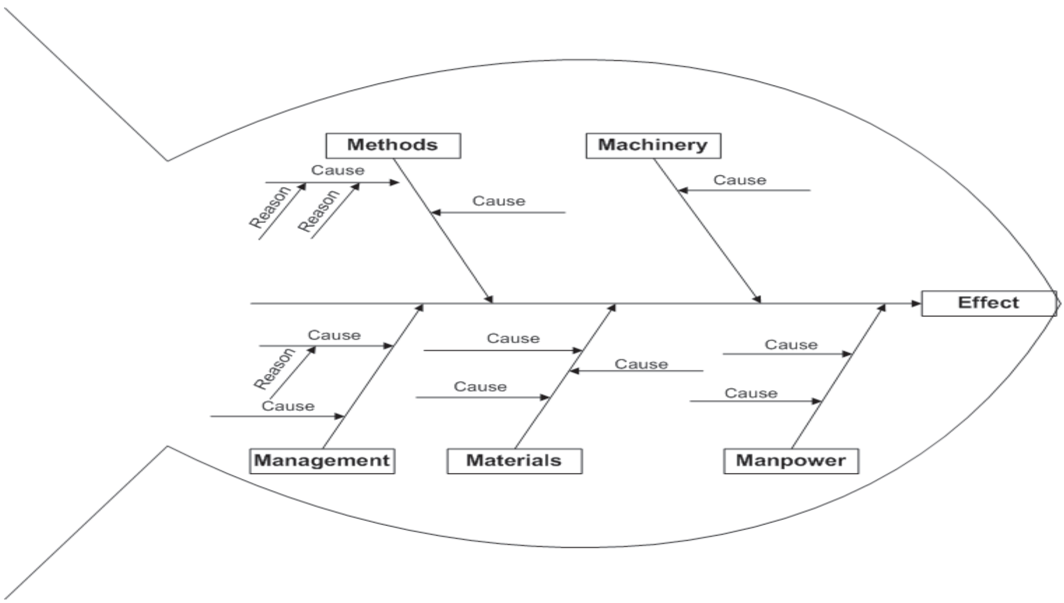

Figure 1: Cause and Effect Diagram

1.2 Defect Analysis by FMEA

Failure Mode and Effect Analysis (FMEA) is a procedure in operations management for analysis of potential failure modes within a system by determination of the effect of failures on the system **[2]**. It is widely used in manufacturing industries in various phases of the product life cycle and also finds application in the service industry. Failure modes are any errors or defects in a process, design, or item, especially those that affect the customer, and can be potential or actual. Effect analysis refers to studying the consequences of those failures.FMEA can provide an analytical approach, when dealing with potential failure modes and their associated causes. When considering possible failures in a design – like safety, cost, performance, quality and reliability – FMEA provides a lot of information about how to alter the development/manufacturing process, in order to avoid these failures. FMEA provides an easy tool to determine which risk has the greatest concern, and therefore an action is needed to prevent a problem before it arises. The development of these specifications will ensure the product will meet the defined requirements.

2 LITERATURE

C.R. Gagg [3] concluded that manufacturing necessitates the transformation of raw materials from their initial form into finished, functional products. This change was achieved by a variety of processes, each of which was designed to perform a specific function in the transformation process. Implicit within the design and operation of such processes was a required understanding of the properties of engineering materials and their specific response to such manufacturing methods. However, various defects can be 'in-built' during the transformation cycle, dependent on factors such as materials, part design, processing techniques and welding techniques. A review of the major routes in the production of engineered components was presented, highlighting the possibilities of introducing defects at each stage.**Pankaj Jalote et al. [4]** described the when–who–how approach for analyzing defect data to gain a better understanding of the quality control process and identify improvement opportunities. At the component level, the analysis provided the capability to assess strength of dependency between components, and new ways to study correlation between early and late defects. They applied this approach for analyzing the defect data. The analysis showed up some clear areas of improvement, like internal teams effectiveness, defect detection capability of the process in early stages, and insufficient operational profile based testing. These observations led to simple yet effective suggestions for improving the quality control processes.**J. Zackrisson et al. [5]** focused on the effectiveness of the on-line quality control in the low scale industries. The basis of the study was manufacturing process of trams. The result indicates that the quality control program demands a solid base to be effective from the beginning of its implementation. Empirical results show that during the off-line process the lead time in the production was reduced by 50% and the mean cycle time of the storage was decreased by 33%. Formally, quality tools were investigated as regards the scale of the industry. **Michael Yu Wang [6]** presented an analysis describing the impact of localization source errors on the potential datum-related geometric errors of machined features. The analysis reveals the error sensitivity and error characteristics of critical points of multiple manufacturing features. It shows the importance to consider the overall error among the multiple critical points in fixture layout design. He also suggested an optimal approach to the locator configuration design for reducing geometric variations at the critical points of machined features. He investigated how geometric errors of machined feature surfaces (or manufacturing errors) are related to main sources of fixel errors. In a mathematic framework he presented, locator positional errors, locator surface geometric errors, and the workpiece datum geometric errors were shown to result in a localization error of the workpiece. The localization error in turn yields a relational form error in a machined feature. These relationships were characterized by the critical configuration matrix relating the critical variations to the fixel errors.

3 CAUSES OF REJECTION

The rejection occurred due to:

- Incorrect setting up of cutter on the machine,
- Incorrect cutting conditions such as depth of cut and feed rate,
- Incorrectly ground tool angles (geometrical parameters) such as rake angle, clearance angle and nose radius,
- Wear of cutting tool,
- Quality of coolant.

The main causes of rejection found were:

- Inaccurate dimensions of pitch diameter due to the variation in depth of thread milling cutter.
- Scored thread is produced when a dull cutting tool is used, or in the case of improper choice of cutting conditions and composition of coolant.
- Crushed surface of the thread is a result of vibration. In the thread milling, workpiece, cutting tool, machine, and fixtures were subjected to vibrations.
- Shear of turns occurs when the traverse of cutting tool does not agree with the pitch of thread and also when the sense of rotation of workpiece or tool was incorrect.
- Low class of surface roughness resulted from improperly ground tool, its heavy wear, incorrect conditions of machining and feeding the coolant, insufficient clamping rigidity of workpiece and tool, etc.
- Incorrect pitch of thread results from incorrect setting up of the machine or from errors in the pitch of thread milling cutter.
- Incorrect thread form was due to incorrect setting of the tool or its incorrect cutting edge.
- Non-uniform depth of thread along the turn occurred because of workpiece run out when it was improperly mounted.

The defect analysis was carried out using Cause and Effect Diagram (Fishbone Diagram). The fishbone diagram represents meaningful relationship between a defect and its causes. It also enables to identify, explore and graphically displays all the possible causes related to a problem. The fishbone diagram for the defects in thread milling process is shown in Figure 3.13. The fishbone diagram shows the major factors which affect the quality of the threading. The major factors depicted in the figure are operator, machine and method. For each factor the possible causes of defect as observed are shown. The main causes of the defects were incorrect setting up of machine tool, incorrect ground tool angles, wear of cutting tool and faulty machine tool. This leads to the defects in component.

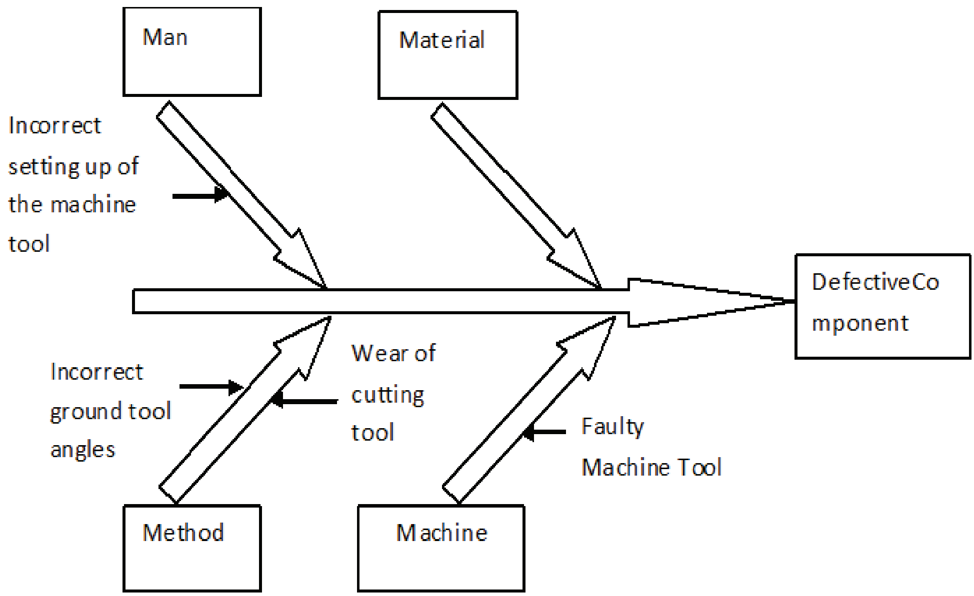

Figure 3.13: Cause and Effect Diagram for Thread Milling Process

Heat Treatment Process

The complete process of hardening consists of first preheating the components to about 400^0 C to 450^0C in a preheating furnace, holding them at that temperature for 2 hours and then heating at a faster rate to 850^0C in salt bath furnace (electrically heated). Salt used is barium chloride. Soaking time is 20 min.

Stepped Quenching

It is employed for producing martensite. After holding the component at the hardening temperature for the required period the components are quenched in salt bath, which was maintained at a temperature slightly above the temperature at which martensite formation starts (i.e. between 160^0 C to 180^0C). The component was soaked in the bath till its temperature comes down to bath temperature (i.e. for 20 min), but it was not allowed to be immersed for a longer period lest the austenite starts decomposing. Here, the salt used was mixture of nitrate and nitride. Its melting point was 140^0 C. It was then removed from the bath and cooled in water. Here austenite was transformed into martensite. Fresh water washing was done for removal of salt from component threaded surface i.e. for the purpose of thread cleaning. Here the hardness of the component was 50-55HRC.

Tempering

Tempering after hardening was essential in order to do away with some extra brittleness. It also helps in removing the internal stresses set up during the hardening process. Tempering involves reheating to specified temperatures followed by cooling. This process enables the steel structure being finally transformed into sorbite, which results in the material attaining high ductility while retaining enough hardness. Plain carbon steel was reheated to a temperature range from 600^0 C to 650^{0}C for 1-1.5 hour. Hardness achieved through this is 30-32 HRC, which is company's requirement.

Reasons for Rejection of Nut Steering Knuckle

- Thread distortion was observed in final product
- Opening of the component from wire bundle after hardening but before tempering leads to breakage of components
- High Hardening temperature
- No proper method for removing component from wire bundle after hardening i.e. in salt bath
- Less skilled operator
- Time error

Figure 3.14 shows the main causes and their effects in heat treatment process. The fish-bone diagram shows the major factors which affect the quality of the threading and breakage of component. For each factor the possible causes of defect as observed are shown. The main causes of the defects were mishandling at heat treatment stage, removing component from wire bundle, high hardening temperature and faulty maintenance. This leads to breakage and thread distortion problem in component.

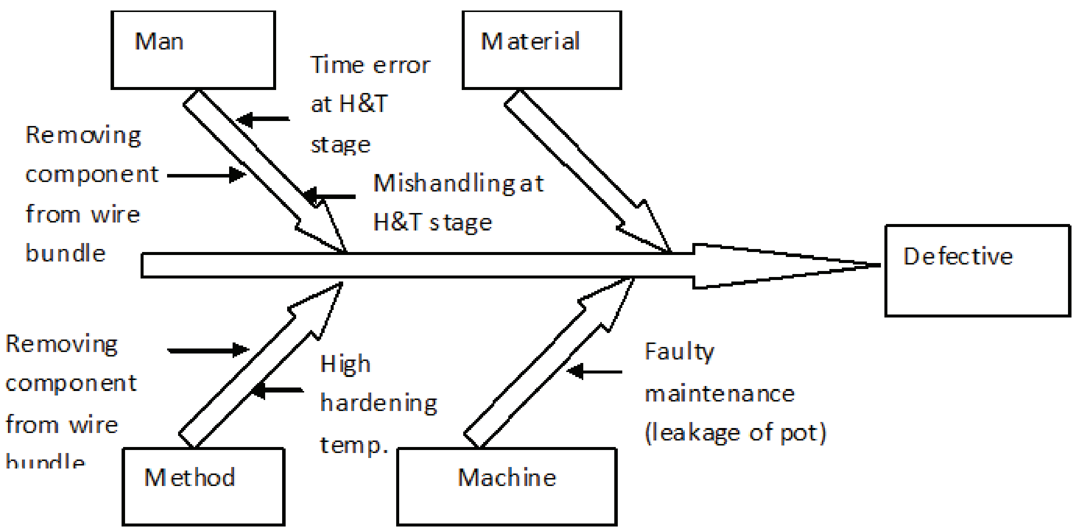

Figure 3.14: Cause and Effect Diagram for Heat Treatment Process

Reasons for Rejection of Nut Steering Knuckle

Since heavy scaling was there, so it was necessary to dip the component for more time in acid to remove the scaling. Because the section of thread was very fine, the acid affected the thread.

4 ANALYSIS OF DEFECTS

Analysis of data is an important task. The production data was collected from July-12 to Dec-12 and analysis of defects was done for four processes as given below:

- Thread milling
- Heat treatment
- Blackening
- Existing fixture

4.1. Thread milling Process

In thread milling process, the rejection occurred due to:

- Incorrect setting up of cutter on the machine,
- Incorrect cutting conditions such as depth of cut and feed rate,
- Incorrectly ground tool angles (geometrical parameters) such as rake angle, clearance angle and nose radius,
- Wear of cutting tool and
- Quality of coolant.

Table 4.1 shows the month wise description of defective pieces of nut steering knuckle in thread milling process.

Table 4.1: Defective Components in Thread Milling Process

Months / Number of components	July-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
PRODUCTION	3000	3000	3500	3000	2500	2500
DEFECTIVE COMPONENTS	40	48	46	40	35	29
% DEFECTIVE COMPONENTS	1.33	1.6	1.31	1.33	1.4	1.16
AVERAGE % DEFECTIVE	1.36%					

The percentage of defective component ranges from 1.16% to 1.6%. The histogram for the above data is shown in Figure 4.1. In this figure, there is a decrease in defective components from July-12 to Dec-12because of decrease in demand of the component.

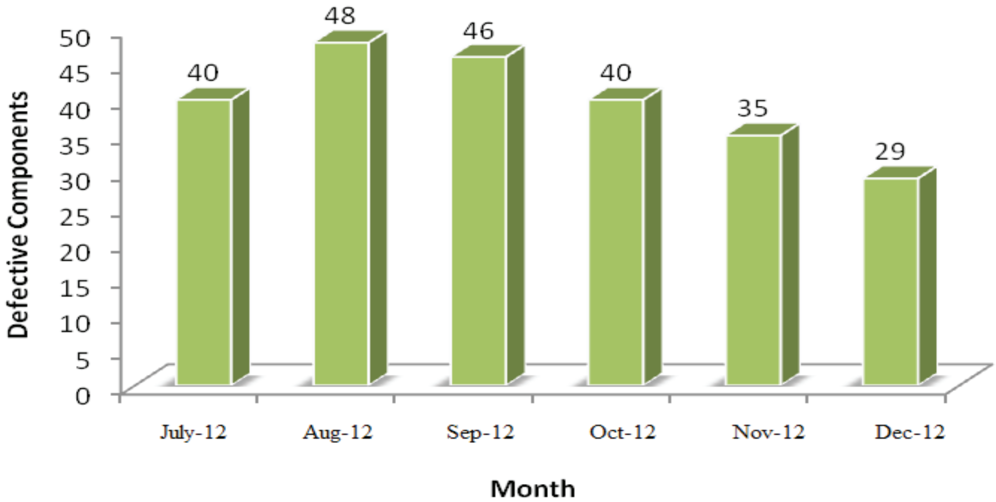

Figure 4.1: Defective Components in Thread Milling Process

4.2. Heat Treatment Process

After thread milling process, analysis of heat treatment process was done. In heat treatment, process the rejections were due to high hardening temperature, mishandling during opening of the component from wire bundle and also due to less skilled operator. Table 4.2 shows the month wise description of defective pieces of nut steering knuckle in heat treatment process.

Table 4.2: Defective Components in Heat Treatment Process

Months / **Number of components**	**July-12**	**Aug-12**	**Sep-12**	**Oct-12**	**Nov-12**	**Dec-12**
PRODUCTION	3000	3000	3500	3000	2500	2500
DEFECTIVE COMPONENTS	308	312	330	311	280	288
% DEFECTIVE COMPONENTS	10.26	10.4	9.42	10.37	11.2	11.52
AVERAGE % DEFECTIVE	10.52%					

The percentage of defective component ranges from 9.42% to 11.52% which is very high. The histogram for the above data is shown in Figure 4.2.

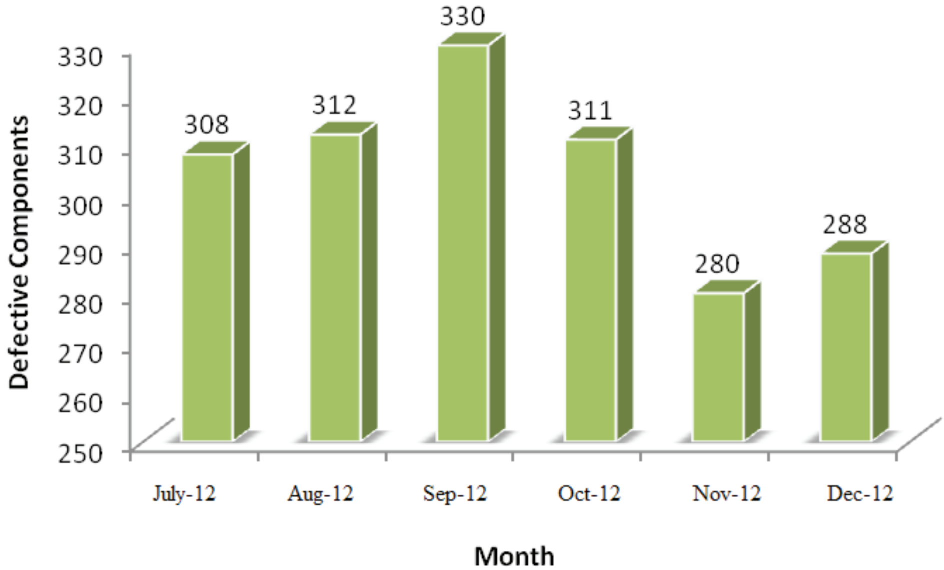

Figure 4.2: Defective Components in Heat Treatment Process

4.3. Blackening Process

In blackening process, the rejections were due to heavy scaling, so it was necessary to dip the component for more time in acid to remove the scaling. Because the section of thread was very fine, the acid affected the thread. Table 4.3 shows the month wise description of defective pieces of nut steering knuckle in blackening process.

