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Journal of Mechanics and Structure

Aims and Scope

Journal of Mechanics and Structure is a journal which offers prompt publication of structural design; this journal publishes peer-reviewed technical papers on state-of-the-art topics and future developments of the profession. Engineers, consultants, and professors detail the physical properties of engineering materials (such as steel, concrete, and wood), develop methods of analysis, and examine the relative merits of various types of structures and methods of fabrication. Subjects include the design, erection, and safety of structures ranging from bridge to transmission towers and tall buildings; technical information on outstanding, innovative, and unique projects; and the impact of natural disasters and recommendations for damage mitigation.

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Contents

High Efficiency Voltage Doubler for Unmanned Multi-Rotor Helicopter Power Supply

Petar Getsov, Svetoslav Zabunov, Garo Mardirossian

A B S T R A C T

During the last few years unmanned multi-rotor helicopters are getting ubiquitous due to their low cost and efficiency. The power supply of these machines is lacking behind as are doing many other modules in the avionics as well and users are suffering from being unable to utilize fully the capabilities of these modern aircraft.

In order to increase flight times, high efficiency power supplies are needed. Current models of lower class use passive power supplies with efficiencies in the range of 50%. More common among expensive models are inductive power supplies. The latter ones offer efficiencies from 70% to 95%. The upper limit is hardly achievable and also these power supplies suffer from a number of drawbacks such as electromagnetic interference, high frequency operation, weight, form factor, etc.

The present article demonstrates a capacitive voltage doubler especially designed for unmanned multi-rotor helicopters with efficiency of over 98% and very small dimensions and weight. The lack of inductors and low working frequency guarantee almost none electromagnetic interference to other modules of the avionics.

Keywords: Unmanned helicopter power supply, Unmanned multi-rotor helicopter.

INTRODUCTION

Onboard unmanned helicopter power supplies are important units of the avionics. If they exhibit high efficiency, the aircraft will be capable of high efficiency of flight, hence longer flying times and increased range. Another aspect of unmanned helicopters power supply is their electromagnetic interference with other more sensitive modules such as the radio transceiver.

In order to increase efficiency and lower the electromagnetic disturbances a capacitive power supply should be addressed for implementation. The inductive power supplies are plagued with electromagnetic interference problems and often have efficiencies in the range of 70-95% but the upper limit is hard to achieve.

Capacitive power supply has no inductors, which radiate magnetic field. The efficiency is greater than 98-99%. Dimensions of these units are more compact and also weight is considerably less in comparison to the inductive modules.

The current article focuses on a capacitive voltage doubler and its most efficient and cost- effective implementation for the onboard power supply of unmanned helicopters.

History of capacitive voltage doublers

One of the oldest voltage doubler circuits is the Greinacher voltage doubler (Fig. 2). It is designed as an improvement of the voltage clamp circuit know as the Villard voltage doubler (Fig. 1).

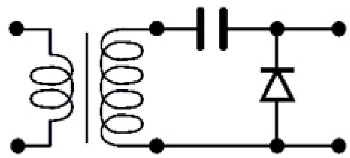

Figure 1. Villard voltage doubler

The Greinacher circuit works by following a Villard stage with a peak detector or an envelope detector stage. The peak detector smoothes the ripple of the Villard stage while assuring a doubled voltage at the output. The circuit was invented in 1913 by Heinrich Greinacher and was used to provide voltage supply for the newly invented ionometer.

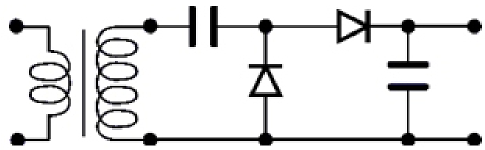

Figure 2. Villard voltage doubler

Later in 1920 this circuit was extended into a cascade of multiplier Greinacher cells known as Cockcroft–Walton multiplier used in the particle accelerator machine invented by John Cockcroft and Ernest Walton.

Why voltage doubler?

Some of the scenarios onboard unmanned helicopters requiring voltage doublers are as follows:

1. Combination of motors working at different voltages. For example 4 motors working at 11.1V and one motor working at 22.2V.
2. Combination of servos with different voltages.
3. Supplying radio transmitters that require high voltage for the final transmitter stage.

The doubler will not present an exact voltage but it will nevertheless offer a close voltage to the nominal for the given module. A voltage regulator after the voltage doubler may be installed. For most units a regulator is either inbuilt or is not needed as is the case with most servos that tolerate certain deviation from the supply voltage.

Voltage doubler to be used onboard of unmanned helicopter series XZ

The Greinacher voltage doubler on Fig. 2 is applicable for AC voltage supply. When used on board of an unmanned helicopter where the voltage source is a battery then a chopper circuit is needed, namely a push-pull transistor generator. Such a solution is shown on Fig. 3.

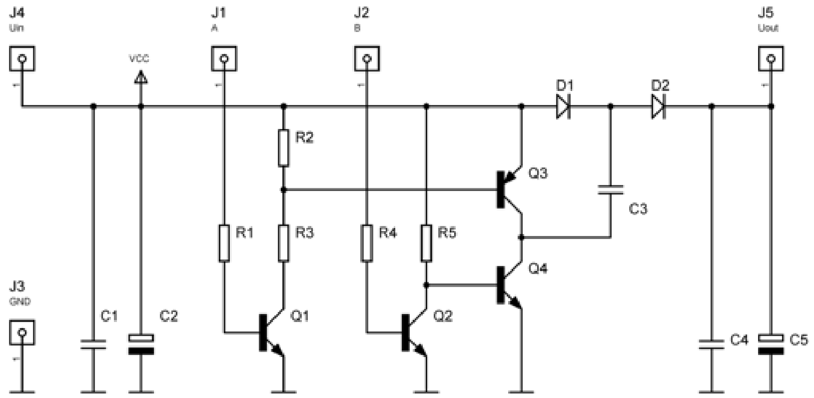

Figure 3. Greinacher voltage doubler with input TTL buffers

The above circuit needs control TTL signals from a microprocessor or another control device. The control signals A and B should have certain timing in order to keep the upper and lower transistors never conducting at the same time (see Fig. 4).

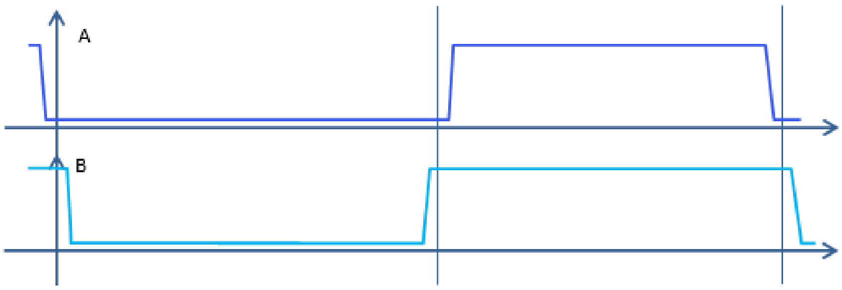

Figure 4. Control TTL signals for the Greinacher voltage doubler with input TTL buffers

Constructed this way the transistor circuit will function properly but at low efficiency especially when drawing current from a low voltage battery of 1 to 6 Li-Poly or Li-Ion cells. The voltage drop across transistors and diodes is in the order of 1.4 V to 3 V making the circuit efficiencylow. For example using a battery of three cells at nominal voltage of 11.1 V the voltage drop in the circuit's semiconductors will be 1 V at the diodes (only if Schottky diodes are used) and 0.4 V at the transistors (only if low VCEsat transistors are used). Thus the total voltage drop will be 1.4 V or 12.6%. The solution to this low efficiency problem is to use a charge pump configuration. Bipolar diodes and transistors should be replaced with MOSFET transistors. An improved circuit is shown on Fig. 5.

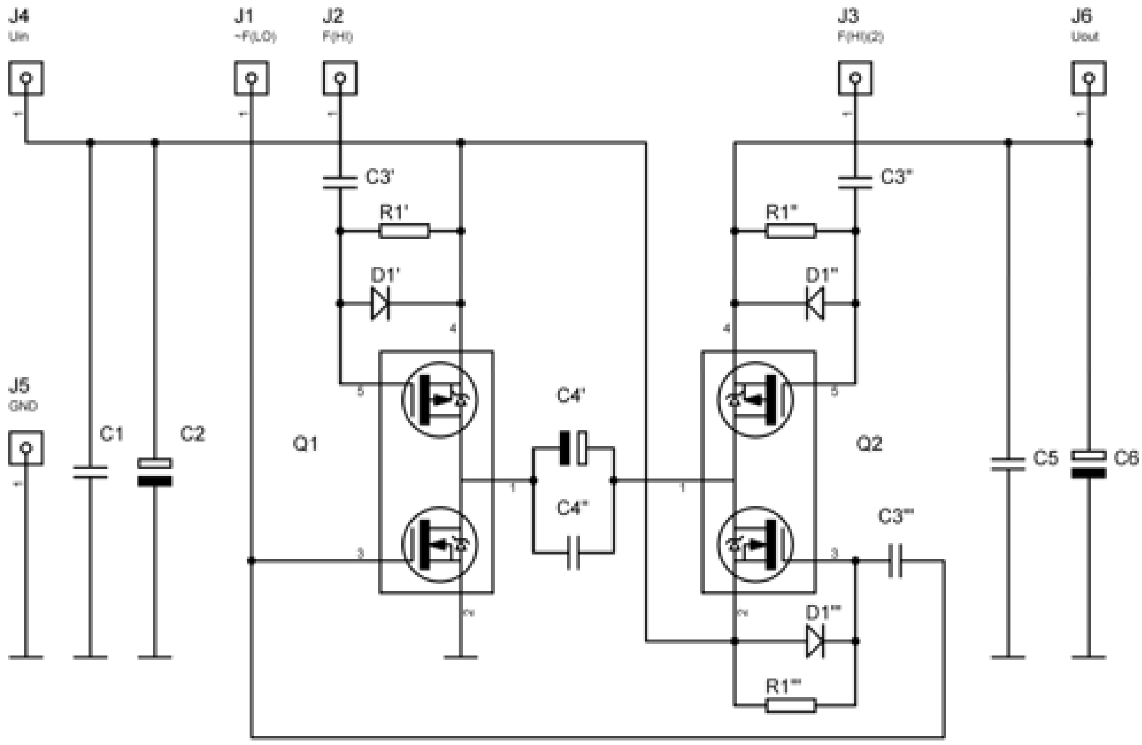

Figure 5. Greinacher voltage doubler in charge pump configuration

The improved circuit from Fig. 5 needs three instead of two control signals, because three of all four MOSFET transistors are controlled using auxiliary charge pumps. Those charge pumps charge at different moments after circuit startup and correct timing could be achieved only using three instead of two control signals. The above circuit delivers power at very high efficiency. For example let us test the circuit again with a three cell battery with nominal voltage of 11.1 V and let us draw 10 A current from it (5 A at the voltage doubler output). Then let us implement transistors with RDSon equal to 1 mOhm each and a capacitor with ESR equal to 2 mOhm. Thenthere is defined a voltage drop across the transistors and capacitor of 10 A * 0.004 Ohm = 0.04 V. The power loss will be 0.4 W. The gate switching loss is Cgate * f * V^2 and is around 60 mW, which can be neglected. Thus the total power loss is only 0.36%. This makes the circuit a winner with efficiency of over 99.5%. The major problem with this circuit is that it needs a microprocessor to run. Is there a way of making it work without a microprocessor thus guaranteeing higher reliability? A voltage doubler driving essential parts of the avionics should be extraordinarily reliable, thus a software error should be excluded. The best solution is to use combinatorial-memory logical circuit when generating the control signals. This solution is shown no Fig. 6.

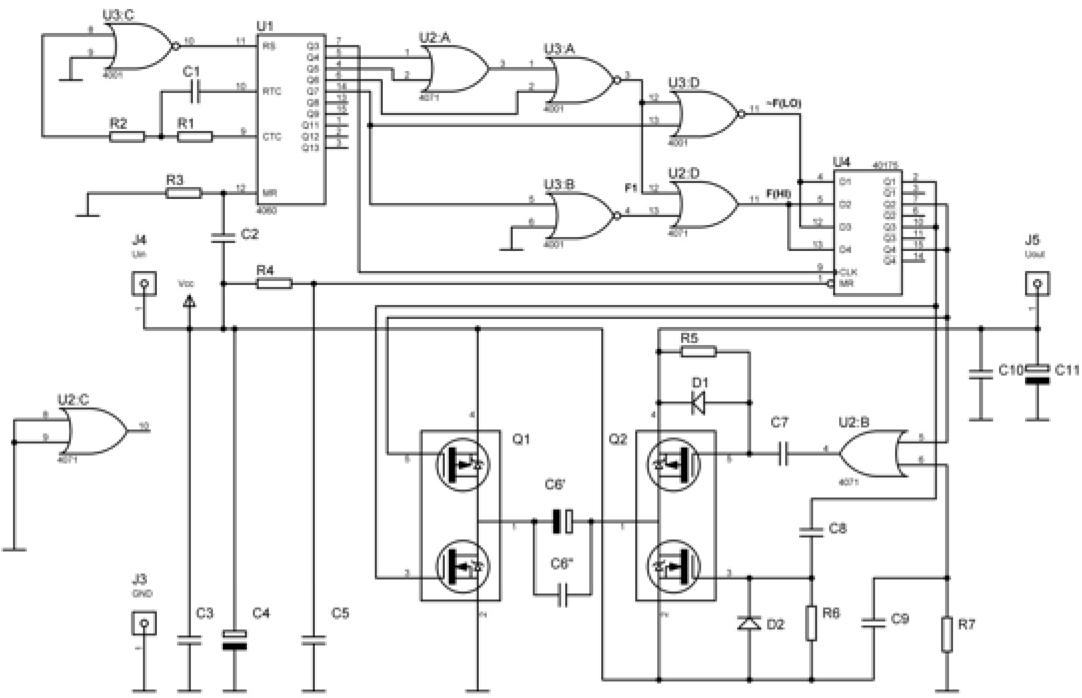

Figure 6. Charge pumped Greinacher voltage doubler with control signals generated without a microprocessor

As already mentioned the control signals should be timed correctly. These signals could be digitized with a granular time step that satisfies the efficiency considerations and timing delays of the used logic gates. A division of the main generator period by 16 is satisfactory. A digitalbinary counter is used for this purpose driven by an RC generator. The timing diagram of the control signals for driving the circuit from Fig. 6 is shown in Table 1 below.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
X_0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
X_1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
X_2	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
X_3	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
FLO	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
FHI	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Table 1. Control signals in digitized time sub-periods

There are two control functions FLO and FHI (see Fig. 6). One needs to generate those using combinational logic circuits. For the purpose of synthesizing the two control functions the logic series 4000 logic gates are used and Veitch charts are drawn (see Table 2 and Table 3).

F_{LO}:

	X_0	X_0			
X_1	1	1	0	0	
X_1	1	1	0	0	X_3
	1	1	0	0	X_3
	1	1	0	1	
		X_2	X_2		

Table 2. Synthesizing control function FLO using Veitch diagram

Canonical disjunctive normal form is used. The minterms of the two given functions are observed and grouped in maximal groups as the rules of the Veitch diagrams denote (see Table 2 and Table 3 blue coloured fields).

F_{HI}:

	X_0	X_0			
X_1	0	0	1	1	
X_1	0	0	1	1	X_3
	0	0	1	1	X_3
	1	0	1	1	
		X_2	X_2		

Table 3. Synthesizing control function F_{HI} using Veitch diagram

The result is as follows:

$$F_{LO} = X_0 \mid \sim X_1 \,\&\sim X_2 \,\&\sim X_3 = X_0 \mid \sim(X_1 \mid X_2 \mid X_3)$$

$$\sim F_{LO} = \sim(X_0 \mid \sim(X_1 \mid X_2 \mid X_3))$$

$$F_{HI} = \sim X_0 \mid \sim X_1 \,\&\sim X_2 \&\sim X_3 = \sim X_0 \mid \sim(X_1 \mid X_2 \mid X_3)$$

It becomes clear that the most appropriate logic gates for synthesizing these two functions are two input NOR and OR gates. Let us define a sub-function F_1:

$$F_1 = \sim(X_1 \mid X_2 \mid X_3)$$

Then F_1 is synthesized as follows:

$$F_1 = NOR_2(X_1, OR_2(X_2, X_3))$$

Further $\sim F_{LO}$ is synthesized:

$\sim F_{LO} = \sim(X_0 \mid F_1) = NOR_2(X_0, F_1)$

F_{HI} is obtained in a similar way:

$F_{HI} = \sim X_0 | F_1 = OR_2(NOR_2(X_0, 0), F_1)$

The correct timing is guaranteed by a four bit D-trigger memory and a few delay networks.

CONCLUSION

Using high-efficiency capacitive power supplies onboard of unmanned multi-rotor helicopters increases range and flying times. Further this solution lowers electromagnetic interference among modules of the avionics guaranteeing higher reliability of the aircraft. To increase the reliability even further the current material presents a microprocessor free solution of a MOSFET charge pump based voltage doubler.

Authors are continuing their work on improving the flying time, efficiency and reliability of the unmanned helicopters thus offering to users even more risk free and capable flying platforms.

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Root Cause Analysis of Defects in Automobile Fuel Pumps: A Case Study

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A B S T R A C T

Quality can be directly measured from the degree to which customer requirements are satisfied. Some problems were reported by the customers of the automobile company under study in the fuel pumps; which is used in an automobile to transfer the fuel from fuel tank to fuel injection system after filtration. This paper presents the implementation of Quality Control tools– Check Sheet, Fishbone Diagram(or Ishikawa Diagram), Pareto Chart and 5-Why analysis tools for identification and elimination of the root cause/s responsible for malfunctioning of the fuel pump in customers" cars. From the Check sheet and Pareto analysis, two major defects were identified which accounted for more than 80% of the problems being reported. The root causes of these two defects affecting the product quality of the company were then further analyzed using the 5- Why analysis.