Table 4.3: Defective Components in Blackening Process

Months / **Number of components**	**July-12**	**Aug-12**	**Sep-12**	**Oct-12**	**Nov-12**	**Dec-12**
PRODUCTION	3000	3000	3500	3000	2500	2500
DEFECTIVE COMPONENTS	74	83	87	77	68	65
%DEFECTIVE COMPONENTS	2.47	2.77	2.48	2.57	2.72	2.6
AVERAGE % DEFECTIVE	2.60%					

The percentage of defective component ranges from 2.47% to 2.77%. The histogram for the above data is shown in Figure 4.3.

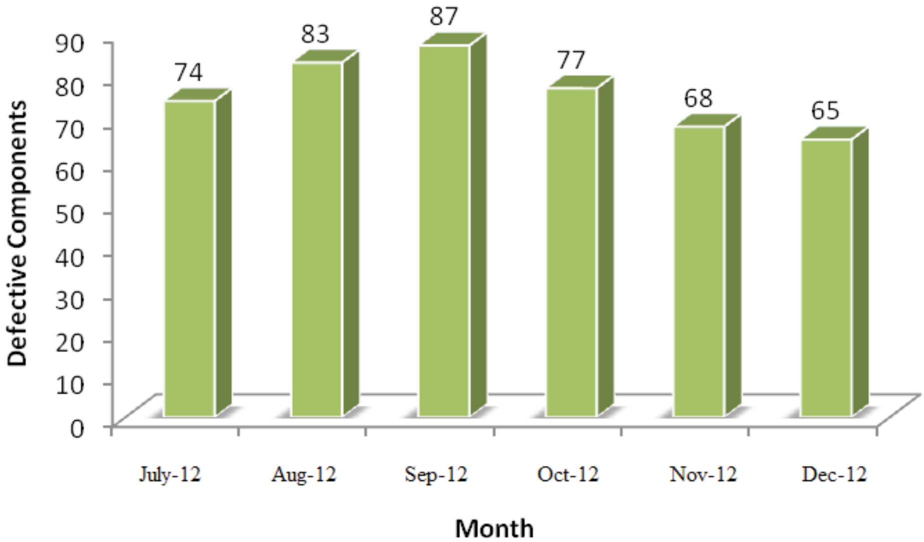

Figure 4.3: Defective Components in Blackening Process

4.4. Existing Fixture

For holding the component on milling machine, company was using threaded mandrel. It was taking more time for clamping the component and by operator's mistake the tendency of thread damage was high. This was because of misalignment of the component and the threaded mandrel which leads to thread distortion. Table 4.4 shows the month wise description of defective pieces of nut steering knuckle using existing fixture.

Table 4.4: Defective Components Using Existing Fixture

Months / **Number of components**	**July-12**	**Aug-12**	**Sep-12**	**Oct-12**	**Nov-12**	**Dec-12**
PRODUCTION	3000	3000	3500	3000	2500	2500
DEFECTIVE COMPONENTS	23	24	30	22	18	20
% DEFECTIVE COMPONENTS	0.77	0.8	0.86	0.73	0.72	0.8
AVERAGE % DEFECTIVE	0.78%					

The percentage of defective component is less than 1%. The histogram for the above data is shown in Figure 4.4.

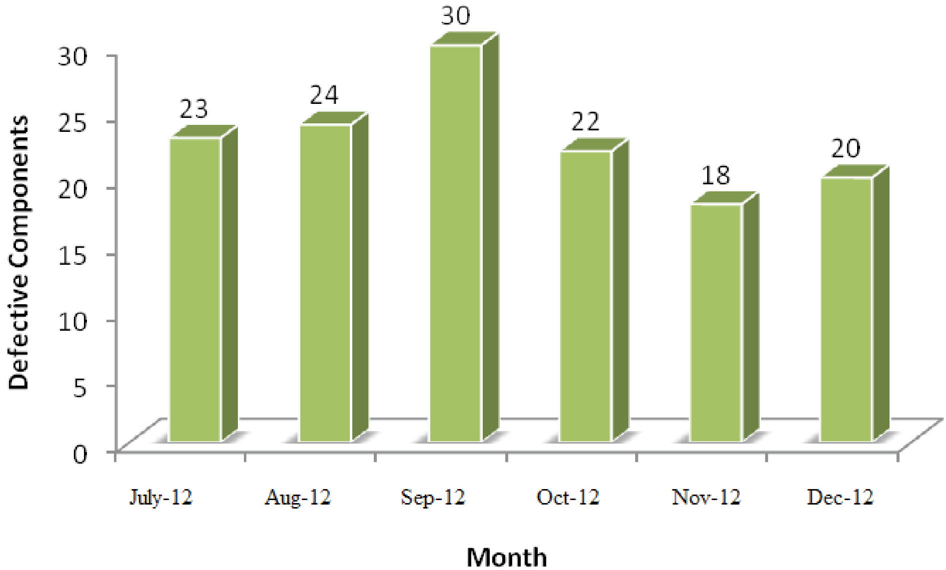

Figure 4.4: Defective Components Using Existing Fixture

Figure 4.5 shows the types of process which causes defects in nut steering knuckle with percentage. The defective components are in heat treatment, blackening process, thread milling process and also due to existing fixture clamping method. The figure shows that heat treatment process accounts for maximum (10.45%) defective components as compared to the other process/means.

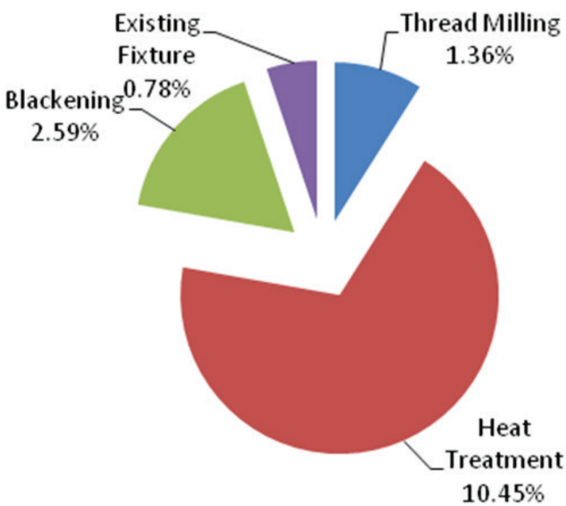

Figure 4.5: Causes of Defects

For the rectification of these problems, following suggestions were approved by the management of the company for implementation:

- Modification of Manufacturing Process
- Fixture Modification

5 CONCLUSION

The defective components were found in heat treatment, blackening process, thread milling process and also due to existing fixture clamping method. The heat treatment process accounts for maximum (10.45%) defective components as compared to the other process/means.

- For the rectification of these problems, following suggestions were approved by the management of the company for implementation:
    a. Modification of manufacturing process
    b. Fixture modification

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Experimental investigation of Surface Integrity of Cobalt bonded Tungsten Carbide (WC-CO) using EDM process material

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ABSTRACT

Electric Discharge machining (EDM) process is the one in which material is removed by thermo-electric action. EDM is an important machining process among non-conventional machining processes.The present research describes the experimental investigation of cobalt bonded tungsten carbide (WC-CO)surface integrity by EDM process using Cu-SiC composite electrode. EDM parameter such as peak current, voltage, pulse duration and interval time taken as input parameters and material removal rate (MRR) and surface roughness (SR) is taken as response parameters. It is found that these parameters have a significant influence on machining characteristic such as metal removal rate (MRR) and surface roughness (SR). MRR increases with peak current. SR decreases with increase of peak current.

Keywords: *EDM, cobalt bonded tungsten carbide (WC-CO), Material removal rate, Surface roughness (SR).*

1 INTRODUCTION

In recent years, materials having the properties of high hardness, high strength, wear resistant and temperature resistant are demanding. Therefore material scientists and researchers are developing materials such as composites, super alloys, tool steels, cemented carbides etc. The applications of these materials are increasing widely in almost every field ranging from automotives to aerospace. Tungsten carbide and cobalt (WC–Co) composite is of special attention in producing cutting tools, dies and other special tools and components due to its very high hardness and excellent resistance to shock and wear. It is possible to machine this material with some conventional methods; however, high accuracy required in machining complex shapes cannot be achieved [1]. Therefore there is a need of the non conventional machining methods. Among the non conventional machining methods, Electric discharge machining (EDM) is one of the techniques used to machine hard, high strength, and temperature resistance materials. In this process, material is removed by means of rapid and repetitive spark discharges across the gap between electrode and workpiece [2]. EDM is used to machine electrically conductive material regardless of its hardness and strength. Therefore EDM parameters (peak current, machining voltage, pulse duration and interval time) are of utmost importance and have significant effect on the machining characteristics such as electrode wear rate (EWR), material removal rate (MRR), surface roughness (SR) etc. The basis of EDM dates back to 1770, when English chemist Joseph Priestly discovered the erosive effect of electrical discharges or sparks [3]. However, it was only in 1943 at the Moscow University where Lazarenko and Lazarenko [4] exploited the destructive properties of electrical discharges for constructive use. At that time EDM was mainly used to remove broken taps and drills from hydraulic valves. The effective use of EDM is achieved only in the 1980s with the advent of computer numerical control (CNC). At present, EDM is a widespread technique used in manufacturing industry for machining all types of conductive materials such as metals, metallic alloys, graphite, or even some ceramic materials precisely and accurately.

One of the earliest researches on EDM of cemented tungsten carbide was done by Pandit and Rajurkar [5].They reported that due to the complex composition and microstructure of the cemented carbide, it is difficult to correlate the effect of operating parameters on the surface integrity. Pandey and Jilani [6] studied the effects of pulse parameters and the carbide composition on the MRR, electrode wear and crater shape and size. Lee et al. studied the effect of machining parameters on MRR, Relative wear ratio (RWR) and SR [7]. Tungsten carbide was used as the workpiece material and graphite, copper and copper-tungsten as electrode material. They concluded that MRR increases with increase in peak current for all the electrode materials, whereas graphite produces higher MRR followed by copper tungsten and then copper. Copper tungsten exhibits the lowest RWR for all ranges of peak current. Copper electrode gives best surface finish followed by copper tungsten and then graphite. Moreover they concluded that SR increases with increase in peak current. The negative tool polarity gives higher MRR, lower RWR and better SR. With the increase of open circuit voltage MRR decreases whereas RWR and SR decreases. Lee and Li [8] investigated the machined workpiece surface integrity, including the microstructures, surface topography, micro-cracks, composition and hardness at various machining conditions. They found no difference between the hardness of the EDMed surface and the original hardness of the workpiece for all EDM conditions. Moreover, scanning electron microscopy (SEM) shows clearly observable damaged layer on the workpiece surface, distinguished by the amount of WC grains and micro-cracks. It is also observed that damage caused by EDM on the EDMed surface is limited to a certain depth only. However, it is also observed that with the increase in peak current and pulse duration, the depth of the damaged layer and the average length, width and number of micro-cracks also increases. At low values of peak current and pulse duration, the damaged layer and micro-cracks disappears. Lajis et al. [9] investigated the effect of peak current, voltage, pulse duration and interval time on MRR, EWR and SR during EDM of Tungsten Carbide with graphite as electrode. Taguchi methodology has been implemented to analyze the effect of machining parameters on the machining characteristics. They concluded that the peak current has a significant effect on EWR and SR, whereas MRR is mainly influenced by pulse duration.

Tomadi et al. [10] analyzed the influence of EDM parameters on surface quality (SQ), MRR and EW of tungsten carbide. Low values of peak current, pulse off time and voltage are used to obtain a good surface finish in the case of tungsten carbide. High values for peak current and voltage produces high MRR. Moreover they concluded that Low EW is obtained at the high values of the pulse off time and low values of peak current. Janmanee and Muttamara [11] studied the performance of different electrode materials on tungsten carbide workpiece with EDM process. They used graphite (Poco EDM-3), copper-graphite (Poco EDM-C3) and copper-tungsten (solid) electrode.They concluded that the electrodenegative polarity performs very well. Poco EDM-3 gives higher MRR as compared to other electrodes. Copper-tungsten gives the best SR at a peak current intensity up to 20 amperes.

2 EXPERIMENTAL SETUP

Cobalt bonded tungsten carbide (WC-CO) was workpiece material used in this investigation. Cu-SiC composite is used as electrode material. Chemical composition (wt %) of workpiece and tool electrode is shown in Table-1. Experiments were performed using a Electronoca Electrical Discharge Machine (EDM) as shown in Figure-1. Kerosene was used as the dielectric fluid in this experiment.

Table-1, Chemical composition (wt %) of workpiece and Tool

Element→ Material↓	W%	Cu %	Al %	Ni%	Sn%	Zn%	Si%	Fe%	Cr%	Co%	C%
Tungsten Carbide	93.36	-	-	-	-	-	-	1.41	0.34	4.89	-
Copper- SiC	-	90	-	-	-	-	10	-	-	-	-

Figure-1, Electronoca Electrical Discharge Machine (EDM)

The MRR and was evaluated for each cutting condition by measuring the average amount of material removed and the required cutting time. Next, the SR of the cobalt-bonded tungsten carbide (WC-CO) was measured by a Surface Roughness Tester, series-Taly-surf.Essential parameters of the experiment are given in Table 2.

Table-2, parameters of the experiment

Work-piece Material	cobalt-bonded tungsten carbide (WC-CO)
Electrode Material	Cu-SiC composite
Machining Parameters	Peak Current (I_p), 5-35 A Pulse-on (T_{on}), 20-100 µs Pulse-off (T_{off}), 10-20 µs
Response Parameters	Material removal rate (MRR) Surface Roughness (SR)

3 Results and Discussion

The following discussion focuses on the effects of process parameters to the observed values(MRR and SR)

3.1 Material removal rate (MRR)

MRR is increasing with increase of peak current. Peak current I_p is directly proportional to the MRR, i.e., by increasing I_p from 5 to 35 A, MRR increases significantly.This is expected because an increase in pulse current produces strong spark, which produces the higher temperature, causing more material to melt and erode from the work. Besides, it is seen that with the increase on T_{on} and T_{off}, MRR decreases first after which it starts to increases up to a maximum value.Figure-2 shows the effect of peak current on MRR by keeping other parameters fixed.

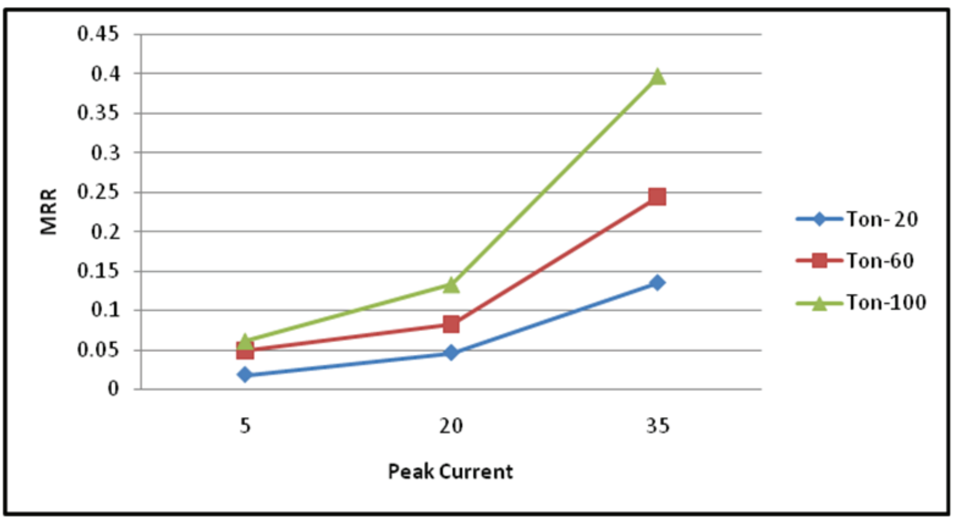

Figure-2, effect of peak current (I_p) on MRR

MRR increases with increase of pulse-on, because higher energy for long time will be tranfred to workpiece and MRR increases speedily as shown in fig-3.

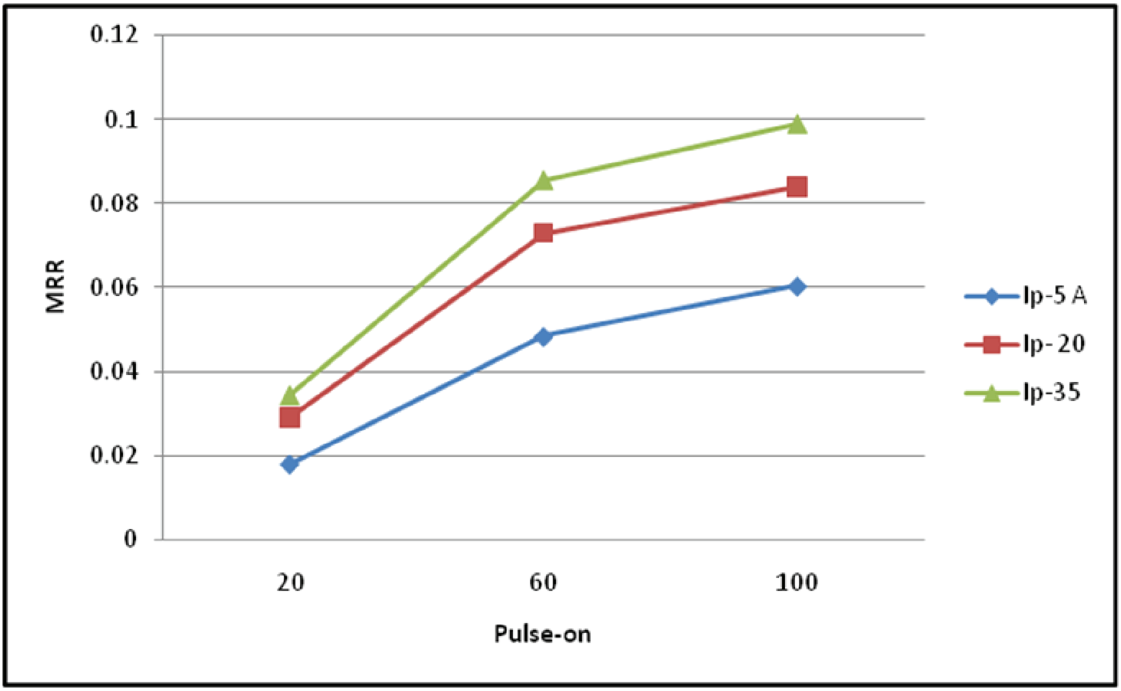

Figure-3, effect of Pulse-on (T_{on}) on MRR

Figure-4 shows that MRR decreases with increase of pulse interval.

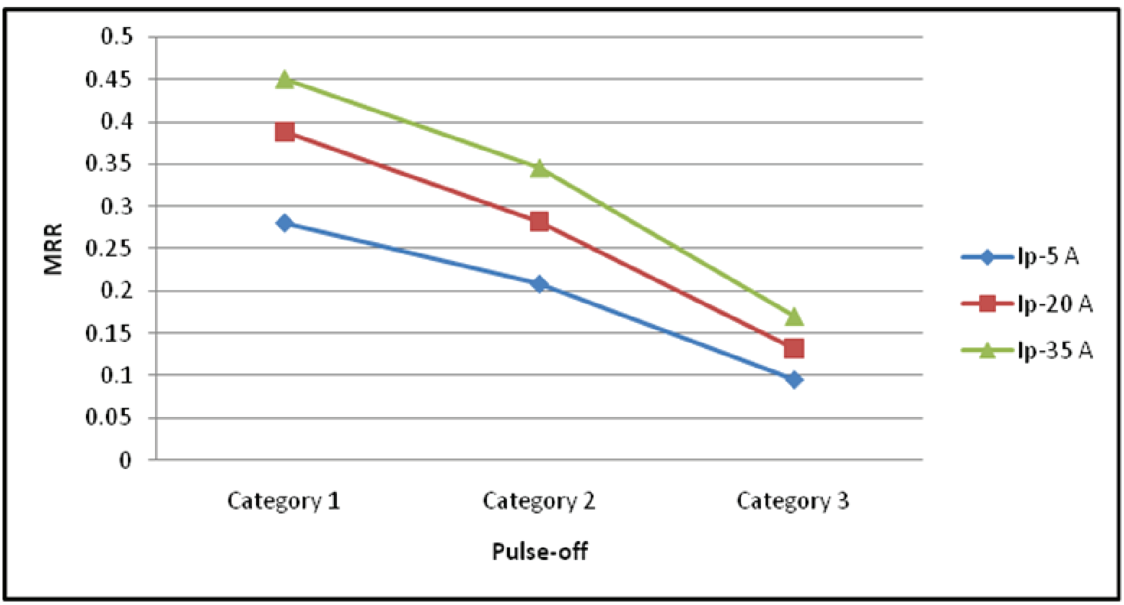

Figure-4, effect of Pulse-off on MRR

3.2 Surface Roughness (SR)

SEM photograph in figure 5 and 6 shows machined work piece surface machined by EDM (with kerosene oil) exhibit non-uniform craters and severe undulations. The craters are bigger in size and their shape is uneven and peculiar. Further, the craters are very distinct and deep with a high density of global appendages.

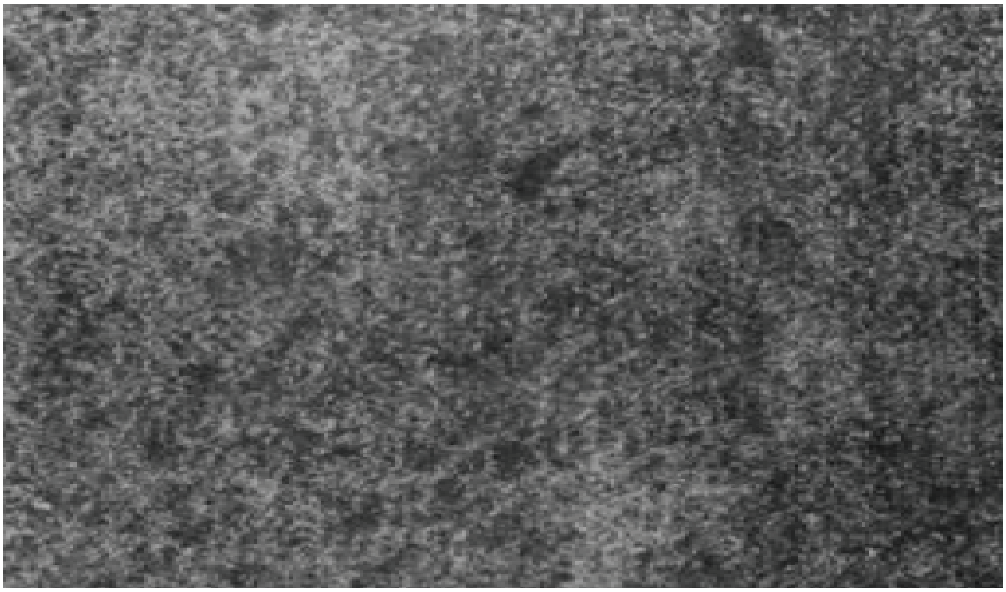

Figure-5, effect of peak current (5 A) on discharge crater

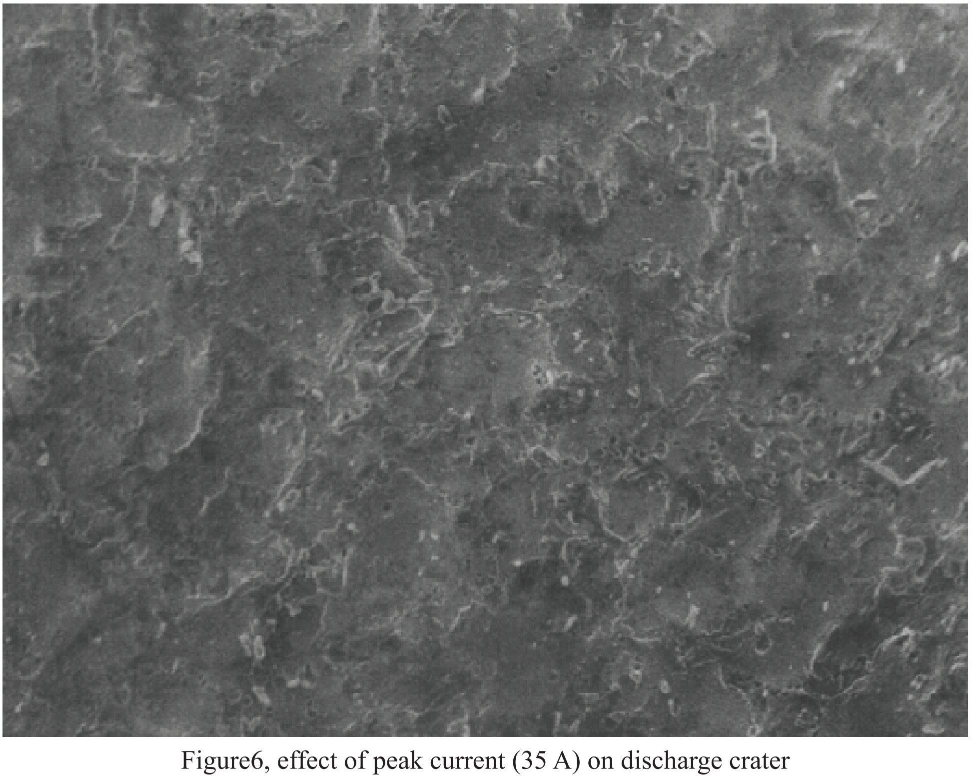

Figure6, effect of peak current (35 A) on discharge crater

Surface roughness decreases with increase of peak current (Ip). Larger craters wereproduced by a larger power supply voltage, possibly producing a larger discharging energy. The variation of crater diameter, depth and volume with respect to peak current is consistentwith the general findings in EDM literature that higher currents generate larger crater and thereforeproduces rough surfaces.

CONCLUSION

This research revealed the feasibility of machining cobalt bonded Tungsten Carbide like high strength cermets by EDM with a Cu-SiC composite electrode. Based on the results presented herein, wecan conclude that, the peak current of EDM mainly affects the MRR and SR. The pulse durationlargely affects the MRR. With the increase of Peak current MRR increases. SR decreases with increases of peak current.

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Experimental Investigation of Process Parameter of MAF on Surface Roughness

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Abstract
Magnetic Abrasive Finishing (MAF) is a non-conventional finishing process in which material is removed in such a way that deburring and finishing are performed simultaneously by magnetic force which forcing the flexible magnetic abrasive particles (FMAP) across the workpiece surface. The process is controllable because the machining pressure is controlled only by the input current to the coil of solenoid. The process embraces a wide range of feasible applications from critical aerospace and medical components to high production volumes of parts. One serious limitation of almost all such processes is low material removal rate. In recent years hybrid machining processes have been developed to improve the efficiency of such processes. In this research paper new hybrid process was developed by providing the rotational motion to the workpiece for enhancing material removal and surface finish in conventional MAF process. In conventional MAF process only a small fraction of abrasive particles are effective in abrading action. Experiments are performed with ferromagnetic stainless steel SS-409.

Keywords: *MAF, FMAB, Surface Roughness, RPM.*

1 INTRODUCTION

The rapid development of the industries like aeronautics, nuclear reactors, semi-conductor, bio-technology, and optical electronics has increased the importance of geometrical precision and part surface quality. Finishing is regularly applied to parts to obtain precise surfaces. Usually in a machining process, simply finishing a product introduces an extra cost that sometimes is as high as 15% of the total cost of production [Rhoades, 1998]. Hence, researchers in the industry and academics have attempted to develop a better means of obtaining a high-precision surface, with low cost, high efficiency, ease of operation and limited environmental pollution. To meet such requirements by traditional material removal processes is very difficult and economically not feasible. To get better surface finish and higher metal removal rate, the machine tools need to be rigid, free from static as well as dynamic errors [Jayakumar et al, 1997]. It is difficult to economically build machine tools that are extremely rigid, vibration and error free [Jayakumar et al, 1997]. So there is a need to economize finishing methods and to bring more of sophistication into surface finishing.

Conventional finishing processes such as grinding, lapping, honing, super finishing are good, but they have some problems such as high cost when finishing high strength materials accurately, high energy consumption, ecologically less safe etc. The pressure they apply on the surface is high and sometimes may damage the surface which they finish. Moreover, control of these conventional finishing processes is also less. Magnetic abrasive finishing (MAF) process was recently created and it is a highly efficient way of obtaining a good surface finish.

Magnetic abrasive finishing process is a magnetic field assisted finishing process by which material is removed in such a way that the surface finishing and deburring is performed with the presence of a magnetic field controls the forces in the machining zone. In magnetic abrasive finishing, machining pressure can be controlled by the input current. Magnetic abrasive finishing has been able to give good surface and edge finishing by means of a flexible magnetic abrasive brush formed in magnetic field. A small amount of material is removed by producing a relative motion between the work surface and abrasive particles, so as to obtain a mirror like finished surface.

The method was originally introduced in the Soviet Union, with further fundamental research in various countries including Japan. Nowadays, the study of the magnetic field assisted finishing processes is being conducted at industrial levels around the world. [Mori 2003]

2 WORKING PRINCIPLE OF MAF

In the Magnetic Abrasive Finishing (MAF) process, the working gap between the workpiece and the magnet is filled with either bonded magnetic abrasive particles (BMAPs) or unbounded magnetic abrasive particles (UMAPs) and form a flexible magnetic abrasive brush (FMAB) between the workpiece and the magnetic pole along the magnetic lines of force. The active magnetic particles trapped between the FMAB and workpiece originate the micro indentation into the work surface. It results in the removal of material due to the relative motion between FMAB and workpiece as shown in Fig-1.

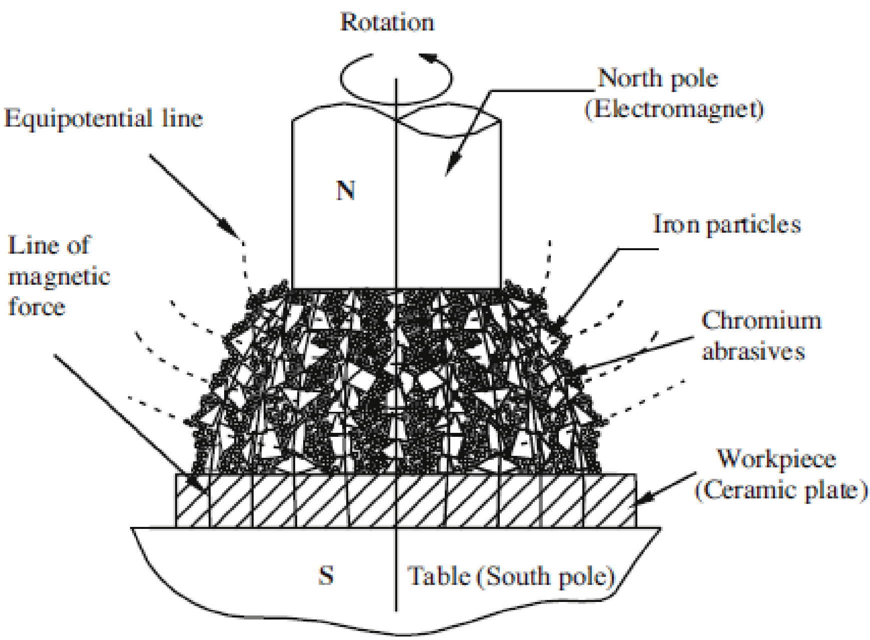

Figure-1 Schematic diagram of MAF showing finishing using magnetic particles

The magnetic abrasive particles (MAP) join each other which are composed of ferromagnetic particles and abrasive powder. MAPs can be used as bonded or unbonded. Bonded MAPs are prepared by sintering of ferromagnetic particles and abrasive particles where as unbonded MAPs are mechanical mixture of ferromagnetic particles and abrasive particles with a small amount of lubricant .The purpose of lubricant is to provide some holding strength between the constituents of MAPs. MAPs of unbonded type are considered in the present work due to their excellent finishing effects. This brush behaves like a multi-point cutting tool for finishing operation. When the magnetic N-pole is rotating, the MAFB also rotates like as a flexible grinding wheel and finishing is done according to the forces acting on the abrasive particles by the magnetic lines of force. It is usually assumed that there is no slip between the N-pole and MAFB.

3 PRODUCTIVITY ENHANCEMENT TECHNIQUES

Literature survey indicates that limited efforts have hitherto been directed towards improving the efficiency of MAF Process to achieve higher material removal rates and better quality surface by applying different techniques. Some of the contributions given by researchers are mentioned below:

An ultrasonically energized magnetic abrasive finishing process, suitable for high-precision finishing for 3-dimentional curve surfaces of micro components. It is a combination of two non-conventional finishing processes of MAF and ultrasonic machining. It increases the material removal rate but a little rougher surface than conventional MAF process. Vertical vibration-assisted magnetic abrasive finishing process is a better process for removing the micro-burr of magnesium alloys could be removed easily in a short time by the use of conventional MAF process [Shaohui Yins 2004].

Electrochemical magnetic abrasive finishing process is the hybrid machining process of electrochemical and magnetic abrasive finishing process that improves the material removal rate (MRR) and reduces surface roughness than conventional magnetic abrasive finishing process on 6061 Al/Al_2O_3 composite [Taweel T.A. 2007].

In spite of the development of above hybrid techniques, they are not being commercially exploited. One reason could be the cumbersome requirements of the process.

4 MAGNETIC ABRASIVE FINISHING PROCESS (MAF)

In the present study of plane surface, MAF process experimental setup was designed and fabricated with keeping in mind, the fundamental requirements of the process. The fundamental requirements of the experimental setup are Machine Frame, Magnetization unit, Magnet rotary motion unit and Workpiece rotary unit (Main parts of the unit are DC Motor (0 to 30Volt), Variable DC supply (0 to 30V, 0 to 5A) and Gear-pinion arrangement) as shown in the fig 1.