Keywords: Quality Control Tools, Ishikawa Diagram, Pareto Chart, 5-Why Analysis

1. INTRODUCTION

Kaoru Ishikawa, the former professor at University of Tokyo, after being inspired by Quality Guru W. Edwards Deming"s lectures, formalized the seven basic Quality Control tools in order to democratize the quality. These tools are Check Sheet, Control Chart, Histogram, Pareto Chart, Ishikawa Diagram, Flow Chart and Scatter Diagram. These techniques are useful in understanding the approaches for identification of deviations from standards and improvement of production processes. These tools act as key indicators of quality and help to identify and hence troubleshoot the problems, ultimately leading to improvement in quality. To enhance the quality, productivity and business, continuous quality and process improvements are required in the organization. Together, all these tools provide excellent techniques of process analysis and tracking that make quality improvements easier to implement, track and review.

The seven basic Quality Control tools are briefly described as follows:

1.1. Ishikawa Diagram

Ishikawa diagram, also known as Fishbone diagram or Cause-Effect relationship establishes a diagnostic relationship between potential causes of a problem leading to a particular effect.

1.2. Check Sheet

Check sheet is used for gathering and organizing the data by categorizing the various defects. This is basically employed to collect the raw data which can be further analyzed; using a Pareto chart.

1.3. Pareto Chart

This tool is used for establishing a set of priorities to be dealt with first. It is based on Pareto‟s 80-20 principle which says that “Almost 80% of the problems can be attributed to only 20% of the causes”.It helps to analyze the problem by prioritizing the reasons leading to most of the defects.

1.4. Histogram

To illustrate the frequency and the extent in the context of the two variables, Histogram is used which represents the distribution by mean.

1.5. Scatter Diagram

The Scatter diagram in a Cartesian plane illustrates the correlation between the two variables. From this, further investigation such as a trend analysis can be performed on the values.

1.6. Flow Chart

This chart is implemented to analyze the sequence of events from start to finish with each step of the process being clearly indicated. It is used to understand a complex process and find relationships between the events.

1.7. Control Chart

Control chart is used to track and monitor the performance of a process. Samples are occasionally received, inspected or measured, and thus the results are plotted on the chart. The chart shows how the variation in a specific indicator changes over time.

Besides the above mentioned tools, 5 Why Analysis is also a model to analyze and solve any problem where the root cause is unknown. It was a model first implemented in Toyota Production System by Sakichi Toyoda. This analysis is used to uncover usually a simple or moderately difficult problem by asking “why” in a repetitive manner. For wider ranging method the Ishikawa Diagram is used for the identification of root problem.

2. LITERATURE REVIEW

Goh (2000) outlined the functions of statistical tools and examined the steps in which they are adopted by non-statisticians in industry. A "seven S" approach is explained, highlighting a strategy for the effective deployment of statistical quality engineering. In a manufactured product attainment of superior quality and reliability depends upon the existence of a framework integrating an organization‟s capabilities in management, technology and information utilization. Evans and Peters (2005) applied Pareto analysis to test the breadth of appeal of the 2005 Emerald Management „Xtra‟ collection of over 100 business and management journals using aggregated usage data gathered from the Emerald web site. The analysis was made on the basis of articles downloaded by all Emerald customers from COUNTER Journal Report 1 Release 1 compliant usage data.

Prajapati and Mahapatra (2007)discussed a very simple and effective design of joint X-bar and R chart to monitor the process mean and standard deviation. The concept of the process chart is based upon the sum of chi-square ($\chi 2$) to compute and compare Average Run Length values (ARLs).They compared the performance of the proposed chart with VSS, VSI and VSSI joint scheme proposed by Costa (1999).

Mazur et al. (2008) evaluated Toyota Production System (TPS) analysis procedure to tackle a medication delivery problem by making use of QC tools like Flow diagram and PDCA Cycle. "5 Whys" tool was utilized as one of the A3 tools for determining the root causes of the problem. The particular advantage of using this tool is that it is iterative since not all problems have a unique root cause. Multiple root causes can be identified by asking different sequences of questions. The 5 Whys analysis can be primarily performed through a Fishbone diagram or a Tabular format. Other A3 tools used to conduct the study included Map-to-Improve (M2I) to complete the process improvement.

Talibet al. (2010) performed Pareto analysis of total quality management factors; critical to success of Service industries. To accomplish this objective, they identified some key factors that contribute to the success of TQM efforts.

Goicoechea and Fenollera (2012) investigated automotive industry so as to establish a significant relationship between the quality tools and various stages of PRP– Product Realization Process. This was aimed at providing support to the organizations when it is required to select some effective quality control tools in accordance with the quality strategy adopted by them. The paper examined and classified various quality tools like Deming (or PDCA) Cycle; Q7; M7 and Planning, Control and Improvement Techniques. They conducted surveys in industries producing entirely different products in order to be consistent with the fact that product type does not affect the type of quality tool chosen. They structured a proper and valuable relationship which shows the type of quality tools to be used at different stages of product development. For example, FMEA to be used to inspect quality in design; Poka-yokes to inspect quality in initial samples; Q7 and 8D Tool to check quality in series; etc. Further, developing a global standard for quality tools to be used at each PRP stage would help industries to identify the quality they are able to establish in their operations.

Aichouni (2012) used basic quality tools to study the manufacturing process of Ready Mix Concrete (RMC) of a construction company. The Histogram tool brought to highlight the variations in the concrete compressive strengths being delivered which were found to exceed the process targets, thus, indicating towards over-designed mixtures. This variability in concrete was further analyzed with the help of a Cause-Effect diagram from which the reasons leading to concrete variability were identified. Apart from this, he employed Control charts to figure out that production processes were out of statistical control and hence narrowed down an assignable cause influencing the production process and quality of concrete. From this case, he concluded that the seven QC tools demonstrate a great capacity to improve processes in manufacturing industries on account of their ability to provide diagnostic information and their effectiveness in defects and errors prevention.

Magar and Shinde (2014) reviewed the seven Quality Control tools to give a systematic approach for the implementation of each tool to analyze and ultimately improve the quality levels in manufacturing processes. They established an easy to implement and step-by-step procedure for collection and analysis of data related to quality issues, identification of their causes and measurement of results using 7 QC tools– Pareto Chart, Ishikawa diagram, Histogram, Check sheets, Scatter diagram, Control charts and Flow charts. Besides, they also suggested steps for a Plan-Do-Check-Act (PDCA) Cycle for effective implementation of QC tools. With the help of a statistical quality control in place, the problem solving skills of the management can be improved.

Vante and Naik (2015) applied the Pareto Analysis, Ishikawa Diagram and Why-Why analysis to solve the problem of variations in dimensions in 3 cylindermetric block castings. It was identified that variation in dimension of casting wall thickness was the major defect that lead to the rejection of casting block.The analysis of root cause in detail resulted into the permanent action to be implemented for the problem. The successful implementation of the permanent action reduced the rejection rate of casting thus improving the quality of the product.

Sharma et al. (2016) furnishes a good example of putting into practice these 7 QC tools by attempting to reduce defects in aluminum alloy wheel casting. The study used a diagnostic approach to reach the root cause of major defects in aluminum casting in a systematic manner. Initially, Pareto‟s 80-20 rule was followed to identify the major casting defects– shrinkage, porosity, cracks and inclusion– leading to as much as 86% of rejections of alloy wheels. Control chart between molten metal temperature and specific gravity gave way to reduce porosity defect. Also, by using Histogram, shrinkage defect was observed to be more for hub than for rim and spokes. Check sheets enabled them to collect data regarding the number of rejections. On the whole, the study well illustrates the use of 7 QC tools.

Perera and Navaratne (2016) assessed the raw material waste generation of powder filling and packing process through Pareto analysis and Fishbone diagram. After identifying that overfilling alone contributed to 91% of waste generation, it became the centre of study and further Fishbone diagram was constructed to find the root cause of this high bulk powder waste. Other key root causes identified during Cause-Effect analysis included high number of dry/wet cleaning and lack of focus among operators. This was followed by a Why-Why Analysis of key root causes to test their underlying reasons and this helped to develop a Corrective and Preventive Action (CAPA) Plan to mitigate the major causes of waste generation.

3. ABOUT THE INDUSTRY

The automobile industry under consideration is one of the biggest automobile industries in the world. The particular plant in which study was conducted is situated in western part ofthe India. It manufactures automobiles in the category of passenger vehicles. The fuel pump used in the passenger vehicle of the company is an out-sourced part; manufactured by a different supplier. The dealers of the company‟s cars used to replace the defected fuel pump in customers‟ cars with the new one. The defected fuel pumps were then received back at the plant for analysis purpose.

4. FUEL PUMP ASSEMBLY

A pumping unit, DC motor (usually permanent magnet) and an end support for electrical and hydraulic pipe connections form the major components of an electric fuel pump generally employed in an automobile. A pump housing, folded at the edge, holds the entire fuel pump assembly.

The fuel pump intakes fuel from the fuel tank. The fuel pressure is increased to specified value by compression (by gerotor) or transfer of momentum (by turbine) which is controlled by a pressure regulator. Then, the fuel pump transfers the fuel at a higher pressure to the engine fuel injectors through supply lines. A pressure regulator sets the fuel pressure. It consists of an air chamber, a diaphragm with relief valve assembly and a regulator spring. As the fuel injector spray tip is exposed to regular changes in the pressure of air inside intake port, the regulator varies fuel pressure and hence, maintains a constant pressure drop across the fuel injector. Relief valve prevents the rise of excessive pressure in case the fuel lines are blocked. Besides, a check valve is incorporated to isolate the system when the pump is turned off.