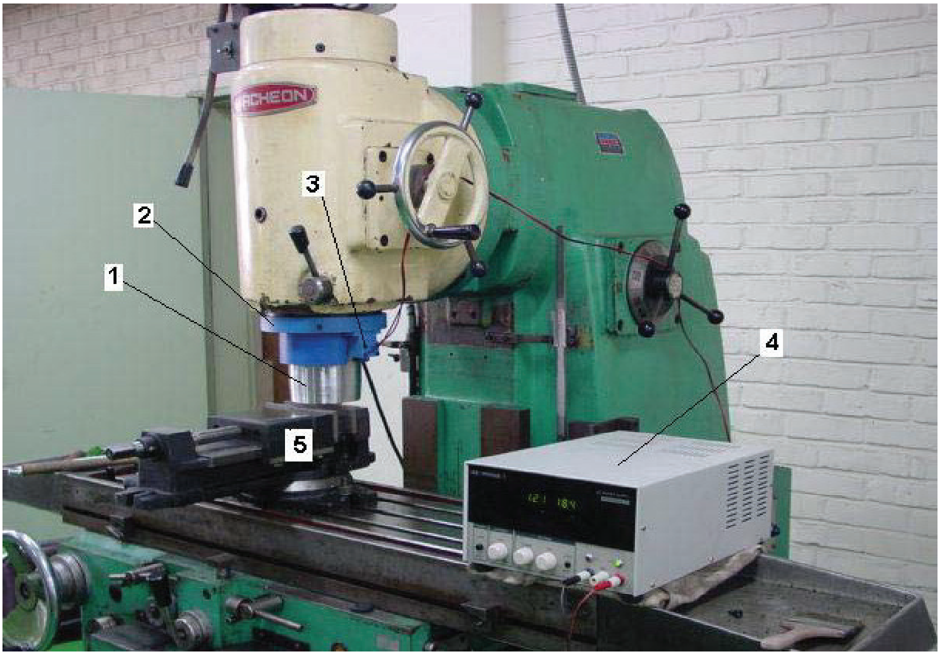

Fig-2 Photograph of MAF Assembly. Machine frame of vertical milling machine is used for the MAF setup. 1. Electromagnet, 2. Rotary attachment 3. Electrode fasteners ,4. Osiloscope, 5. Workpiece.

This arrangement provides the rotation motion to flat workpiece in the opposite direction to the electromagnet. It enhances the surface finish and the material removal from the workpiece by increasing the contact number of active MAP with the workpiece and enhances the productivity of MAF process. This process termed as Rotated workpiece Magnetic Abrasive finishing process (MAF). The size of the work piece should always be slightly greater than the diameter of the FMAB diameter because in this case there will be no chance of breaking of flexible brush during finishing.

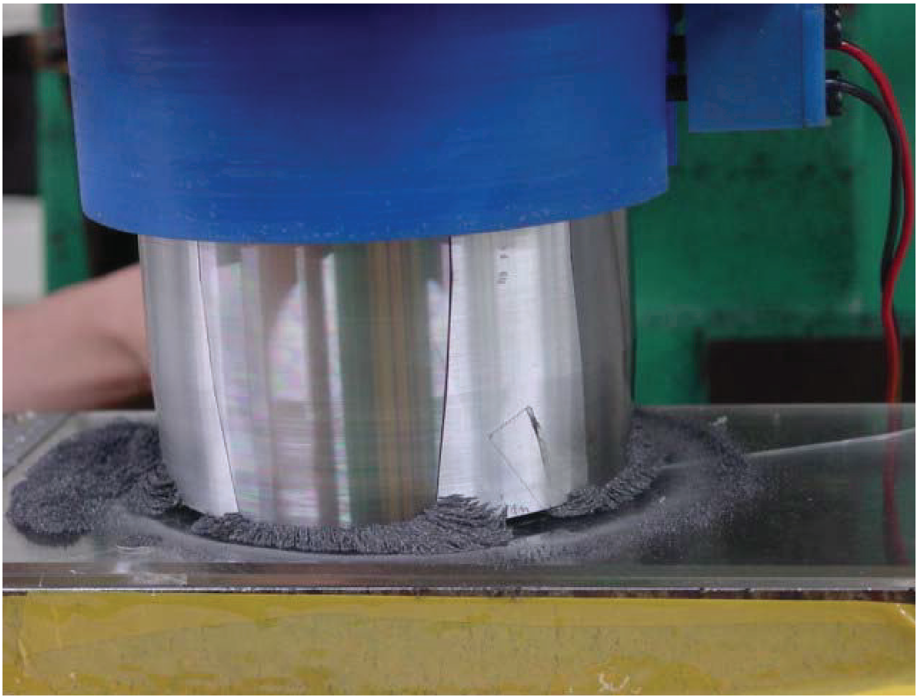

Fig 3, Finishing process by MAF

5 MAF PROCESS PARAMETERS

The optimum level of MAF parameters were determined in order to obtain better quality of surface produced. Based on the literature survey and the brain storming session, process variables for the MAF were grouped in the following three categories are:

A. **Machine based parameters:** Flux density/current supplied to the magnet, Rotational Speed of workpiece, Rotational Speed of Electromagnet and Percent composition of iron in MAPs.
B. **MAP based parameters:** Type and size of abrasive particles used in MAP, percentage composition of iron particles and abrasive particles in MAP, Size of iron particles used in the MAP and amount of oil added to MAP as a bonding agent.
C. **Workpiece and Fixture based Parameters:** Initial surface roughness of the work piece, property of work material, rotational speed of electromagnet, percentage of iron particles on surface finish are in under consideration in this research.

The Ishikawa cause and effect diagram illustrating the possible of process parameters on the surface quality is shown in the fig 3. All the above parameters have their direct effect on the surface quality produced by MAF.

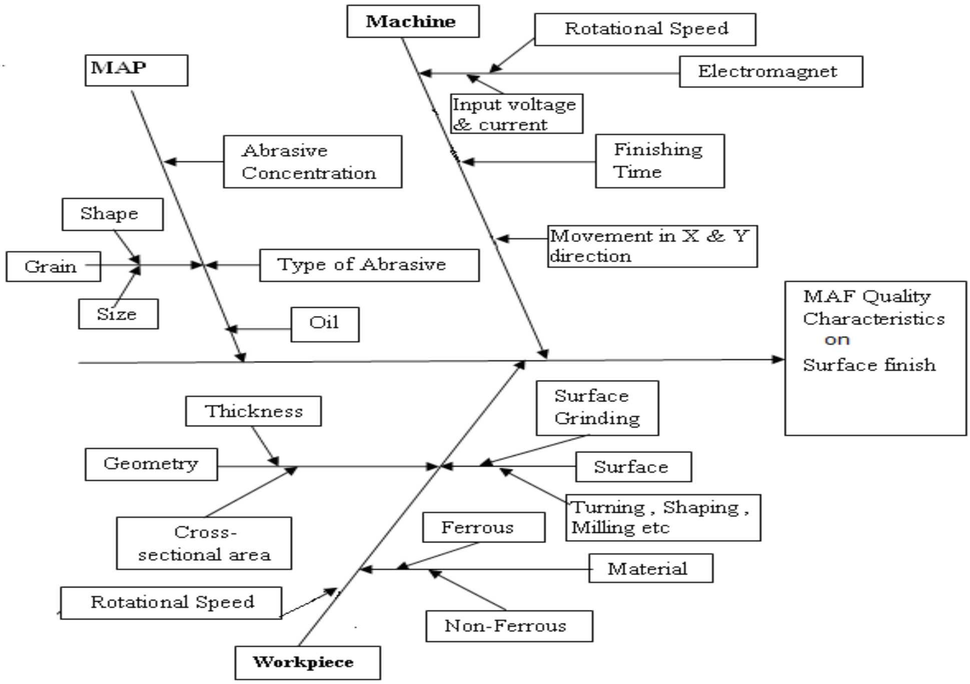

Fig. 3 Ishikawa Diagram for machining Parameters

TABLE II Matching Parameters and Their level

Machining parameters	Levels		
	L-1	L-2	L-3
Mesh size of the abrasive particle (M)	50	175	300
Current (amp) (I)	0.3	0.6	0.9
Percent composition of iron in MAPs (Fe)	60%	70%	80%

The flat surface of the work pieces was finished by MAF at different rotational speeds of work piece. Each work piece was machined for a predetermined number of cycles. Only those specimens whose initial surface roughness of the hole was in a quite narrow range were selected for the experiments so as to avoid any extrageneous effect on the response parameters. Before and after processing a test specimen the surface roughness (*Ra*) was measured at different random locations on the flat surface of workpiece using a Talysurf. The average of Ra values was calculated and the percentage decrease in roughness (ΔRa) was estimated as follows:

ΔR_a = (Initial roughness – final roughness after finishing) x 100 / Initial roughness

6 Results and Discussion

During the experimentation, it is found that the mesh size of abrasive particle have the major role on improving the response parameters (Surface Roughness and Material Removal) in the MAF process on the ferromagnetic stainless steel due to increasing the active no of particles in the finishing process.

In the first set of study, the following process parameters are chosen: parameters are type of abrasive (SiC), size of iron powder (300 mesh), percentage of iron powder (65%), percentage of bonding oil (3%), working gap (4mm), RPM of electromagnet (56), power supply to electromagnet (18V, 0.75A), and finishing time (15 min.). Variable parameter was mesh size of abrasive particle for study the effect on percentage improvement in Surface Roughness of work surface.

It has been observed that maximum percentage improvement in surface roughness by removing the minimum material removal at mesh size of 300 as shown in the figure 4.

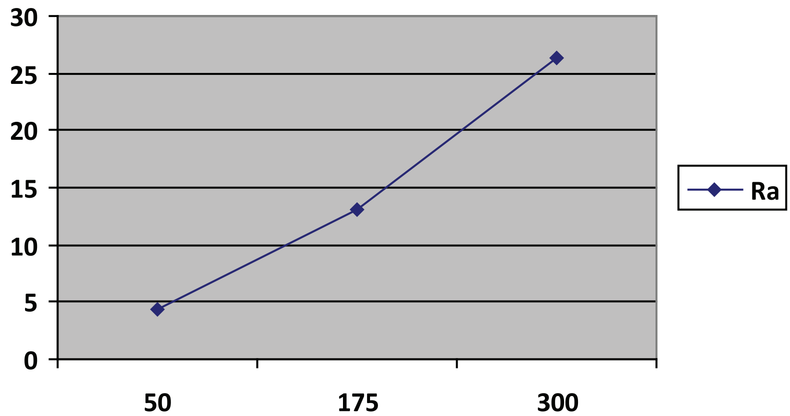

Figure 4. Effect of Mesh size on %age ΔR_a

In the second set of experiment, the effect of current on surface roughness by reducing the working gap and other parameters remains same.

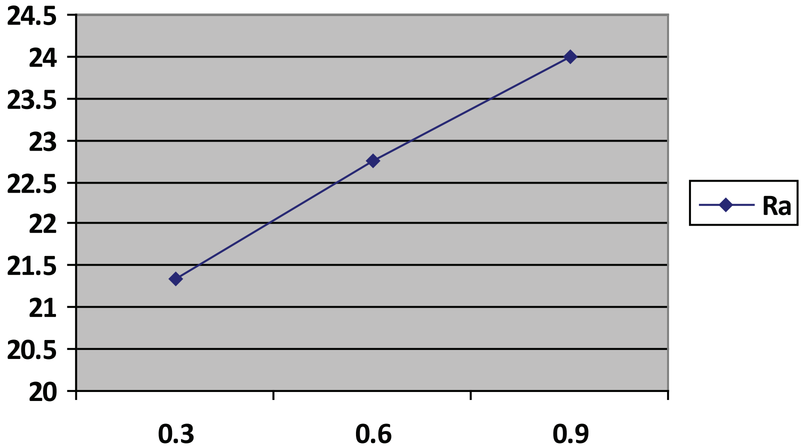

Figure 5. Effect of current on %age ΔR_a

The observations has been taken at 3mm working gap, it has been found that maximum percentage improvement in surface roughness and the value of material removal increases by increasing the current and found that the best values of Ra at the current as shown in the figure 5.

In the third set of experimental work, the effect of % Composition of Iron on percentage improvement in surface roughness and material removal at 3mm working gap, and other parameters remains same. It has been found that maximum percentage improvement in surface roughness at 80 % composition of Iron particle of electromagnet as shown in the figure 6.

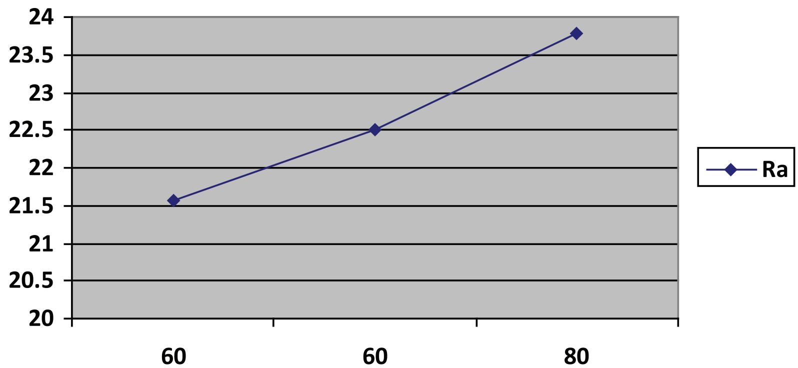

Figure 6. Effect of % Composition of Iron on % change ΔR_a

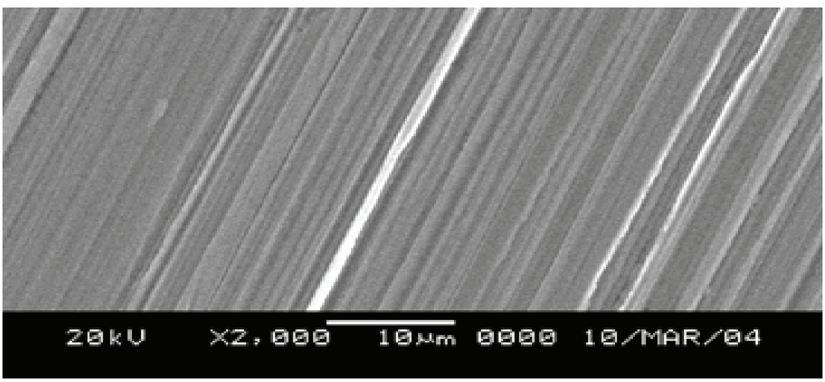

Fig.7 before finishing

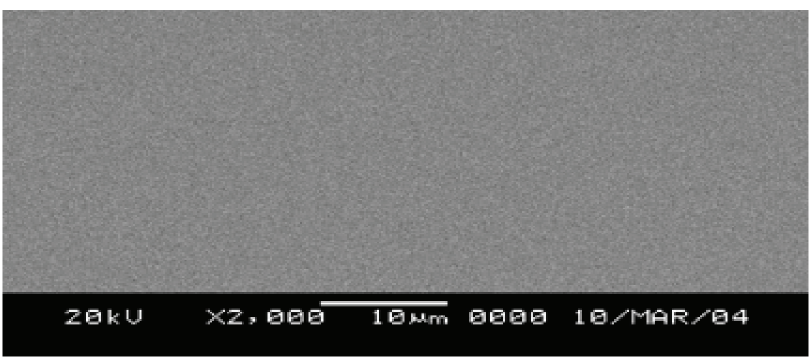

Fig 8 after finishing

Figure 7 and 8 shows the flat surface of work piece before and after machining. The surface is improved after MAF process and this finishing process if highly recommended for industrial application.

7 Conclusions

The following conclusions can be drawn from the study:

1. Surface roughness value of 275 nm has been achieved. This shows the capability of this process to get nano-finish on the work piece.
2. Mesh size and percentage composition of iron particles, both are most significant factor for ferromagnetic work piece material.
3. The percentage improvement in surface roughness value increases as the Mesh size and percentage composition of iron particles increases.
4. Working gap is also the most significant factor for ferromagnetic work piece material.
5. Percentage improvement in surface roughness and material removal increases as the working gap reduces but it starts decreasing after a certain limit.

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Identity Crisis: A Study of Anita Desai's Voices In The City and Where Shall We Go This Summer?

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Abstract
Post 1980s is acclaimed unanimously a post modern era. In this era, Identity Crisis is a social reality which is truly depicted in Indian English Fiction post 1980s.It is one of the prominent existential predicaments faced by modern man. The age is full of conflicts and in the complicated situations of life, there is a lot of difference between aspiring for something and to achieve that very thing what one had aspired for and this enhances the feeling of nothingness in man. Various Indian writers have exhibited this social dilemma in their literary pieces. Anita Desai is the prominent Indian writers who have clearly depicted this psychological dilemma through various themes, for e.g. Sita in Where Shall We Go This Summer?, Monisha in Voices in the City by Anita Desai.

Introduction

Identity Crises is the main existential problem faced by the people in our post- modern contemporary era. Life has become very fast and people find their life time very short to achieve their goals. So everybody finds himself in hurry to run the race of life. At a point in life, man finds himself lost in the confusions of the world. He faces identity problems. He loses the sense of understanding; meaningless questions arise in his mind as why is he in this world? and what is he doing here? and so on. Various contemporary writers have beautifully portrayed in their creative works the life picture of various characters in their respective identity problems. I have taken up two novels for my study: Voices in the City and Where Shall We Go This Summer? by Anita Desai, an eminent contemporary author of Indian English Fiction. She has deliberately presented the contemporary social realities in all her novels with the help of the life story of her characters.

Voices in the city

Voices in the City is a story of three middle class intellectuals of Calcutta. This is an unforgettable story of a Bohemian brother and his two sisters caught in the countercurrents of changing social values. Nirode, a journalist, settles down in Calcutta and becomes absorbed into its bohemian life. His sister Monisha is got married in Calcutta against her wish. The novel unfolds an individual's fight against the self and the consequent defeat of the individual. Nirode is a rootless nihilist around whom whole of the novel is woven. He does not have any definite goal in life and is obsessed strongly by failure. He is an anonymous clerk in a newspaper but calls himself a journalist. He, an aimless wanderer,

wants to achieve success and fame. He talks about the artists, caves of Ajanta-Ellora, and Elephanta and longs for such fame for writers also. He struggles for his identity in a metro city Calcutta. There is emptiness in his life. He admits it to David:
'I want it to fail- quickly. Then I want to see if I have the sprit to start moving again towards my next failure. I want to move from failure to failure to failure, step by step to rock bottom. I want to explore that depth. When you climb a ladder, all you find at the top is space; all you can do is leap of- fall to the bottom. I want to get there without that meaningless climbing. I want to descend, quickly.' (p.40, Voices in the City)

Nirode, being an existential character, suffers from identity crises. He experiments with life and failures and tries to seek meaning of life and in the end after Monisha's suicide he gets nothing in his search except a mere realization. On the contrary, Monisha is a submissive person. She has a vacuum both inside and outside. There is loneliness and in communication in her married life. Her life becomes worse when the news of her infertility comes before the family. She remains confined in the four walls of her room. Total detachment from outside life fills her with agony. She suffers from identity problems. Lack of communication with her husband, absence of love and understanding in her married life, her loneliness, her infertility, her confinement behind the bars torture her mentally. She finds no escape from her problems. Her submissive and introvert nature drives her to suicide as the only solution of her identity problems. She expresses it in these lines:

If I had religious faith, I could easily enough renounce all this. But I have no faith, no alternative to my confused despair, there is nothing I can give myself to, and so I must stay. The family here and there surrounding, tell me such a life can not be lived- a life dedicated to nothing- that this husk is a protection from death. Ah, yes, yes then it is a choice between death and mean existence, and that, surely is a difficult choice. (p.121, Voices in the City)

Where Shall We Go This Summer?

Another novel Where Shall We Go This Summer? is a psychological study of the protagonist Sita. She lives in Bombay city with her husband and four children. She was born and brought up in the tranquil environment of Manory Island. But after her marriage she has to stay in Bombay with her husband. She is an oppressed mind. Life in Bombay is busy and full of humdrum that disturbs and irritates her. She feels reminiscence about the tranquil life that she lived in her patriarchal home. Her problem of identity crises exaggerates due to maladjustment with her husband. She is fed up with her businessman husband who is completely ignorant about her feelings and that brings her on the verge of insanity. At a deeper level Sita's quest for identity is the result of husband-wife conflict. The home life and surrounding atmosphere is nauseating her. She always feels to escape from her present situations to some lonely place. The news of her pregnancy with her fifth child exaggerates her problem. She wants to escape from this pregnancy also and takes an absurd decision. She decides to escape to her patriarchal home on Manori Island. She feels that the magical spell of the tranquil place will help her not to deliver the child and she will always remain pregnant. She saw that island illusion as a refuse:

She had come here in order not to give birth….Wasn't this Manori, the island of miracles? Her father had made it an island of magic once, worked miracles of a kind. His legend was still there in this house…and he might work another miracle posthumously. She had come on a pilgrimage to beg for the miracle of keeping of her baby unborn. (p.31, Where shall we go this Summer?)

Her childhood and past life also bears the reason of her present disturbances and her insanity. Her mother's betrayal of her father, her father's affair with a mistress and her father's relationship with Sita's step sister are responsible for her neurosis and identity crises. Nothing changes in the end and she makes a compromise with her life for the sake of her children and returns back to Bombay.

Conclusion

Now a days, man has got success in leaps and bounds but simultaneously he has lost something. He has sacrificed personal relationships in lieu of it in the race of life. Changing cultural ideals has added fuel in the confusions of men. The dissatisfaction in personal life has exaggerated the identity problems. People do not get satisfied in their personal relations. This race of life is not going to get a stop and the identity crises as well as these two are interconnected. But we are human beings and we cannot let the things go like this. So we will continue our search of identity till we don't achieve it.

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Performance Analysis of Multiple Key having Variable Length in Multinode Network

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Abstract
Cryptography is a technique used to protect the data from an unauthorized access. Encryption algorithm and Key management are the two main parts of cryptography. Encryption is a process in which original data (plaintext) is converted into the encoded format (cipher text) with the help of a key. Key is used in the encryption algorithm and is composed of alphanumeric words. Multiple key having variable length have been used for encryption in Multinode Network. Performance of variable keys have also been analyzed using C++; it has been observed that time available with hackers to generate random attacks reduces significantly.

Key Words: Encryption, Multinode Network (MN), Keys, hacker.

Introduction

The strength of any model in MN network depends upon the key selection and replacement of faulty keys with new key [1,4]. In this exercise, key shifting time has a very important role; there are three main processes in the key shifting time operation; i) Key generation time, ii) key testing time and iii) key processing time. The key shifting is optimized by initiating the generation of the 2nd key operation when the failure rate of 1st key increases beyond 17% [3,8]. The testing of newly generated key (inspection of key strength) has been carried simultaneously with the encryption process carried out by 1st key. Whenever the failure rate of 1st key crosses 43% then key replacement operation starts. In multinode network the failure rate of keys has been calculated on the basis of S-Boxes, key length, data length and number of nodes [5-7]. S. Zhong (2002) proposed a practical key management scheme for access control in a user hierarchy. The scheme allowed the users of each security class to derive the keys from their subordinating classes [9]. Their scheme was focused on the key selection; not on the key generation from the lower classes. H. Huang et. al. (2008) presented a generalized public key cryptosystem based upon a new Diffie Hellman problem. The main limitation of the work was that the scheme was based upon one way key exchange protocols [2]. Although the Group Diffie-Hellman (GDH) approach had efficient protocols for group communication but it required member serialization. From the literature survey, it has been observed that multiple keys having different failure rates can be achieved by varying the key length. They are always preferred for encrypting the data in MN having large number of nodes. Multiple keys have different failure rates due to presence of different key length, keys may be of different order and different polynomials may be used for the encryption [10-

12]. Simulation results of a MN having eight and sixteen S-Boxes used for encryption of the data with multiple keys having same length have also been verified on DSP Kit (TMS 320 ADP6713). It helps the users to encrypt the data by keeping an eye on processing and hacking time. The processing and hacking times for the various combinations of data and key length designed by S-Boxes (8 and 16) have been evaluated and their observations are given in the following section.

Simulation Results for Processing and Hacking Time for Variable Key Lengths

The simulation results for processing and hacking time for different input data streams when encrypted by multiple keys of variable length in a MN have been carried out in this section. The multiple keys of variable length provide an option to the user to decrypt the data in MN; the keys of variable length have been used to provide more secured system. For different nodes having eight and sixteen S-Boxes used to encrypt the data with multiple keys having same length have been considered in this section.

Case –I: For Nodes=5, S-Boxes= 8, 1st key length= 8-16 bits, 2nd key length= 8-16 bits

S. No.	Data Length (Bits)	Processing time (ns)	Hacking Time (min)
1.	16	28.21	70.23
2.	32	22.24	48.28
3.	64	22.95	49.63
4.	128	23.44	53.06
5.	512	24.10	54.84

Table 1: Processing and Hacking time for 16, 32, 64, 128 and 512 data length by using multiple keys having variable key length for 1st and 2nd respectively designed with 8 S-Boxes

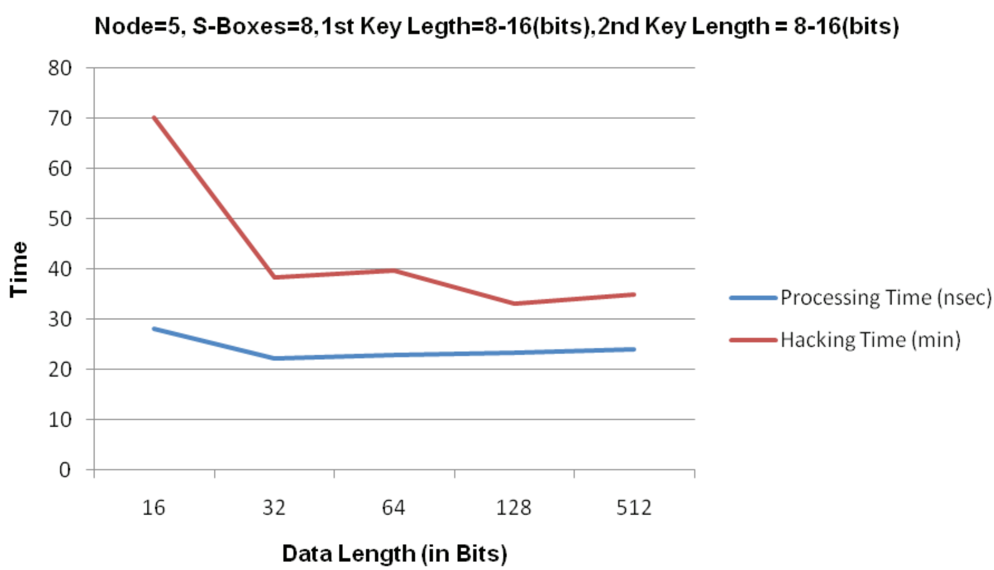

Figure 1: Processing and Hacking time Vs Data length for Node=5, S-Boxes=8 having multiple keys of variable lengths (8 to 16 bits for both 1st and 2nd key)

It has been observed that the multiple keys having variable length has provided less hacking time e.g. for 5 nodes; the hacking time of 59.65 minutes has been achieved when multiple keys of fixed length (8 bits) have been used. The hacking time is further reduced to 48.28 minutes for the same data length if multiple keys of variable length are used. There has been an increase in the processing time from 7.99 ns to 22.24 ns due to increase in number of nodes in MN.

Case –II: For Nodes=5, S-Boxes= 8, 1st key length= 8-16 bits, 2nd key length= 16-32 bits

S. No.	Data Length (Bits)	Processing time (ns)	Hacking Time (min)
1.	16	29.38	70.61
2.	32	25.21	49.92
3.	64	25.62	49.98
4.	128	26.32	54.12
5.	512	27.19	55.28

Table 2: Processing and Hacking time for 16, 32, 64, 128 and 512 data length by using multiple keys having variable key length for 1st and 2nd respectively designed with 8 S-Boxes

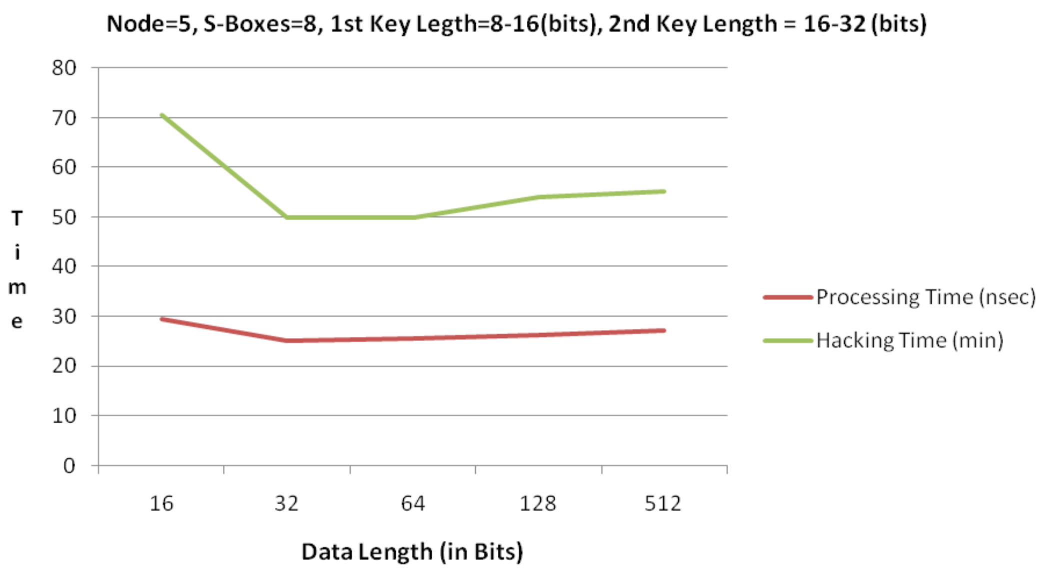

Figure 2: Processing and Hacking time Vs Data length for Node=5, S-Boxes=8 having multiple keys of variable lengths (8 to 16 bits for 1st and 16 to 32 bits for 2nd key)

It has been observed from the table 5.19 and figure 5.20 that this configuration is not suitable because both the number of users and the number of nodes are increased which allows an easy access to hackers. The hacking time for the data bits ranges from 16-512 has been increased due to additional iterations performed by eight S-Boxes in order to generate the 2nd key. If these iterations are performed for the 1st key instead of 2nd key, more reliable results can be obtained.

Case –III: For Nodes=5, S-Boxes= 8, 1st key length= 16-32 bits, 2nd key length= 8-16 bits

S. No.	Data Length (Bits)	Processing time (ns)	Hacking Time (min)
1.	16	29.14	71.19
2.	32	25.92	36.51
3.	64	25.98	38.19
4.	128	26.28	41.29
5.	512	27.16	42.61

Table 3: Processing and Hacking time for 16, 32, 64, 128 and 512 data length by using multiple key having variable key length for 1st and 2nd respectively designed with 8 S-Boxes

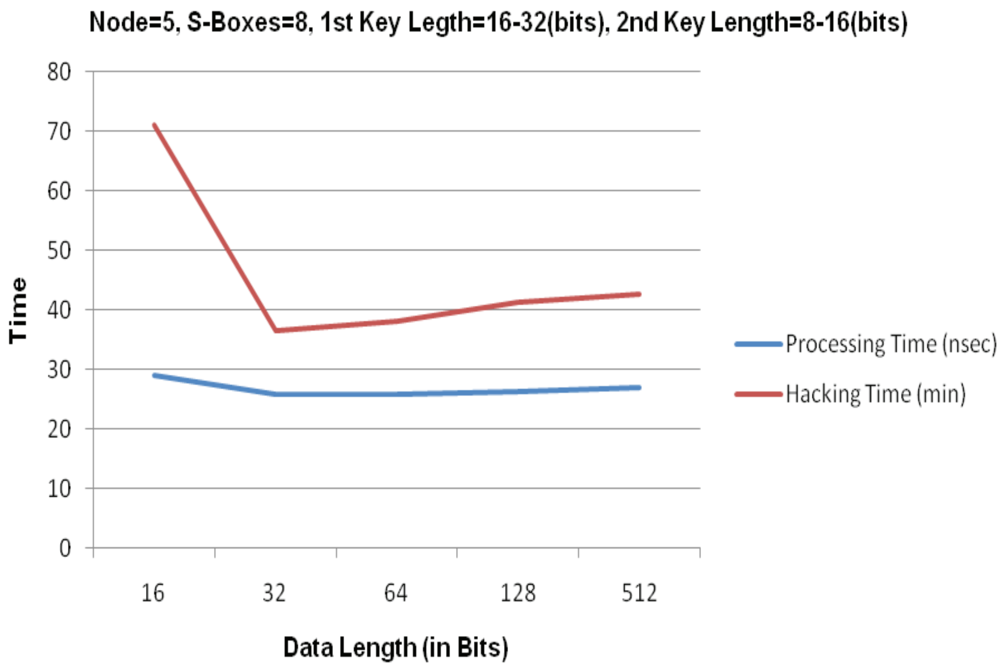

Figure 3: Processing and Hacking time Vs Data length for Node=5, S-Boxes=8 having multiple keys of variable lengths (16 to 32 bits for 1st and 8 to 16 bits for 2nd key)

From the table 5.20 and figure 5.21, it has been observed that the hacking time reduces for the different input data streams due to the presence of multiple keys. Both the keys have been designed with the help of 8 S-Boxes, 1st keys undergoes 16 iterations controlled by round functions. Hence, slight increase in the processing time has been observed. The processing time for the 1st key is large as compared to 2nd key due to the use of 8 S-Boxes. The initial response of the model has been very good due to the use of long 1st key length; the 2nd key plays its part whenever the 1st key fails. 2nd is of 8 to 16 bits; therefore, there has been slight decrease in the security level. The model offers a variety of arithmetic and logical operations ranges from 1 to 16 in the generation process of 1st key. The number of these functions is reduced from 1 to 8 in the case of 2nd key generation process. The sequence only provides reliable results whenever data length is in the range of 1-32 bits. Slight increase in the processing time may result in the congestion whenever multiple data streams can be processed at a time.

Case –IV: For Nodes=5, S-Boxes= 8, 1st key length= 16-32 bits, 2nd key length= 16-32 bits

S. No.	Data Length (Bits)	Processing time (ns)	Hacking Time (min)
1.	16	50.17	71.56
2.	32	36.14	8.23
3.	64	37.24	**9.62**
4.	128	47.14	10.21
5.	512	49.92	12.18

Table 4: Processing and Hacking time for 16, 32, 64, 128 and 512 data length by using multiple keys having variable key length for both 1st and 2nd respectively designed with 8 S-Boxes

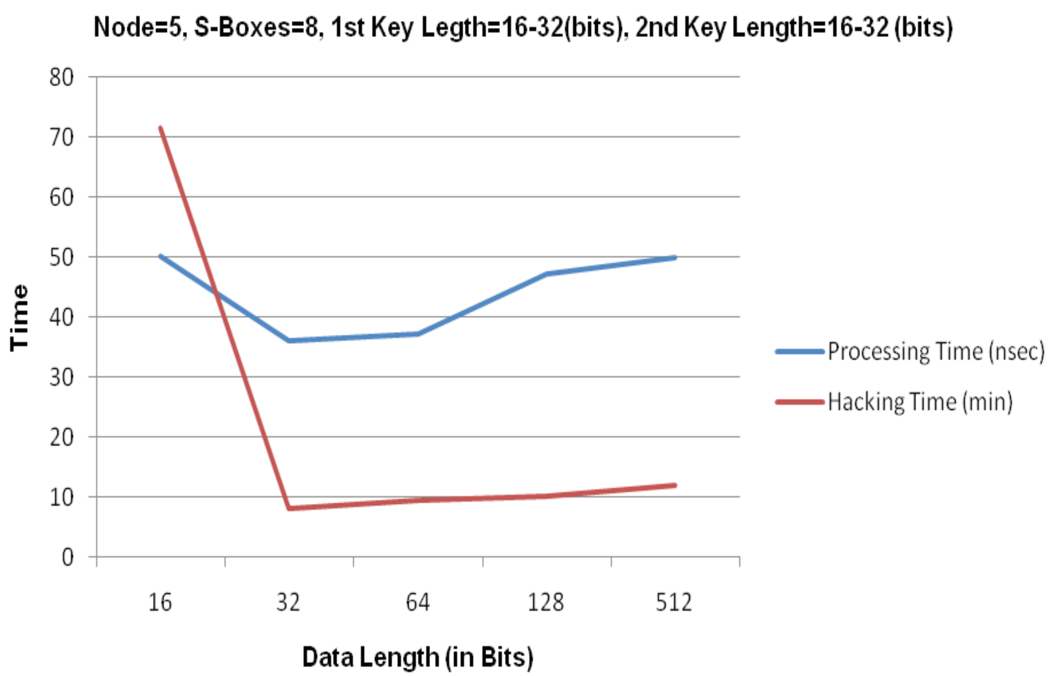

Figure 4: Processing and Hacking time Vs Data length for Node=5, S-Boxes=8 having multiple keys of variable lengths (8 to 16 bits for 1st and 16 to 32 bits for 2nd key)

It is clear from figure 5 that for a MN having less number of nodes (1-5), this configuration has been preferred as it provides very less time to hackers. For 64 bits, multiple keys having length 8 to 16 bits have been used to protect the data. Both the keys have been formed by the help of 8 S-Boxes. Eight S-Boxes have performed 16 iterations for the generation of keys. Encryption algorithm has less number of operations; therefore, parallel processing has not been performed and system has taken more processing time. Hacking time can be further reduced by employing more number of round functions which are controlled by S-Boxes. At this point, it is also required to increase the number of S-Boxes.