The delivery mechanism of a fuel pump in an automobile is shown in Fig. 1.

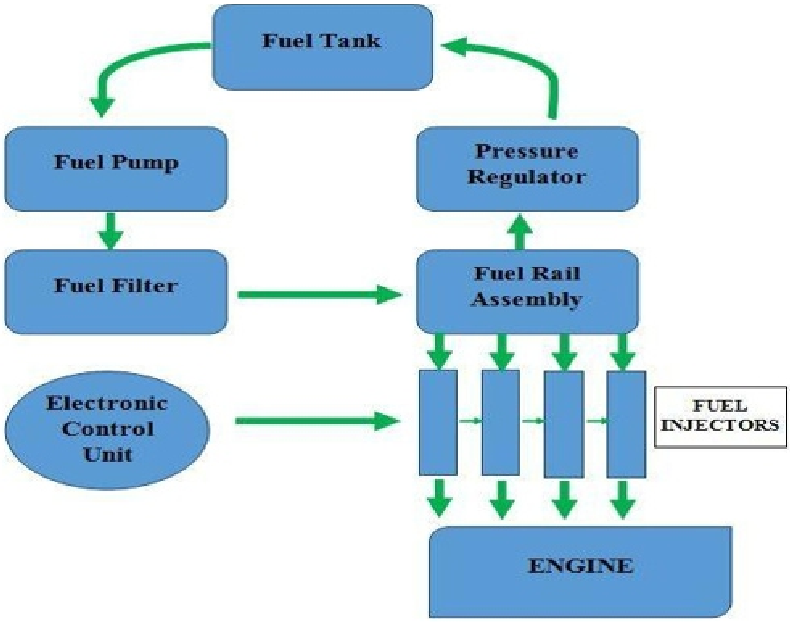

Fig. 1: Fuel pump delivery system

5. ANALYSIS

In this research, the root cause analysis of the problems in the fuel pump has been conducted. The quality issues are identified after the voice of customers is noted, which is nothing but a feedback of the problem from the customers. Fuel pump is an automobile component that pumps the liquid fuel to fuel injection system of the engine from the fuel tank. It pushes or pumps fuel from the gas tank to the fuel injector or carburetor. It creates the adequate amount of pressure to ensure that the required amount of fuel shall be supplied to the engine, regardless of external conditions. The 47 numbers of fuel pumps were received back from the dealers in February 2016; which were still in warranty period. The data regarding the quality issues were then gathered through Voice of customers. An analysis of those 47 fuel pumps was performed in the plant; using various quality control tools, including Cause-Effect diagram, Checksheet, Pareto analysis and 5-Why analysis, and presented in the following section:

5.1. Fish-Bone Diagram/Ishikawa Diagram

A fish bone diagram is presented in order to find the causes of the effect. In this study, various men, materials, methods, equipments, environment causes have beenanalyzed against the effect of defective fuel pumps and the resulting Ishikawa diagram is shown inFig. 2.

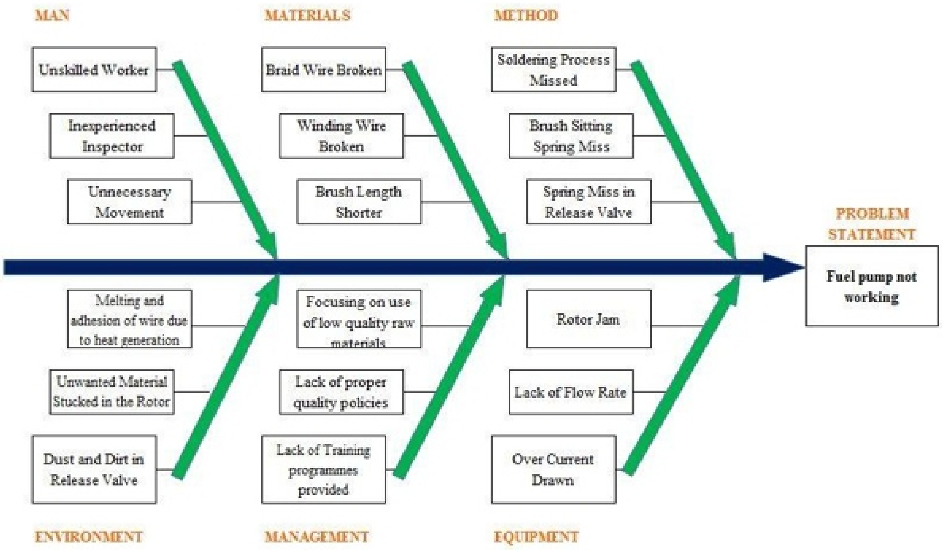

Fig 2: Fishbone diagram for defective fuel pumps

5.2. Check Sheet

The number of occurrence of each effect in the fuel pumps i.e. the frequency of defects is gathered and organized using the Check sheet; shown in Table 1.

Table 1: Check Sheet of the defects

Defects	No. of Defects	Frequency of Defects
Positive brush length shorter than specifications		21
Negative brush length is shorter than specifications		17
Winding wire broken		4
Over current in vehicle system		2
Winding wire short circuit		1
Soldering process missed		1
Dust on release valve		1
Total		47

5.3. Pareto Chart

The data obtained from the Check sheet was further employed for the construction of Pareto Chart. Pareto analysis helped to identify and prioritize two major defects–Positive Brush length- shorter than specification and Negative Brush length- shorter than specification, contribute about 81% of the defective fuel pumps.

The Pareto analysis of various defects is represented in Table 2 and Fig. 3.

Table 2: Percentage of the defects

Defects	Frequency of Defects	Cumulative Frequency	Percentage
Positive brush length shorter than specifications	21	21	44.68%
Negative brush length is shorter than specifications	17	38	80.85%
Winding Wire Broken	4	42	89.36%
Over Current in Vehicle System	2	44	93.62%
Winding Wire Short Circuit	1	45	95.74%
Soldering Process Missed	1	46	97.87%
Dust on Release Valve	1	47	100.00%

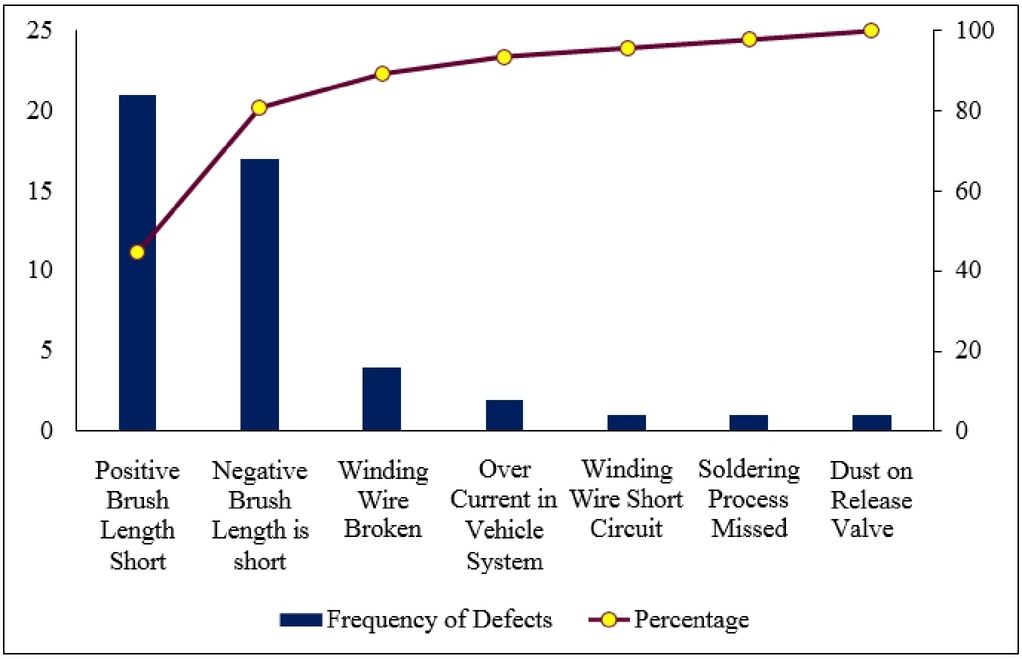

Fig 3: Pareto Diagram for defects analysis

5.4. Why-WhyAnalysis

The Why-Why analysis wasalso done in order to identify the root cause of the two major defects which was identified using Pareto chart. These "whys" were posed to concerned people in management and workers to obtain precise reasons behind the defects.Table 3 shows the 5 Why‟s for Positive Brush length and Table 4 shows the 5 Why‟s for negative Brush length.

5.4.1. Root Cause 1: Positive Brush Length

Table 3: Root Cause Analysis of Positive Brush Length Shorter than Specifications

Why 1	Fuel Pump isn?t working
Why 2	Positive brush length is shorter than specification
Why 3	Wear out of positive brush is caused with use of product
Why 4	Arcing on positive side leading to wear
Why 5	Low resistance of brush leading to high arcing
Root Cause	Low resistance of brush leading to high arcing

5.4.2. Root Cause 2

Table 4: Root Cause analysis of Negative Brush length-shorter than specifications

Why 1	Negative brush length is shorter than specifications
Why 2	Brush wear out with use of product
Why 3	High current flow through the brushes
Why 4	Short circuit (Hypothesis): "Coil to armature" or "Coil to Coil"
Why 5	Insulation of wire is insufficient
Root Cause	Insulation of wire is insufficient

6.RESULTS AND DISCUSSION

It was observed from the Fishbone diagram and Check sheet that brush length is shorter than the specified, winding wire broken, over current drawn, winding wire short circuit, soldering process missed and dust in the release valve are the main causes for the defective Fuel pumps.