Case –V: For Nodes=5, S-Boxes= 16, 1st key length= 8-16 bits, 2nd key length= 8-16 bits

S. No.	Data Length (Bits)	Processing time (ns)	Hacking Time (min)
1.	16	51.18	72.95
2.	32	38.62	9.18
3.	64	39.43	9.95
4.	128	48.18	10.55
5.	512	50.92	12.82

Table 5: Processing and Hacking time for 16, 32, 64, 128 and 512 data length by using multiple keys having variable key length for both 1st and 2nd respectively designed with 16 S-Boxes

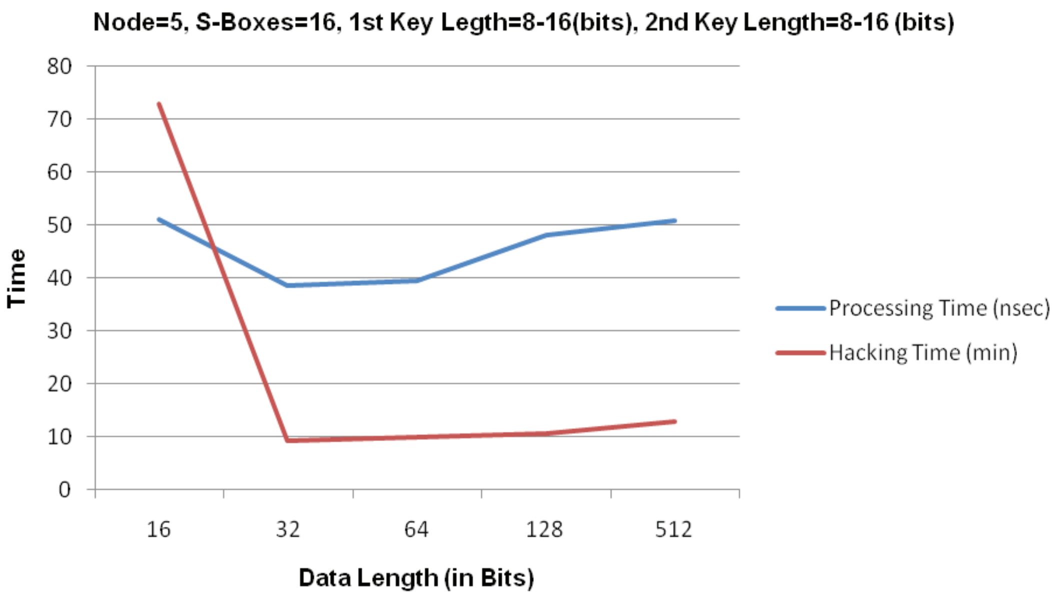

Figure 5: Processing and Hacking time Vs Data length for Node=5, S-Boxes=16 having multiple keys of variable lengths (8 to 16 bits for both the keys)

Figure 6 indicates that the use of 16 S-Boxes has provided more number of round functions which have been used to generate the multiple keys. It has reduced the hacking time from 48.28 (see table 5.18) to 9.18 minutes for 32 bit data sequence with slight increase in processing time (16.38ns). Encryption model still offers smooth and reliable results even if the data bits have further been increased from 32 to 64 bits. The hacking time has been increased from 9.18 to 9.95 minutes which is not significant. It suggests that the cryptographic model has not much been affected by the change in data length.

Case –VI: For Nodes=5, S-Boxes= 16, 1st key length= 8-16 bits, 2nd key length= 16-32 bits

S. No.	Data Length (Bits)	Processing time (ns)	Hacking Time (min)
1.	16	52.16	73.16
2.	32	39.92	9.92
3.	64	40.99	10.12
4.	128	49.82	10.87
5.	512	51.74	14.19

Table 6: Processing and Hacking time for 16, 32, 64, 128 and 512 data length by using multiple keys having variable key length for 1st and 2nd respectively designed with 16 S-Boxes

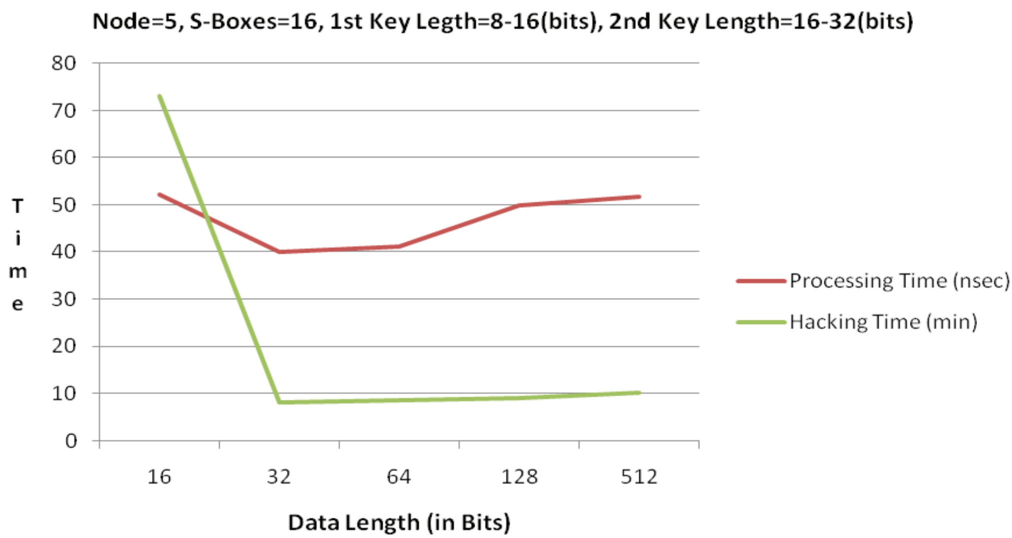

Figure 6: Processing and Hacking time Vs Data length for Node=5, S-Boxes=16 having multiple keys of variable lengths (8 to 16 bits for 1st and 16 to 32 bits for 2nd key)

In the Case-VI, the increase in the hacking time has been observed due to the use of 1st key shorter than 2nd key in length. Overheads have been slightly increased as compared to Case V due to increase in round functions used for 2nd key. The scheme has provided reliable results for the encryption of 1-128 bit data stream. If data length is further increased, hacking time increases from 10.87 to 14.19 minutes. Although net increase is 3.32 minutes but in terms of percentage the increase is 23.39% which is quite significant in MN.

Case–VII: For Nodes=5, S-Boxes= 16, 1st key length= 16-32 bits, 2nd key length= 8-16 bits

S. No.	Data Length (Bits)	Processing time (ns)	Hacking Time (min)
1.	16	52.16	73.15
2.	32	39.92	8.14
3.	64	40.96	8.56
4.	128	49.82	9.12
5.	512	51.77	10.11

Table 7: Processing and Hacking time for 16, 32, 64, 128 and 512 data length by using multiple keys having variable key length for both 1st and 2nd respectively designed with 16 S-Boxes

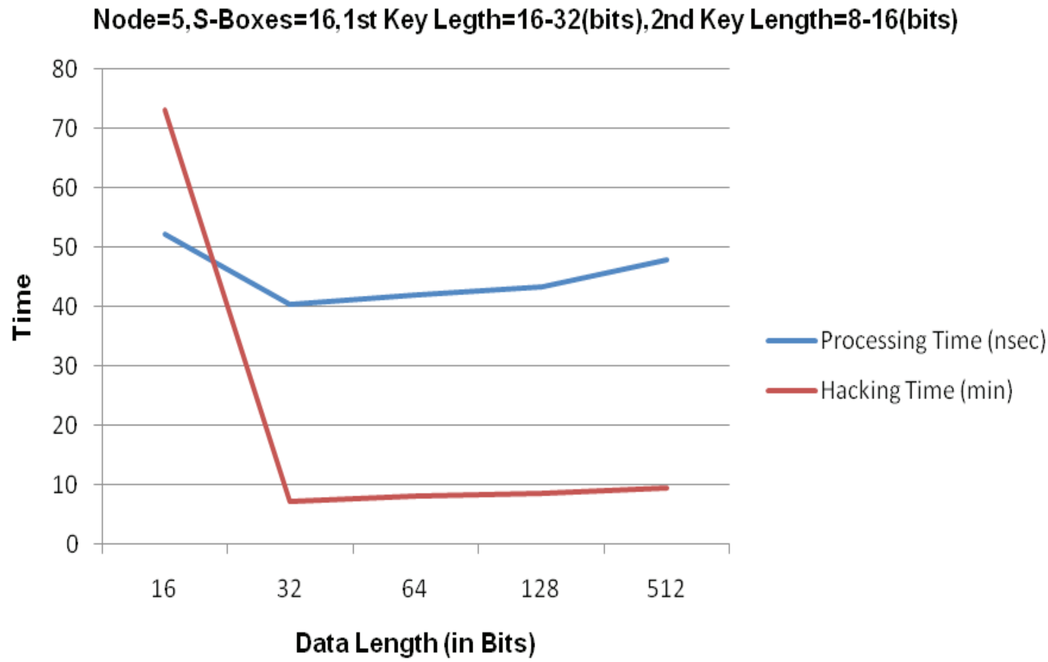

Figure 7: Processing and Hacking time Vs Data length for Node=30, S-Boxes=16 having multiple keys of variable lengths (16 to 32 bits for 1st and 8 to 16 bits for 2nd key)

From the Case-VII, it has been observed that the hacking time is very large in the initial phase 73.15 minutes due to set up time. As soon as the encryption algorithm has started its operation the hacking time has been reduced to nearly 11 minutes for the data sequences ranges from 1-512 bits. The increase in the processing time has been observed due to the use of 16 S-Boxes.

Case –VIII: For Nodes=5, S-Boxes= 16, 1st key length= 16-32 bits, 2nd key length= 16-32 bits

S. No.	Data Length (Bits)	Processing time (ns)	Hacking Time (min)
1.	16	52.16	73.15
2.	32	40.33	7.13
3.	64	41.94	7.97
4.	128	43.19	8.43
5.	512	47.83	9.39

Table 8: Processing and Hacking time for 16, 32, 64, 128 and 512 data length by using multiple keys having variable key length for both 1st and 2nd respectively designed with 16 S-Boxes

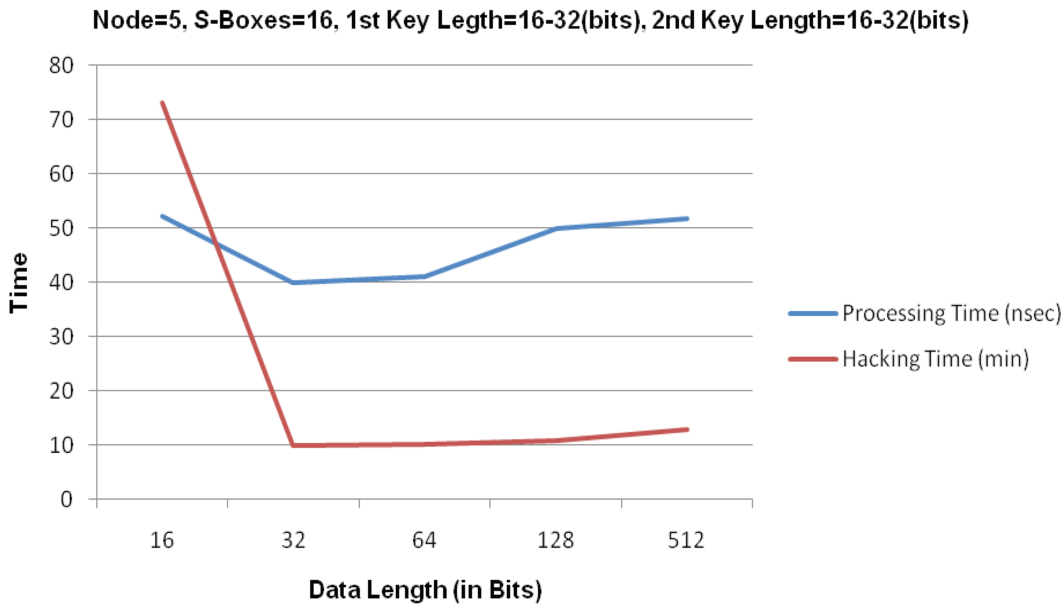

Figure 8: Processing and Hacking time Vs Data length for Node=5, S-Boxes=16 having multiple keys of variable lengths (16 to 32 bits for both keys)

Conclusion and future Scope

Multiple keys of fixed lengths are good for short data sequences and have only provided secured results in small MN. As the data sequences size increases, the security level decreases, therefore, the model requires multiple keys of variable length. The long data sequences are required for multiple key structures especially in large MN in order to achieve secured transmission. The hacking time has been increased with increase in data length and number of nodes; the secured level has been achieved by using more round functions generated by S-Boxes. The work can be extended by incorporating more number of S-Boxes which will lead to more secured and optimized cryptographic model.

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Process Capability Evaluation by Overall Equipment Effectiveness (OEE) and GR&R Method for Medium Scale Industry

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ABSTRACT

The present research work is done in a medium scale industry to enhance productivity, calculate the overall equipment effectiveness (OEE) and to analyze the current status of overall equipment effectiveness (OEE) on manufacturing cells and assesses current performance of the assembly line and identify the major opportunities for improvement in the short term.Company is manufacturing plastic moulded and plated parts for the major OEM automobile companies. The cycle time and manufacturing method for all the machines and manufacturing/assembly lines and material flow in the plant are recorded. Time and Motion study and Method study was also done on different machines. OEE is calculated for all machines and manufacturing lines and also the bottleneck areas are find out to improve OEE. Suggestions are also given to company to minimize material handling on machine and also in between different departments which will improve quality of the product as well as OEE of the manufacturing lines.

KEYWORDS: *OEM automobile companies, Overall equipment effectiveness (OEE), Time and Motion study, material handling, Quality.*

1 INTRODUCTION

In this evolutionary world the global economy has expanded the base of competition for all business. Every organization is focusing on more sales and increased profit. In order to survive (for an organization) in this competitive world, it is necessary to meet customer's expectations. So the total elimination of waste is necessary for the survival of the organization. The waste generated due to the failure or shutdown of facilities or the waste such as defective products, should be completely eliminated [1,2].In the manufacturing industry, the utilization of installed capacity is rather low for various reasons. According to Ahlmann the overall utilization of installed capacity is around 60 per cent in a number of Swedish industries.

Huang et al. [3] also state that due to intense global competition, companies are continuously trying to improve and optimize their productivity in order to remain competitive. This would be possible if the production losses were identified and eliminated so that the manufacturers could bring their products to the market at a minimum cost. This situation has led to a need for a rigorously defined performance measurement system that is able to take into account different important elements of productivity in a manufacturing process.The industrial application of OEE varies from one industry to another but the basic concept of measuring effectiveness is derived from the original OEE concept. OEE can be best illustrated by the six metrics that comprise the system. The hierarchy consists of two top-level measures and four underlying measures.

In this present research, Process capability of medium scale industry is evaluated by the use of OEE data and by using GR&R method.Product design complexity and operator skill also influence the OEE, to find the effect of these parameter and to use them in OEE metrics is still a challenge.

2 LITERATURE REVIEW

Fleischer et al. [4] stated that the competitiveness of manufacturing companies depends on the availability and productivity of their production facilities. In a manufacturing scenario, the desirable productivity, cost, inventory, quality and delivery all depend on the efficient functioning of the company's facilities.According to **Jonsson and Lesshammar [5]**, the OEE tool is designed to identify losses that reduce the equipment effectiveness. These losses are due to manufacturing disturbances that are either chronic or sporadic. Chronic disturbances are small and hidden, and are a result of several concurrent causes. Sporadic disturbances on the other hand are more obvious since they occur quickly and have large deviations from the normal state. It is a bottom-up approach to eliminate six large losses stated by Nakajima in 1988).**Huang et al. [6]** stated that although the OEE tool has become increasingly popular and has been widely used as a quantitative tool essential for measurement of productivity, it is only limited to productivity behavior of individual equipments. **Scott and Pisa [7]** pointed out that the gains made in OEE, while important and ongoing, are insufficient. It is necessary to focus one's attention beyond the performance of individual tools towards the performance of the whole factory. The ultimate objective is a highly efficient integrated system, not brilliant individual tools. The authors coined the term overall factory effectiveness (OFE), which is about combining activities and relationships between different machines and processes, and integrating information, decisions, and actions across many independent systems and subsystems.

Gauge Repeatability and Reproducibility (GR&R) is used to measure capability of a measurement system by comparing it to the total variability. Repeatability is the variability of the measurements obtained by one person while measuring the same item repeatedly and is also referred to as equipment variation. Reproducibility is the variability of the measurement system caused by differences in operator skills. The commonly used method for calculating GR&R is the Range and Average method [8].

Here OEE matrices are used to assess the capability of a process by using the Range and Average method typically used for GR&R calculations. The current method used for measuring the process capability, like C_p/C_{pk}, lays large emphasis on the quality of the output (variation) when it is compared to the specification limits provided by the customer. This method does not include some vital process conditions such as downtime losses, adjustment times and setup parts, operator skill, part complexity and is focused completely on the output quality. As explained above, OEE data for a machine includes some of this information and if the two matrices are combined, it will result in broader definition of capability rather than just the ability to meet the specifications. The OEE data of the machine for a consecutive period of 8 weeks was used to assess the capability of the process consisting of the man, machine, method, material, measurement system and the environment. Three cases studies were completed at a plastic emblems manufacturing facility using large injection molding machines. The OEE data for consecutive 8 weeks was collected and analyzed for assessing the process capability.

3 OVERALL EQUIPMENT EFFECTIVENESS (OEE)

OEE quantifies how well a manufacturing unit performs relative to its designed capacity, during the periods when it is scheduled to run. OEE is a multiplication of availability (actual run time vs. scheduled time), speed rate (actual rate vs. ideal speed rate) and quality rate (good product vs. total product) and is given by equation (1.1).

OEE=Availability% ×Performance% ×Quality%……....eq. (1.1)

OEE metric is a multiplication of availability, speed rate and quality rate.

3.1 Availability

Availability is defined as the ratio between the total available time (uptime) and the scheduled production time. An availability of 85% implies that the equipment/process was actively producing product for 85% of the scheduled production time and for the remaining for 15% of scheduled production time the equipment/process was not available to produce (for example equipment failures, material shortages etc.). Availability can be calculated by using equation (1.3).

Availability%=TotalAvailableTime/ScheduledProducationTime%……..eq. (1.3)

3.2 Performance

Performance is defined as the ratio between the theoretical production time for the total product produced during available time (uptime) and the available time (uptime). A Performance of 90% implies a Speed Loss of 10%. Performance can be calculated by using equation (1.4).

Performance%=TheorticalProducationTime/AvailableTime%…….eq. (1.4)

3.3 Quality

Quality is defined as the ratio between the good units produced and the total Production. A Quality score of 95% implies a Yield Loss of 5% due to scrapping and/or reworking of product (this reworking consumes capacity in the equipment/process). Quality can be calculated by using equation (1.5).

Quality%=GoodUnitsProducs/TotalProducation%……..eq. (1.5)

3.4 SIX BIG LOSSES

One of the major goals of OEE programs is to reduce and/or eliminate the losses (which happened during manufacturing) and improve the efficiency of the manufacturing system. These losses are known as Six Big Losses in OEE. The following table lists the Six Big Losses, and shows how they relate to the OEE Loss categories.

Table 1.1: Six big losses of OEE [4]

Six Big Loss Category	OEE Loss Category	Examples
Equipment Breakdown	Down Time Loss	• Tooling Failures • Unplanned Maintenance • General Breakdowns • Equipment Failure
Setup & Adjustment Time	Down Time Loss	• Setup/Changeover • Material Shortages • Operator Shortages • Major Adjustments • Warm-Up Time
Minor Idling Losses	Speed Loss	• Obstructed Product Flow • Component Jams • Misfeeds • Sensor Blocked • Delivery Blocked
Cycle Time Losses	Speed Loss	• Under Design Capacity • Equipment Wear • Operator Inefficiency
Setup Parts Losses	Quality Loss	• Scrap • Rework • In-Process rejection • Assembly Rejection
Nonconformance, Rework Losses	Quality Loss	• Scrap • Rework • In-Process rejection

The metrics used to calculate OEE are summarised on figure 1.1

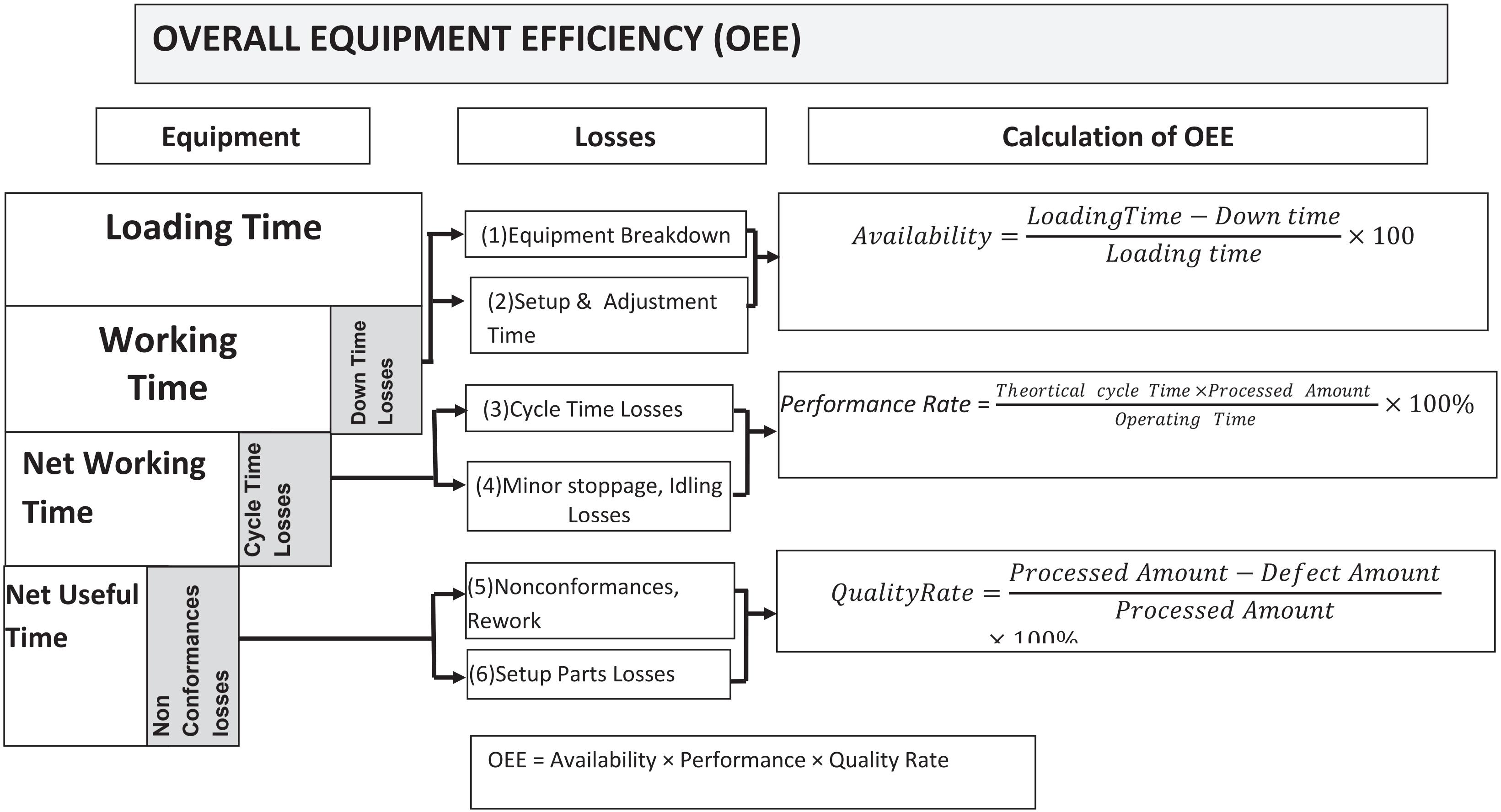

Figure 1.1: Overall Equipment Efficiency- Three metrics Combined

4 METHODOLOGY

Although experimenting in a real manufacturing environment on the shop floor is expensive and time consuming, it is still the most effective and desirable way to understand a manufacturing system. In the present study, the OEE data of critical machines has been used to understand the capability of a process. The current methods to assess capability of a process, such as Cp/Cpk, do not provide the complete picture of a manufacturing process. The focus in a capability analysis is solely on measuring and reducing variation which works well as a quick assessment tool and does not provide a glimpse of the process performance over the long run. OEE measurements have wider ramifications as it includes data related to all losses and not just the losses due to quality. The study was carried out in a leading Indian company manufacturing plated plastic molded emblems. The company is supported by in-house design and development facilities like modern tool room for manufacturing of moulds, dies, jigs and fixtures, and design facility is supported with leading modeling software. The study was carried out in the molding section housing 15 large to medium sized plastic injection molding machines. The process on these machines is highly automated and is operated by skilled workers under qualified and controlled process conditions. The precise details of the molding section are proprietary information of the company.

A conceptual OEE measurement methodology was developed using standard MS Excel® sheet using the indices reported in the literature. The data was collected from each machine in the manufacturing facility on a daily basis consecutively for a period of three months.

5 PROPOSED METHOD FOR CAPABILITY ASSESSMENT

The OEE data from each machine was calculated for each working, each part and each operator separately. The machines run 24 hours, three operators worked on these machines rotating in three shifts. Since the OEE data was available for three different operators making the same part for a significantly longer duration of time, the assessment of their performance and capability was the next step. One of the potential outcomes of this study was to study the effect of three different operators, who are all skilled and have been running the machines for a long duration of time, on the process capability. The Average and Range method for assessing the GR&R was used to complete the capability assessment of the process. The Average and Range method for GR&R is used to determine the equipment and the appraiser variation and the same has been used in this study to evaluate the process capability using the OEE data. This method allows the process to be decomposed into two separate components, equipment and the operator variation.

6 CONDUCTING THE STUDY

The operators in these studies have been referred to as A, B and C who work on an Injection Molding Machine ‘M1’ to produce Part 1001. Each of the three operators routinely work on this machine to make Part I. The OEE data for each of the three operators was calculated for each working day of the month for this part. The OEE data for one week (same week for each operator) was recorded on the observation sheet shown in Figure 6.1 for the first month for each operator. Similar one week data for each operator for the next two months was also recorded in Table 6. The calculations for equipment and operator variation are shown in Table 6.

6.1 Equipment and Operator Variation - Calculations

The range of variation for the OEE data for each operator for the OEE data of three weeks was calculated by subtracting the largest OEE from the smallest and recorded at the appropriate column in Figure 2. The average range, $R_{A,}$ $R_{B,}$ and R_C for each operator was calculated by dividing the sum of all ranges by the number of range values. The average of the three mean ranges for the three operators was designated as R_{mean}. The R_{mean} value is indicative of the equipment variation which is calculated by equation 6.1.

$$EquipmentVariation(EV) = \bar{\bar{R}} \times K_1 \quad \text{eq. (6.1)}$$

Where K_1 is a constant that depends upon the number of trials used in this study.
The mean OEE for each operator was calculated by averaging the OEE for each day and then dividing the sum by the number of repetitions in each month. The range of the difference in the means, designated as X_{mean} for the three operators was calculated by subtracting the maximum mean OEE from the minimum OEE. The X_{mean} is a measure of the variations due to differences in the skill level of the operators. The operator variation is then given by equation 6.2.

$$OV = \{(X_{DIFF} \times K_2)^2 - (EV^2/nr)\}^{1/2} \quad \text{eq. (6.2)}$$

Where n is no. of pieces, r is no. of repetitions and K_2 is a constant that depends upon the number of appraisers used in this study.
The combined effect of the two variations is given by equation 6.3.

Equipment and Operator Variation (EOV)

$$E \ \& \ O = \{(EV^2 + AV^2)\}^{1/2} \quad \text{eq. (6.3)}$$

Then we calculate the OEE Variation (OEEV) which is given by equation 6.4

$$OEEV = R_p \times K_3 \quad \text{eq. (6.4)}$$

LSL for OEE is 90%. This is the Acceptable OEE (AOEE).
So now we can calculate the percentage of each of the variation.
% EV = 100 (EV/A OEE)
% OV = 100 (OV/A OEE)
% E & O Variation = 100 (E&O/AOEE)
% OEEV = 100 (OEEV/AOEE)
Similarly OEE data of the different machines recorded and calculate the repeatability of the machine and reproducibility of the different operator. GR&R calculation for some of the machines are given in table 6.

6.2. COMPARISON OF CAPABILITY INDEX AND EOV VALUE

To find the value of Cp and Cpk thirty pieces on each machine are checked. Table 6.5 shows the result of Gauge R&R and Cp and Cpk value.

Table 6.5: Combined Variation and Cp and Cpk Values

M/C No.	Equipment Variation (%)	Operator Variation (%)	EOV/Combined Variation (%)	OEE Variation (%)	Cp Value	Cpk Value
M1	14.47	2.69	14.72	6.05	1.28	1.22
M2	22.71	6.35	23.58	7.18	0.86	0.78
M3	28.38	5.63	28.94	17.94	0.97	0.90
M4	58.96	14.23	60.66	13.30	0.63	0.58
M5	14.41	0.5	14.4	20.0	0.86	0.81
M6	19.3	9.2	21.4	8.8	1.13	0.98
M7	20.4	5.0	21.0	19.7	0.98	0.91
M8	17.6	2.6	17.7	10.8	1.05	0.95
M9	21.7	2.6	21.8	9.7	1.13	1.08

7 INTERPRETING THE RESULTS

It was found that in moulding machine M4 the value of combined variation is more than 30% so this machine is unacceptable for long term production. Combined variation in machine M2,M3,M6 and M7 range inbetween 20% to 30% which is more than lower acceptable value. So there is need of improvement to reduce this variation. Combined Variation of machines M1, M5 and M8 are within the specified control limit. From the above result it was concluded that capability index Cp/Cpk affects the value of combined variation. Values of Cp/Cpk reduce as the combined variation increase and value of Cp/Cpk increase as the combined variation reduce. This behavior in the trends of combined variation and Cp/Cpk indicates that there is a relationship between the OEE of a machine and its capability. As quality factor is used to calculate the OEE therefore if there is any improvement in the value of Cp/Cpk will reduce the combined variation. As Cp/Cpk only measures the quality parameter of the process so capability assessment by using machine OEE with Gauge R&R is a reliable method.

8 CONCLUSION

OEE is a very powerful tool which can be utilized as a productivity improvement. A lots of scope are there to improve OEE and productivity in small/medium scale industries where technology used is not so high. These industries can use OEE metrics to find the hidden and bottleneck areas of improvement and can increase their profit. A systematic approach is necessary for better results.

Use of OEE data with Gauge R&R is a better option for the purpose of long term capability assessment of machine or manufacturing line. Capability indices consider only quality parameter of the machine. OEE data also includes availability of machines, performance of machines which is affected by man, part design complexity, material flow, environment etc. So to measure the capability of the machine by using OEE data gives us better picture of machine ability to perform for a longer period.

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New Dual-Band CPW-FED Slotted Rectangular Patch Monopole Antenna for Wlan/ WiMax Applications

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ABSTRACT

A new dual-band design of a finite ground coplanar waveguide (CPW)-fed monopole antenna is presented. This design simultaneously satisfying wireless local area network (WLAN) which cover (2.4/5.2/5.8 GHz)and worldwide interoperability for Microwave Access (WiMAX) which cover (2.5/3.5/5.5 GHz) applications. The proposed antenna, comprising a rectangular planar patch element embedded with two circular slots, stair shape meandering in the middle of the patch element and one circle at the top of rectangle. It printed on an inexpensive FR4 substrate. The simulated -10 dB bandwidth for return loss is from 2.38 to 2.95 GHz and 4.0 to 6.13 GHz, covering the(2.4/5.2/5.8 GHz) WLAN bands and (2.5/5.5 GHz) WiMAX bands. The parametric study is performed to understand the characteristics of the proposed antenna. Also, good antenna performances such as omni directional radiation patterns and antenna gains over the operating bands have been observed and simulated peak gain of the antenna is 3.77 dBi at 5.26 GHz. To investigate the performance of the proposed antenna configurations moment method code, IE3DTM, was used for required numerical analysis and obtaining the proper geometry parameters.

KEYWORD:- Dual-band; CPW-fed antenna; Monopole Antenna; WLAN ; WiMAX.

INTRODUCTION

In the era of modern wireless communication systems, dual-band or multiband antennas with Omni -directional radiation characteristics play a vital role [1, 2]. Advances in wireless communication technologies are placing greater demands on higher antenna impedance bandwidth and smaller antenna size. The design of broadband antennas has received the attention of many antenna researchers due to their various applications [3]. The currently popular designs suitable for WLAN operation in the 2.4 GHz (2.4–2.484 GHz) and 5.2/5.8 GHz (5.15–5.35 GHz/5.725–5.825GHz) bands and WiMAX operation in the 2.5/3.5/5.5 GHz bands have been reported in [1-10]. The planar monopole antenna has received much more interest than others, due to its potential in providing the various radiation features required for dual-band or multi-band, wide bandwidth, low profile communication systems. However, these kinds of antennas mostly need a large ground plane, which is often printed on the opposite side of the substrate from the radiating plane. Thus a via-hole connection is always necessary for feeding the signal, and this increases the manufacturing difficulty and cost.

Recently, the coplanar waveguide (CPW)-fed monopole antenna has become very popular in WLAN and WiMAX systems, owing to its many attractive features such as, wider bandwidth, low radiation loss, a simple structure of a single metallic layer and easy integration with WLAN integrated circuits. WLAN standards in the 2.4/5.2/5.8 GHz operating bands, various antenna designs have been developed and presented in the literature. These presented antennas include the planar inverted-F antennas (PIFAs) [11], the meander-line chip antennas [12], and the planar monopole antennas [13]. Among these antennas, the planar monopole antennas have especially received much more interest than others due to their potential in providing various required radiation features of dual band or multiband, wide bandwidth, and low cross polarization for a communication system. However, such kinds of antennas mostly need a large size of ground plane, which is often printed on the different side of the substrate from the radiating plane, and thus a via-hole connection is always necessary for feeding the signal and this increases the manufacture difficulty and cost. However, the presented dual-band CPW-fed antennas, including the strip-loaded square slot antenna [14], the parasitic monopole antenna [15] and the E-like strip-fed slot antenna [16], are either narrow in bandwidth or complex in antenna shape. In this paper, a proposed antenna design with CPW-feed technology has been used to achieve dual-band operation for both WLAN and WiMAX bands. In order to attain the Dual-band characteristics, the antenna has a rectangular planar patch element embedded with two circular slots, stair shape meandering in the middle of the patch element ,one circle at the top of rectangle and a rectangular ground plane. It has been observed that the resonant frequencies of the antenna could be independently varied by changing the dimensions of the structure. Since the proposed antenna design is based on analytical relations, this structure can be used to design in other frequencies and applications. The antenna can achieve a dual-band performance to simultaneously cover the most commonly used WLAN and WiMAX bands. WLAN's are designed to operate in the 2.4 GHz (2.4–2.48 GHz) and 5 GHz frequency bands (5.15–5.35 GHz and 5.725– 5.825 GHz). Also WiMAX (Worldwide Interoperability for Microwave Access) which is allocated the 2.5– 2.69/3.4–3.69/5.25–5.85 GHz bands. The fundamental parameters of the antenna such as return loss, VSWR, gain, directivity and radiation patterns are obtained. All meets the acceptable antenna standards. Simulation tool, based on the method of moments (MOM)-ZELAND IE3D version 14.10 has been used to analyze and optimize the antenna. Details of the proposed antenna design are described in the paper, and simulated results are presented and discussed in the following sections.