Further, a Pareto analysis of these causes identified from Cause-Effect relationship, the two major defects– „Positive brush length‟ and „negative brush length‟ contributed to more than 80% of the total returned and defected fuel pumps.

As a next step, the root causes of these two major defects were determined through implementation of the 5 Why‟s tool. Low resistance of brush leading to high arcing was identified as the root cause of positive brush length being shorter than specified length and insufficient insulation of wire was identified as the root cause of negative brush length being shorter than specified length.

The concerned authorities have been conveyed these suggestions to eliminate the root causes of the defects resulting in operational-level malfunctioning in most of the automobile fuel pumps. The implementation of a preventive action shall definitely lead to reduce the defects in fuel pumps which shall improve the product quality.

7. CONCLUSION

All manufacturing firms aim for the continuous improvement of the products in order to provide complete customer satisfaction which depends on an un-interrupted part functioning. Seven Quality Control tools and 5-Why Analysis are important instruments in order to analyze defects in quality of products of the organizations at customer operation levels. By implementing these tools, manufacturing as well as service organizations can clearly identify the ground reasons affecting their quality levels and can take necessary steps to reduce the short-comings and enhance their product or service quality.

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He is having the teaching and research experience of more than 20 years and published more than 120 research papers in international and national journals of repute and in the proceedings of the conferences. He is also reviewer of 8 international journals. He also guided 4 Ph.D. and more than 24 post graduate theses and guiding 8 research scholars at present. He has also chaired international and national conference in India and abroad. He also organized two short term courses and two national level conferences for the faculty of technical institutions and industries. He is also recipient of first D. N. Trikha research award for excellent research publications in international journal for the year 2009 in PEC University of Technology.

Mechanical Behaviour of Polystyrene Reinforced Sugarcane Bagasse Composites

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ABSTRACT

This paper presents the study on some of mechanical properties of PS-SCB composites. The SCB was taken 10% by weight in all the synthesized PS-composites. Four different sizes namely, 75µm to 105µm, 105µm to 150µm, 150µm to 255µm and 255µm to 350µm of SCB particle were used to synthesize the composites. The composites were prepared by in- situ polymerization method. Hand operated injection moulding machine was used to make the test specimens. The effect of SCB particle size on the mechanical properties of the PS-SCB powder composites was studied

1. INTRODUCTION

Composites are combinations of two or more than two materials in which one of the materials is reinforcing phase (fibers, sheets or particles) and the other is matrix phase (polymer, metal or ceramic) [1]. The final properties of composites are function of the properties of the constituent phases, their relative amounts, as well as the geometry of the dispersed phase [2]. The use of natural fibers as reinforcements for composite has attracting more interest of industries. Fibers reinforced polymer composites have many applications as class of structural materials because of their ease of fabrication, relatively low cost and better mechanical properties compared to polymer resins. For example in the automotive industry, the effort to reduce weight in order to improve fuel economy and to comply with tighter governmental regulations on safety and emission has led to the introduction of increasing amounts of plastics and composites materials in place of the traditionally used steels [3]. Natural fibers reinforced polymer composites represent one of today's fastest growing industries. These fibers present a potential alternative in reinforced composites because of growing environmental awareness and legislated requirements compared to synthetic fibers such as carbon and glass [4]. Over the last few years, a number of researchers have been involved in investigating the utilization of natural fibers as load bearing constituents in composite materials. The use of such materials in composites has increased due to their relative cheapness, their ability to recycle and for the fact that they can compete well in terms of strength to weight ratio of material [5]

In this study we have used Sugarcane bagasse (SCB) as filler material. Bagasse is the fibrous residue which remains after sugarcane stalks are crushed to extract their juice. It is mainly used as a burning raw material in the sugar mill furnaces. The low caloric value of bagasse makes it a low efficient fuel. Also, the sugarcane mill management encounters problems of regulating the clean air, due to the quality of the smoke released in the atmosphere.

Sugarcane bagasse (SCB) wastes are chosen as an good raw material in manufacturing new products because of its low fabricating costs and high quality green end material. It is ideal due to the fact that it is easily available, given the extensive sugarcane cultivation making its supply constant and stable [5].

2. MATERIALS AND EQUIPMENT

1. Sugarcane bagasse (SCB): We obtained the sugarcane bagasse from Jamalpur, Aligarh, UP (India) to use as a filler material.

Figure 1.1 Formation of Bagasse composite

2. Matrix (styrene monomer): Styrene, the monomer, used in polymerization to synthesize virgin as well as PS-SCB composites.
3. NaOH of N/10
4. Acetone
5. Benzoyl peroxide (BPO)
6. Glassware and equipment

3. EXPERIMENTAL PROCEDURES

Sugarcane bagasse (SCB) particle was used as filler material. The SCB was first cleaned to remove contaminant and then dried for 5 days in sunlight. After drying, the SCB was ground in a food processor to obtain filler powder/particle. The fillers then passed through sieves of different sizes to get the required filler sizes. In the present study four different sizes of the filler powder i.e. 75μm to 105μm, 105μm to 150μm, 150μm to 225μm and 225μm to 350μm were used. The weight% of sugarcane bagasse filler of each type was kept constant which was equal to 10% of weight of styrene.

3.1 Washing of styrene

Styrene monomer is taken into separating funnel and shaken with N/10 solution of NaOH in water. This method is suitable for water insoluble monomer. The inhibitor reacts with alkali and the reaction product, being water soluble, comes out of the monomer phases and can be removed along with the aqueous phase. After through shaking, the NaOH/styrene solution is made still for about 2 minutes to separate out the monomer and alkali from the solution. The alkali solution is removed from the separating funnel. Washing with alkali is repeated twice to obtain pure styrene in this work.

3.2 Synthesis of polystyrene composites by in-situ polymerization

Through literature it has found that 0.011 g BPO is required for 5.5 ml of monomer. Hence in this case 1.0g of BPO is required for 500ml of monomer.

Synthesis of polymer composites by in-situ polymerization basically involved the dispersion of filler in styrene followed by free-radical polymerization initiated by the addition of benzoyl peroxide. Styrene monomer containing the desired amount of filler was mechanically mixed by stirrer for 30 minutes at room temperature in order to obtain better dispersion. The required quantity of benzoyl peroxide was then added to the mixture to initiate the polymerization which took place at 95°C at a constant speed (650 rpm) of stirrer in each case for approximately one and a half hour till the monomer solution becomes viscous i.e. completion of the reaction.

3.3. Sample Preparation.

The composites obtained at the end of polymerization were kept in an oven at 85°C for 2-3 days to complete polymerization and remove the remaining moisture and liquid styrene. Then the products were ground and subsequently the test specimens were prepared using a full ounce hand operated injection molding machine. The ASTM D638 and ASTM D790 Standards are used for tensile and flexural test specimen respectively.

Figure 3.1: Tensile test specimen (SCB and polystyrene composite)

Figure 3.2: Tensile test specimen (virgin)

Figure 3.3: Flexural test specimen (SCB and polystyrene composite)

Figure 3.4: Flexural test specimen (virgin)

4. RESULTS AND DISCUSSION

4.1. Tensile test

Tensile test was performed on UTM (universal testing machine) having maximum load of 5kN. The test was carried out at speed of 2mm/min at atmospheric condition (25 ^{0}C). The size of the specimens was in accordance of ASTM D638.

Table 4.1 Tensile strength of polystyrene composites

Filler content, (wt. %)	Filler size, (µm)	Max. Load. (N)	Tensile Strength, (MPa)
Virgin	-	166.67	4.51
10	255 to 350	667.5	18.05
10	150 to 255	872.5	23.7
10	105 to150	890.34	24.3
10	75 to105	1150	27.05

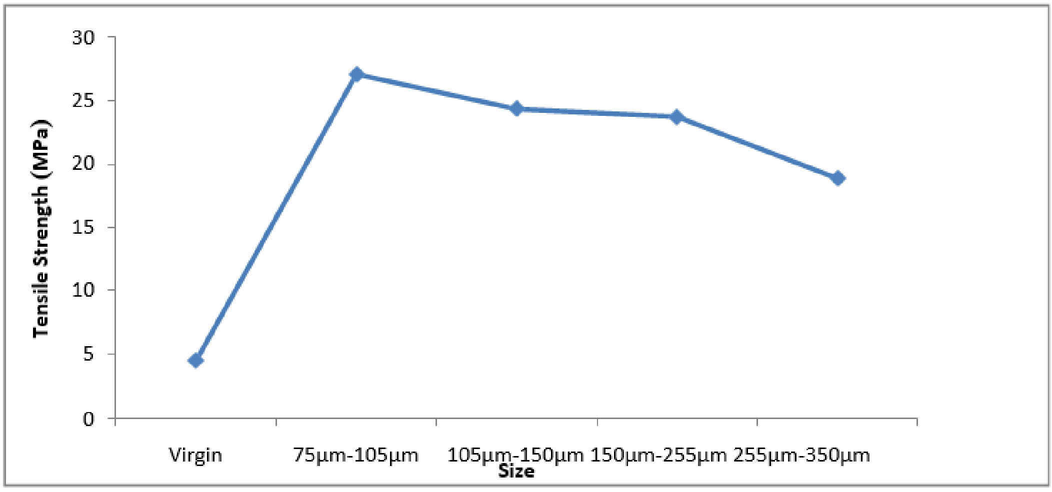

Figure 4.1: Effect of fillers size on tensile strength of synthesized polystyrene composites.