DESIGN OF ANTENNA

Fig.1 shows the geometry of the proposed finite ground coplanar waveguide (CPW) fed dual-band monopole antenna. The proposed antenna is printed on dielectric substrate of FR-4 with relative dielectric constant €r = 4.4. and thickness of h=1.6 mm. On the top of the substrate, a rectangular planar patch element embedded with two circular slots, stair shape meandering in the middle of the patch element, one circle at the top of rectangle and a rectangular ground plane is printed to create three appropriate frequency bands.. This structure is fed by a CPW-Fed line of 50 Ω. The proposed monopole has wide impedance bandwidths 2.38 to 2.95 GHz and 4.0 to 6.13 GHz, covering the (2.4/5.2/5.8 GHz) WLAN bands and (2.5/5.5 GHz) WiMAX bands respectively. To investigate the performance of the proposed antenna configurations in terms of achieving the wideband dual-frequency operations a commercially available moment method code, IE3DTM, was used for required numerical analysis and obtaining the proper geometry parameters in Fig. 1, and then the optimal dimensions were determined from experiments. The antenna has overall dimensions of length L=29.350 mm × width W1= 24.450 mm and with a vertical spacing of G2= 0.50 mm away from the ground plane. A conventional CPW fed line designed with a fixed signal strip thickness Wf=4.325 mm and a gap distance between the signal strip and the coplanar ground plane is used for exciting the radiating patch element. The space between the rectangular patch and ground plane G1= 1.775mm Two finite ground planes with the same size of width W3=9.50 mm and length L2= 13.050 mm, are situated symmetrically on each side of the CPW feeding line.

The final optimized dimensions of proposed antenna are: length of the rectangular patch L1=14.575 mm, width of the rectangular patch W1=24.450 mm, Meandering Slot length are: L3=3.025 mm, L4=3.05 mm, L5=2.925 mm and having meandering slot width are: W4=3.025 mm, W5=2.925 mm, W6=3.025 mm. The optimum parameters are obtained with the aid of IE3D software.The following table is optimal parameters of the proposed antenna to reach the desirable performance.

Table 1.Antenna dimensions

PARAMETER	W1	W2	W3
VALUE	24.450mm	12.175	9.50mm
PARAMETER	W4	W5	W6
VALUE	3.025mm	2.925mm	3.025mm
PARAMETER	L1	L2	L3
VALUE	14.575mm	13.050mm	3.025mm
PARAMETER	L4	L5	L6
VALUE	3.05mm	2.925mm	0.975mm
PARAMETER	R1	R2	G1
VALUE	2mm	3mm	1.775mm
PARAMETER	G2	Wf	
VALUE	0.50mm	4.325mm	

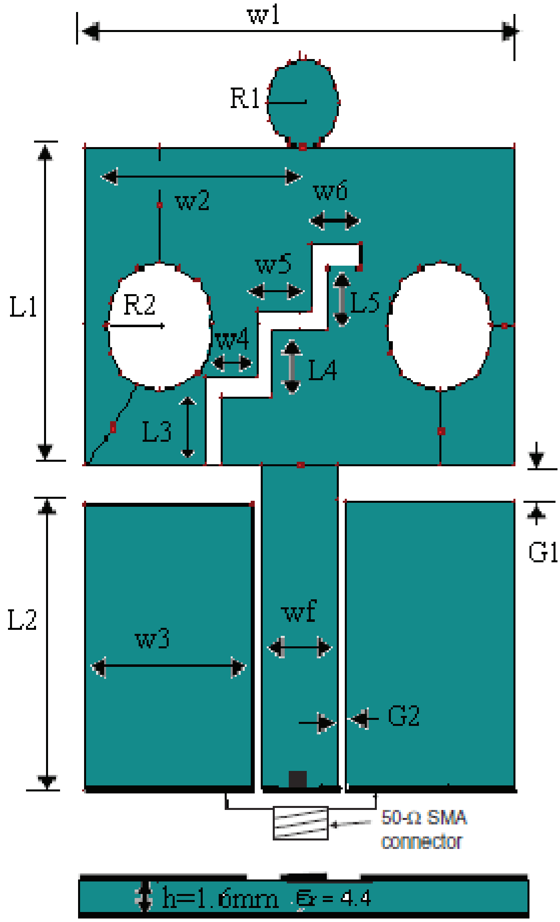


Fig 1: Geometrical configuration of proposed CPW-fed monopole antenna for dual band operation.

SIMULATION RESULTS AND DISCUSSION

Based on the design dimensions shown in Fig. 1, a prototype was built and tested. The simulated parametric study results and return losses for the proposed monopole antenna are obtained. The simulated return losses are presented for the optimized set of antenna parameters in Fig.2. Obviously, the simulation results show that the resonant modes are excited at frequencies of 2.4/5.2/5.8 and 2.5/5.5 GHz .The simulated impedance bandwidth of the proposed antenna covers two impedance bandwidths, 2.38 to 2.95 GHz as the lower band and 4.0 to 6.13 GHz as the upper band, respectively. It can cover the WLAN bands (2.4/5.2/5.8 GHz) and the WiMAX bands (2.5/5.5 GHz) of wireless communication system.

Prototypes of the obtained antenna for wide band operation were predicted and measured antenna performance such as input return loss, impedance bandwidths, radiation patterns, Gain, current distribution and VSWR are presented and discussed. We compared the measured data with the simulated results obtained from the IE3DTM electromagnetic solver. The agreement seemed good and a similar curve trend between the measurement and the simulative results is seen over the whole operating bands beyond existing a slight frequency shift and a frequency discrepancy that may mainly due to the frequency response of the substrate permittivity. The VSWR of the proposed antenna using IE3D simulator is shown in Fig.3. Fig. 4 shows the measured peak antenna gains for frequencies across the three operating bands antenna using IE3D simulator.

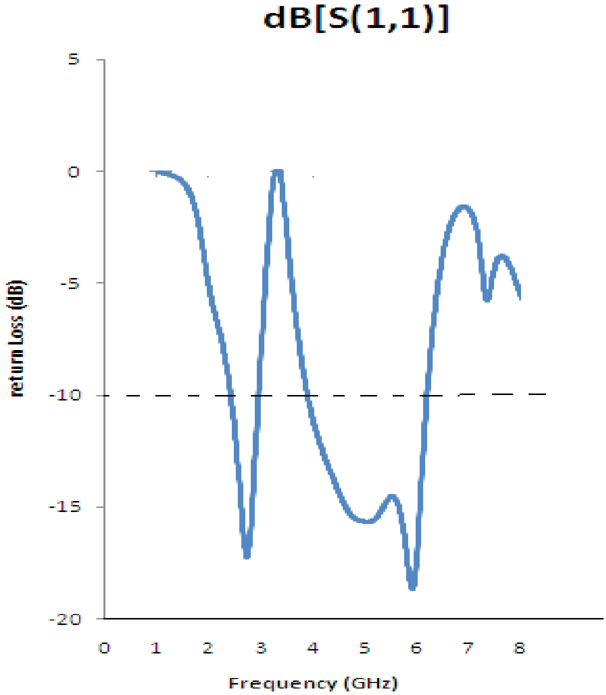


Fig 2: Return loss against frequency of proposed antenna from simulation

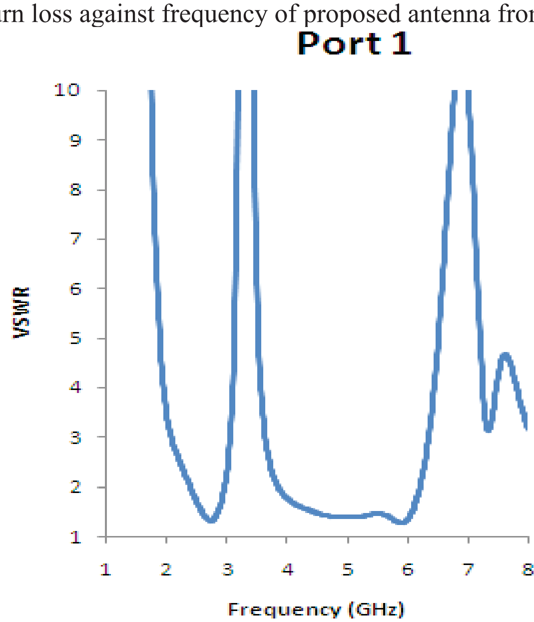


Fig 3:VSWR of proposed antenna.

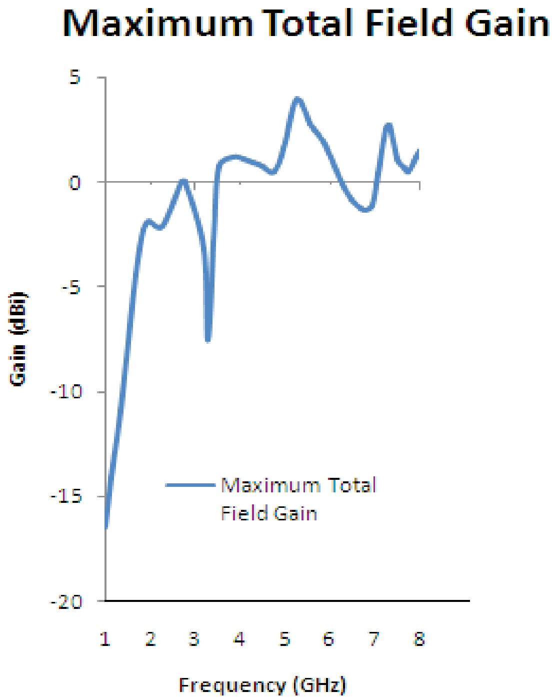
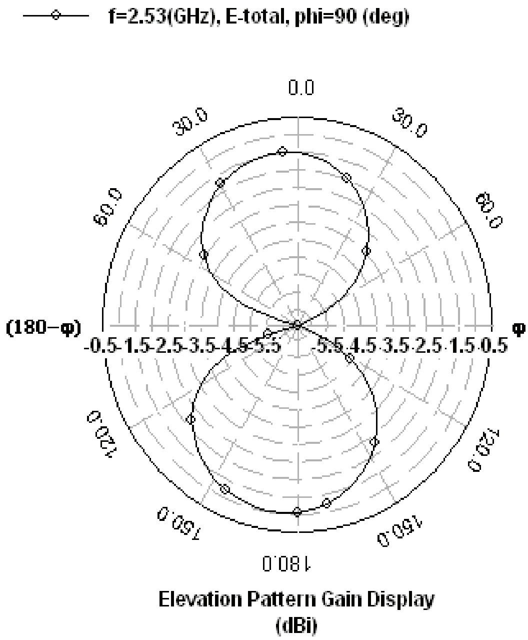


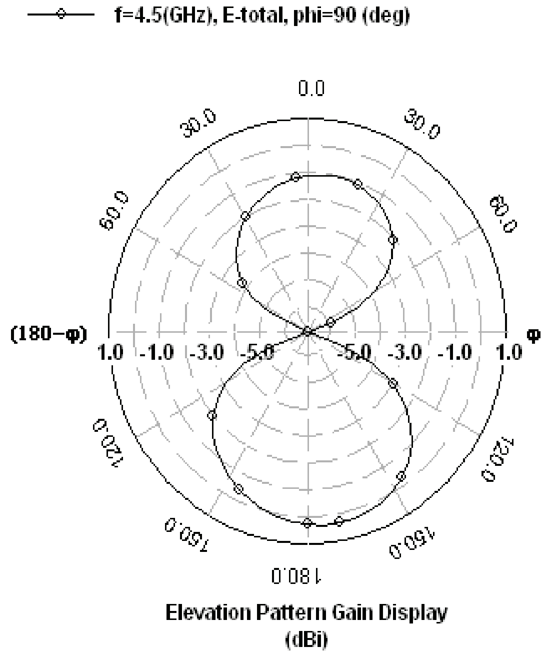
Fig 4: Gain of proposed antenna.

Fig 5: Current distribution of proposed antenna.

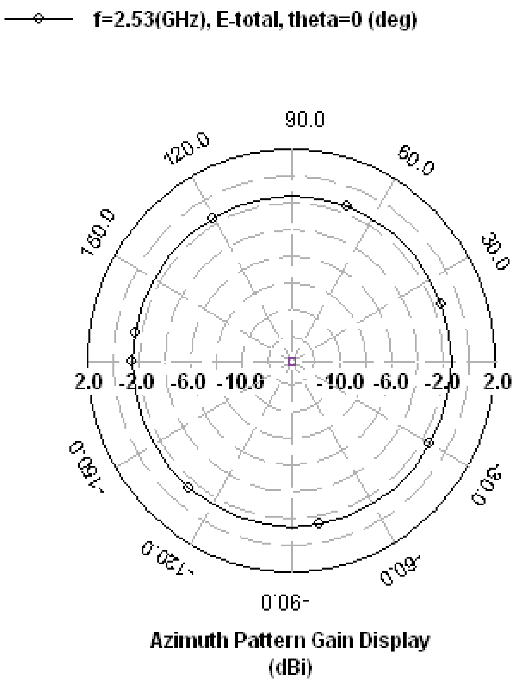
The current distribution of the proposed antenna using IE3D simulator is shown at the Resonant Frequency in Fig.5. The 2D radiation pattern of the antenna is shown at the different frequency in Fig.6. These radiation pattern are shown at the 2.53 GHz, 4.5 GHz.



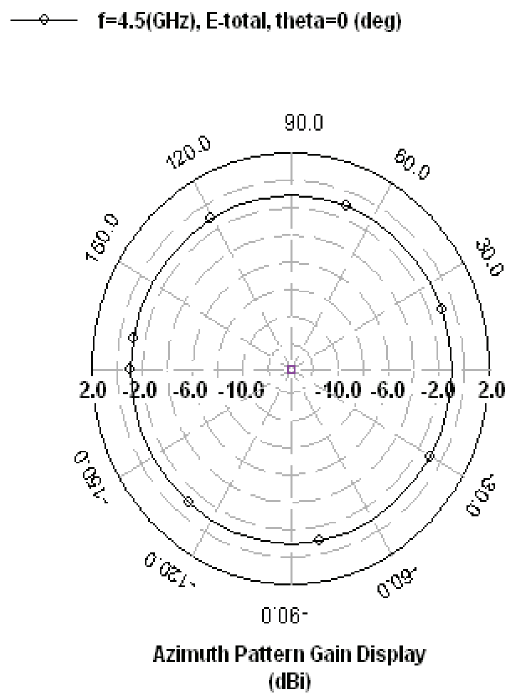
(a)



(c)



(b)



(d)

Fig 6: 2D Radiation pattern of proposed antenna.

The 3D radiation pattern of the antenna is shown in Fig.7. This antenna show the omni directional radiational patteran.

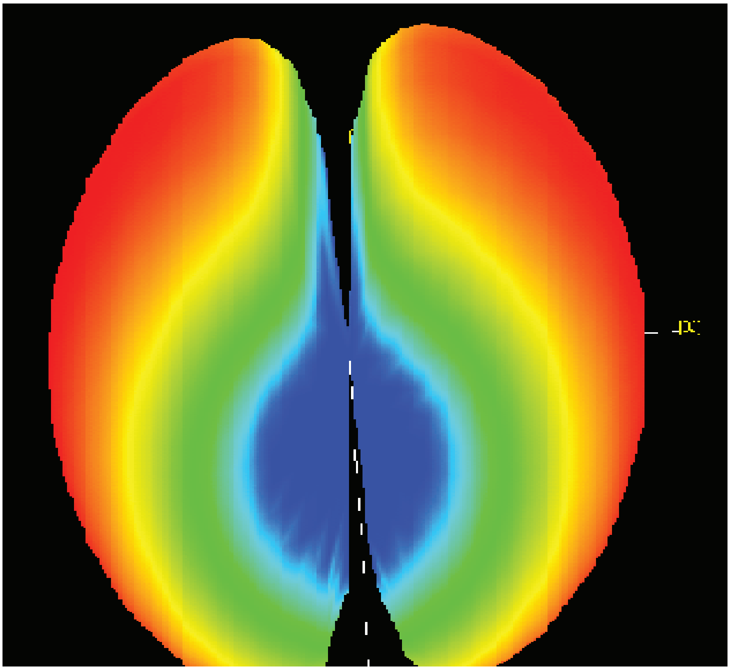


Fig 7: 3D Radiation pattern of proposed antenna.

CONCLUSION

A low-profile CPW-fed antenna for dual-band operation has been proposed and implemented. The various parameters of the proposed antenna are optimized through simulation. Prototype of the proposed antenna has been designed, and simulated. With the embedment of two circular slots, stair shape meandering in the middle of the patch element and one circle at the top of rectangle, the proposed antenna can excite sufficient impedance bandwidths and suitable radiation performance for triple-frequency operation covering the 2.38 to 2.95 GHz and 4.0 to 6.13 GHz, which covers WLAN bands (2.4/5.2/5.8 GHz) and the WiMAX bands (2.5/5.5 GHz) respectively. The proposed antenna provides nearly omni-directional radiation characteristics with moderate gain and efficiency which is suitable for the next generation wireless communication gadgets. The antenna is compact, mechanically robust, and easy to fabricate and integrate with the application-specific circuit.

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