Table 4.1 shows the effect of particle size on the tensile strength of the SCB-PS composites. It is observed that addition of 10% filler of all the four different sizes is acceptable and it may be use. Addition of 10% filler drastically improves the tensile strength as compared to virgin polystyrene. The tensile strength increases as we decrease the size of the fillers. The tensile strength is maximum in SCB-PS composites of having filler particle size 75µm to 107µm. The maximum tensile strength comes out to be 27.05MPa. This may be due to the better dispersion in all filler size used in this study.

4.2. Flexural strength test

Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis. Test sample for flexural test was 127.0mm x 12.7mm x 3.2mm in size.

Here three point loading system was used. The specimens of above dimension were put on two supports and were loaded by means of a loading nose midway between the supports.

Table 4.2 Flexural strength of polystyrene composites

Filler content, (wt. %)	Filler size, (µm)	Load, (N)	Flexural Strength,(MPa)
Virgin	-	39	43.5
10	255 to 350	50	50.3
10	150 to 255	104.3	107.3
10	105 to 150	95.67	109.1
10	75 to105	63	52

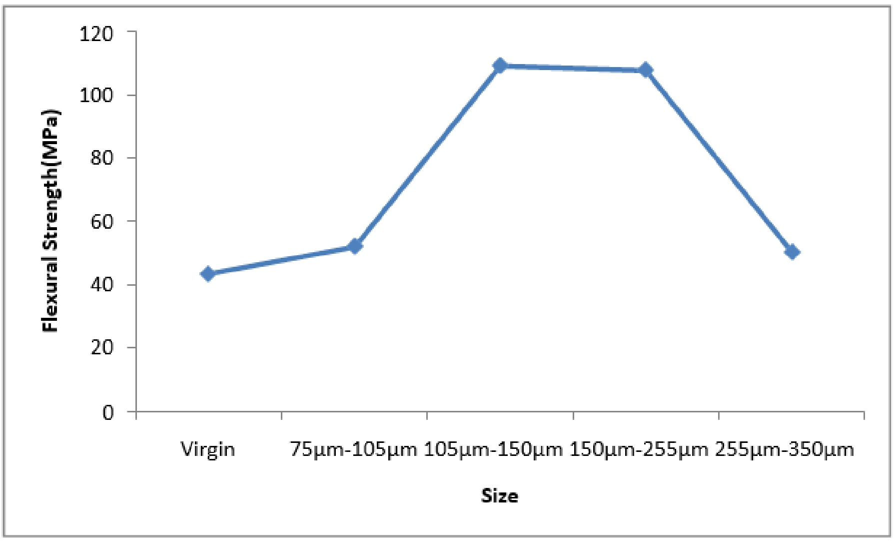

Figure 4.2: Effect of fillers size on flexural strength of polystyrene composites

In general, the addition of filler increases the flexural strength. The effect of particle size is significant at a level of 105µm - 255µm of particle sizes. It may be due to more uniform dispersion of filler.

3.1. Wear test.

Pin-on-disc test apparatus, of DUCOM Company Bangalore (India), was used to investigate the dry sliding wear characteristics of the synthesized polystyrene composite specimens. Composites were pressed against a rotating EN32 steel disc (hardness 65 HRC) of diameter 70mm and thickness 8mm, Figure 4.3(a). Three different loads viz. 3kg, 5kg and 7kg were applied normal to the specimen at a room temperature about 25°C. The speed of the rotating disc was kept constant i.e. 455 rpm. The time for each sample was set for 4 minutes. Test results were reported as weight loss in mg/min.

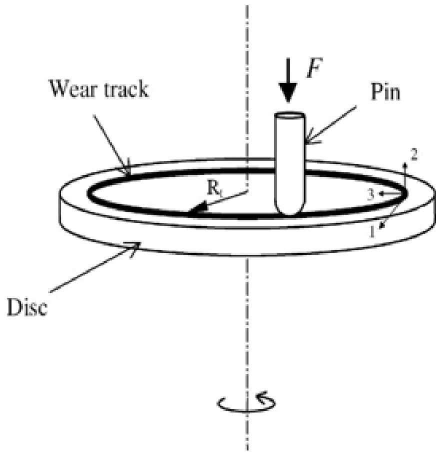

Figure 4.3(a): Wear principle **Figure 4.3(b): Wear testing machine**

Table 4.3 Wear rate of polystyrene composites

Filler content (wt. %)		Wear rate (mg/min) at load		
	Filler Size(µm)	3kg	5kg	7kg
10	255 to 350	12.45	26.98	33.8
10	150 to 255	9.77	17.0425	23.66
10	105 to 150	8.062	13.5025	17.32
10	75 to105	3.6	9.72	17.13
Virgin	Virgin	28.3	34.4	54.6

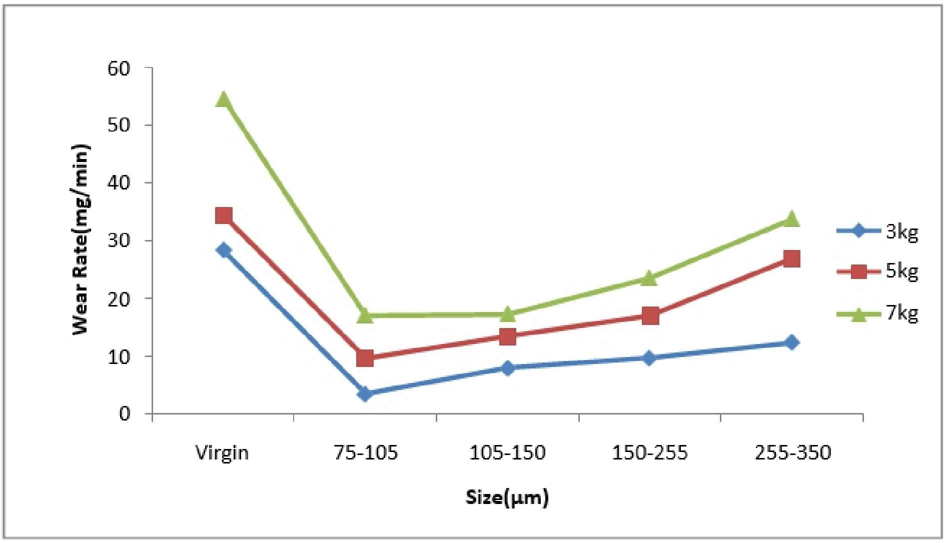

Figure 4.4: Effect of fillers size on wear rate of polystyrene composites.

As shown in table the wear rate increases as applied load increases. It is due to increase in friction between composite and the rotating disc. The wear rate decreases with addition of filler irrespective of particle sizes. The effect of the particle size on the wear rate is significant particularly at the level of 255 µm- 350 µm. the pattern is same for all the loads applied in wear test.

CONCLUSION

Addition of filler particles improves the mechanical properties and as the size of the particle decreases, tensile strength increases. Also with increase in filler size, flexural strength increases upto a level and then decreases. Composite having filler size 105µm to 150µm gives a significant increase in flexural strength. The effect of particle size on wear rate is significant. The lower the particle size, the lesser would be the wear rate at all the loads studied.

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Experimental Studies on Effect of Biological Quenching Media on Micro Structural and Mechanical Properties of AL Alloy Materials Used For Manufacturing IC Engine Piston Heads.

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A B S T R A C T

Literature revealed extensive work carried out, on the failure analysis of IC engine piston heads. The main focus was on determining the mechanical properties of piston head material, their microstructure, quenching media etc. The microstructure depends on densification during cooling, materials and alloying elements. Discrete references were reported in the literature on effect of variation of quenching parameters on the microstructure and mechanical properties of cast Al alloys used for manufacture of piston heads. The composition of the quenching media with additives needs an in depth study. An attempt is made in this paper to add different percentages of cow and sheep urine in the base quenching media and to study its effect on the micro structural and mechanical properties of the cast Al alloy materials used for piston heads. Cow and sheep urine are supposed to contain rich percentages of sodium, nitrogen, sulphur, manganese, silicon etc., homogeneously present and these elements will remarkably alter the microstructure in the areas namely, grain refinement, interlocking of grain boundaries and result in marginal to considerable improvement in the mechanical properties of the Al alloys. Sodium present is the cow and sheep urine results in grain refinement and si along with other elements helps in interlocking of grain boundaries. The present experimental work consists of i) quenching process using different percentages of cow and sheep urine in the base quenching media, ii) Testing of different mechanical properties like tensile strength, yield stress, etc and iii) obtaining the Microscopic images of the fractured test specimens. Various experimental results are presented and discussed. The conclusions drawn out of the present work are listed. The major contribution of the present work is to study the effect of adding cow and sheep urine with different percentages during quenching process and to note the mechanical properties and microstructure. It has been observed that there is an over all marginal improvement in the mechanical properties of the Al alloys and there is appreciable refinement in the grain boundaries, paving way for improved mechanical properties.

Keywords: Piston heads, Mechanical properties, Microstructure, Grain Refinement, Failure Analysis.

1.0. INTRODUCTION

In the area of IC Engines, piston head happens to be the most critical part and lot of research is being undertaken for the failure analysis of piston heads covering poor lubrication, insufficient clearances, abnormal combustion and thermal and mechanical fatigue failure [5]. The research was aiming at detection of failure and to develop a preventive maintenance plan against the total failure of piston heads and related crucial parts like piston rings, etc. The analysis of microstructure of the failed piston heads revealed that the failure or initiation of cracks have developed at places where there was defects in the microstructure, areas where there was stress concentration and dendrite formation areas. The local microstructure bears a good correlation with the piston head failure [8]. The casting method used for manufacturing piston head is very important since it decides the failure. The microstructure which is responsible for failure of piston heads depends not only on the casting method, but also on the parameters used for quenching the piston heads [2]. Water, oil and gas quenching were tried and the microstructure for above was studied. Manganese, silicon, nickel etc are mixed with quenching media and experimental studies were conducted to study the microstructure and mechanical properties [4]. It was reported that there was a marginal improvement in the grain refinement in the microstructure followed by improvement in the mechanical properties. However there were only discrete references in the literature on above wok and consolidated results are yet to be obtained. This paper attempts to add different percents of cow urine and sheep urine with the quenching media and to study the effect of the same on microstructure and mechanical properties of cast Al alloys which are used for manufacture of piston heads. The important reason being sodium, nitrogen and silicon etc [3] , during the process of quenching help the grain refinement of microstructure, interlock the grain

boundaries with above additives. Literature only made discrete references on above method of quenching and an in depth study is yet to be carried out. This paper attempts to investigate the effect of variation quenching parameters like temperature of quenching, media of quenching with special reference to addition of different percentages of cow and sheep urine in the conventional quenching media, cooling rate, addition of additives etc. The metallurgical microstructure and mechanical properties are experimentally obtained and recorded. Various conclusions are drawn based on the experimental results. Various minerals and metals present in the cow and sheep urine are homogenously mixed. The presence of sodium relieves residual stresses resulting in improved mechanical properties [6,7]. Further addition of alloying elements will improve the mechanical properties [9]. Tensile strength, yield strength, hardness, toughness, etc are some of the mechanical properties observed at different quenching parameters together with the microstructure for each case. Basically quenching is a heat treatment process used for improving the mechanical properties of the components. Once the Al alloy has been heated to the recommended temperature and quenched at a rapid rate, a supersaturated solution forms between the media and Al alloy matrix. Simultaneous cooling rate during quenching is controlled by both temperature and the degree of agitation. This results in elimination of distortion and initiation of cracking. A detailed methodology of conducting experiments and strength values are given in sections present work and experimental work.

2.0 LITERATURE REVIEW

Extensive literature review was done on the quenching of Al alloys with varying quenching parameters like temp of quenching, quenching media and their effect on the mechanical properties and microstructure of the Al alloys. A brief review is presented below.

O.K. Abubakre etal [1], made detailed investigations on the properties of Al alloys quenched using different quenching parameters. They prepared specimens of 6061 Al alloys and quenched in water sea nut oil, palm oil at different temps (400°C, 450°C and 530°C). The effect of variation in temperature and quenching media on the mechanical properties were studies by them. They came out with distinct conclusions.

Arunkumar sathasivam etal [2], conducted experiments on antimicrobial activities ofcow urine distilled against clinical pathogens and established that cow urine could be used in treating metals and materials for their improved properties.

Pitawall etal [3], did extensive work on the chemical structural changes in biolite in medical field using cow urine as solution media and have suggested that the same can be extended to metals. They concluded that the ph value helps in removing the toxic elements and improve the properties of the biolite material.

Ipsita etal [4], did extensive work on diversified uses of cow urine and has reviewed many research articles. They have identified many fields where cow urine is used as a medicine and have suggested the application of the same for metallurgical materials. Cow urine contains sodium, nitrogen, sulphur, mn, silicon etc and can be used as a quenching media for metals. The in gradients of cow urine will drastically change the microstructure of the metals.

Kunyn etal [5], studies mechanical properties and microstructure of Al alloy 2618 with Al3 (Sc,Zr) phases at different temperatures. The addition of sc and Zr resulted in grain refinement with increased strength properties. Normally at elevated temperature it is difficult to maintain toughness and microstructure . The addition Sc and Zr has addressed this issue considerably, leading to better thermal stability and precipitation hardness.

S.P Nikanoror etal [6], studied structural and mechanical properties of Al- Si alloys obtained by fast cooling of a levitated melt, and extended its applications to materials used for IC engine piston heads. The process of solidification demines the properties of the solid. They tried different percentages of si in Al matrix and tried at different temperatures and analysed the mechanical properties and microstructure.

Cheefai etal [7], conducted hardness tests on precipitation hardening of Al alloy 6061-T6. Precipitation hardening is a thermal process which consists of heat treatment, quenching and artificial ageing process. They worked in a temperature range of 175°C to 420°C and arrived at optimum ageing time and temperature. They listed their conclusions.

Garibaldi etal [8], did extensive experimental work on fracture toughness and microstructure in Al 2XXX aluminium alloys. They studied the toughness properties of Al alloys with different micro structural conditions. The tests were performed at room temperatures as well as at elevated temperatures. They concluded that toughness and microstructure are inter related.

R.S. Rana etal [9], presented reviews on the influence of alloying elements on the microstructure and mechanical properties of Al alloys and Al alloy composites, they referred to the application of Al alloys in automotive industries. Through pure Al has inherent draw bacs, suitable alloying elements improve the properties. Al alloy composites find wide applications. Suitable alloying helps improving the microstructure and there by improves mechanical properties.

3.0. ISSUES AND CHALLENGES RELATED TO PRESENT WORK

1. Extensive literature reviewed is to be made to ascertain the as on today technology on quenching methods.
2. A scientific method is to be developed for studying the metallurgical microstructure of the fractured specimens.
3. Standard test specimens for estimating various strength properties are to be designed and machines.
4. Suitable strength measuring equipments are to be selected.
5. What is being done in the current work is a simulation work. The results are to be transformed for real time piston head Al alloys.

4.0 SCOPE AND OBJECTIVES OF PRESENT WORK

The scope of present work is to study the effect of varying quenching parameters, with special reference to adding different percentages of cow and sheep urine in the base quenching media, on the micro structure and mechanical properties of Al alloys with an objective of obtaining improved mechanical properties of Al alloys used for manufacture of piston heads.

5.0. FORMULATION OF PROBLEM

Since piston heads form the critical components of IC engines and are subjected to extreme stress conditions, any research through improved micro structure goes a long way in the life of piston heads. The methods of casting, heat treatment and quenching play a major role in deciding the strength of the Al alloys used for manufacture of piston heads. Hence the current problem consists of using different percentages of cow and sheep urine in the base quenching media and conduct quenching. The microstructure and mechanical properties are investigated.

6.0. PRESENT WORK

The Present work is carried out through the following steps.

6.1. Selection of materials

The Material chosen for present work is cast Al alloy with IS designation 2585 (Al 2585), which has good strength and hardness at elevated temperatures. About 5 Kg of small billets of this Al alloy is obtained from M/s Suthakar Al alloys ltd. Coimbatore, Tamil Nadu, in addition quenching medium namely water, medium capacity melting furnace (up to 1000°C), heat transmit furnace (up to 500°C) are also procured.

6.2. Selection of Testing Equipment

Various measuring equipment like, tensile testing machine, grinding machine etching reagent and poly shine metallurgical microscope are selected based on the requirement.

Etching Agent for aluminium is : Ammonium Sulphate Paste
Nital : remaining materials

Tensile test Machine Specifications:

MODEL: WDW-300

Max load :300KN Load accuracy : ≤± 1%

Load range 2% - 100% of full scale Test speed : 0.01-250mm/min Speed accuracy: ≤± 1% Displacement resolution 0.01mm Effective test width: 570mm

Load frame type :table type Effective tensile space : 600mm Effective compressive space : 700mm Dimensions: 1130X650X2650 mm Power supply :380 V 3ph,413 KW Weight: 1800kg

Grips: Plate type

Metallurgical Micro scope Specifications

Magnification 30X Model No: METZ-1395

Diameter: 20mm

Number of axis : 3 – axis (2 table, 1- eyepiece)

Eyepiece: WF15 X with cross recticle Objective: 2X

Grinding Machine Specifications:

Surface plate material Grey cast Iron duly ground level to 00 level.

Water circulation tube diameter 12mm duly perforated to drip the water on respective surface plates.

Clamp material :Hylam strip. Clam type : M6 wing nuts.

Dimensions "18X12". Weight 15kg.

Polishing machine Specifications: (double disc)

Mechanical dimensions :405mm height, 350mm width, 550mm length

Drive: two independent drive Drive capacity: 0.25HP A/C motor 220 volts 50Hz

Drive control: with 1000 watt capacity electronic regulator

Disc dia: 210mm 8"

Disc material: special alloy casting cloth hold through grooved spring setup.

Table top: Laminated plywood optional Basin: rust proof SS basin

Tap: 360 degrees swivel lab cock Power switch : rocket with indicator Finish: power coated

Mounting : table top or civil platform mounting.

6.3. Identification of chemical composition of Al 2585

The following is the composition of Al 2585.

Cu – 10%

Mg – 0.3%

Si – 2%

Fe – 0.7%

Mn – 0.5%

Ni – 0.5%

Zn – 0.1%

Pb – 0.1%

Na – 0.1%

Al – 87.5% (remaining)

6.4. Quenching media

Base quenching media is water with 10%, 20%, 30%, 40% and 50% of cow and sheep urine mixed separately.

6.5. Experimental procedure

30 sand moulds are prepared for casting standard lab tensile testing specimens and the casting are obtained. Preliminary heat treatment is done for the specimens to relieve residual and thermal stresses.

Followed by heat treatment, quenching operation at 3 different temperatures (350°, 400° and 450° C) with 10%, 20%,30%,40% and 50% cow and sheep urine mixed with water carried out. A total of 30 specimens are required for above quenching operations.

After quenching , various strength tests namely tensile strength, yield strength are carried out. The usual lab testing procedure is followed for above purpose.

The broken specimens are polished, etched and the microstructure of the broken surface is considered using metallurgical microscope. Actual experimentation is described in the next section.

7.0 EXPERIMENTAL WORK

Quenching media with 10% of cow urine is prepared and mixed well and a machined specimen is quenched at 350°C. The experiment is repeated with 20%,30%,40% and 50% of cow urine at the same 350°C (Total 5 specimens).

The above experimentation is repeated at 400°C and 450°C (total 5+5=10 specimens).

Hence a total of 15 specimens are used for above experimentation.

The above sets of experiments are repeated with sheep urine (Another 15 specimens). Hence a total of 30 specimens are made ready for strength testing.

Further the microstructures of the 30 specimens are obtained after suitable polishing and etching.

The values are tabulated, suitable graphs are drawn and the results are discussed in the next section (section 8 results and discussions).

8.0 RESULTS AND DISCUSSIONS

Experiments are conducted in line with what was described in sections 6 and 7 and the values are tabulated though tables 1 to 17 and using the tabulated values graphs (Graph 1 to Graph 17) are drawn as detailed below.

From tables 1 to 17 and graphs 1 to 17 we observe the following.

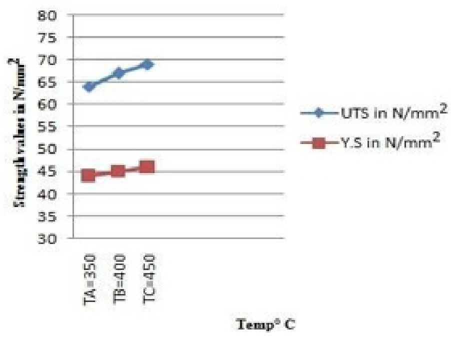
1. For 100% water quenching media the strength values (UTS & Y.S in N/m m2) are lower than any percent of cow urine or sheep urine at the corresponding temperatures.
2. For a given percentage of cow or sheep urine mixed in water quench media the strength values are always lesser than 100% water.
3. For a given percent of cow or sheep urine mixed in water the strength values increase with temperature.
4. For a given temperature as the percent cow or sheep urine increases the strength values increase.
5. A close examination of the microstructure revealed that, in general the Na present in the urine is responsible for grain refinat and si present is responsible for interlocking of grain boundaries. The combined effect is responsible for increased strength values.
6. Cow urine mixing has more influence on strength values than sheep urine mixing.
7. It is expected that variation of quenching time will influence the strength preparation and this fact may be verified by conducting another series of experiments.
8. In general, as the percent cow or sheep urine increases there is an increase in the strength values. However beyond some percentage the strength values get reduced. This is because too much of Na or Si will reduced the grain strength and hence the strength values.
9. The above fact can be seen clearly through the microscopic pictures. (The pictures will be provide latter).

The tables and graphs are presented below.

A. 100 % Water with Temperature variation

S. No	% Water	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm2	Y.S in N/mm^2
1	100	350	90	64	44
2	100	400	90	67	45
3	100	450	90	69	46

Table 1

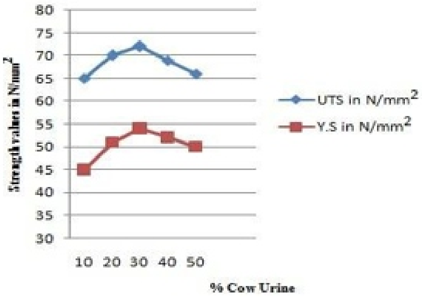


Graph 1

B.Different % of cow urine with Temperature

S. No	% cow urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm2	Y.S in N/mm^2
1	10	350	90	65	45
2	20	350	90	70	51
3	30	350	90	72	54
4	40	350	90	69	52
5	50	350	90	66	50

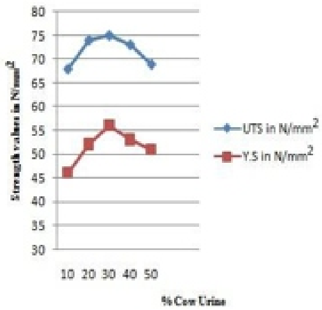
Table - 2



Graph – 2

S. No	% cow urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm2	Y.S in N/mm^2
1	10	400	90	68	46
2	20	400	90	74	52
3	30	400	90	75	56
4	40	400	90	73	53
5	50	400	90	69	51

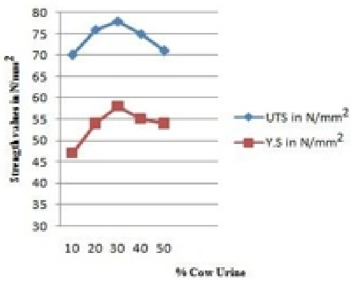
Table - 3



Graph - 3

S. No	% cow urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm2	Y.S in N/mm^2
1	10	450	90	70	47
2	20	450	90	76	54
3	30	450	90	78	58
4	40	450	90	75	55
5	50	450	90	71	54

Table - 4

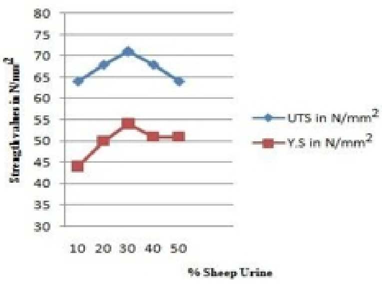


Graph – 4

C.Different % of Sheep urine with Temperature

S. No	% Sheep urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm2	Y.S in N/mm^2
1	10	350	90	64	44
2	20	350	90	68	50
3	30	350	90	71	54
4	40	350	90	68	51
5	50	350	90	64	51

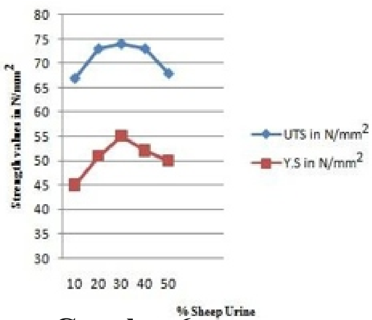
Table - 5



Graph – 5

S. No	% Sheep urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm2	Y.S in N/mm^2
1	10	400	90	67	45
2	20	400	90	73	51
3	30	400	90	74	55
4	40	400	90	73	52
5	50	400	90	68	50

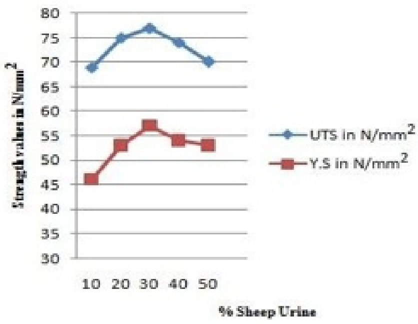
Table - 6



Graph – 6

S. No	% Sheep urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm2	Y.S in N/mm^2
1	10	450	90	69	46
2	20	450	90	75	53
3	30	450	90	77	57
4	40	450	90	74	54
5	50	450	90	70	53

Table - 7

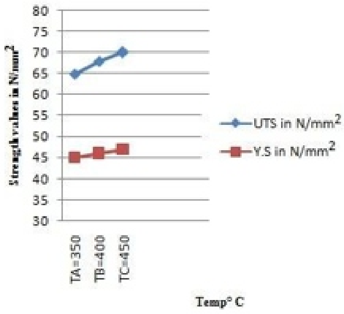


Graph - 7

D. Different Temperatures with Fixed % Cow urine

S. No	% Cow urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm^2	Y.S in N/mm^2
1	10	350	90	65	45
2	10	400	90	68	46
3	10	450	90	70	47

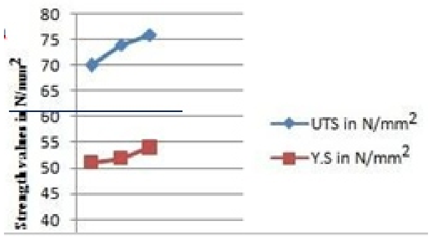
Table - 8



Graph – 8

S. No	% Cow urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm^2	Y.S in N/mm^2
1	20	350	90	70	51
2	20	400	90	74	52
3	20	450	90	76	54

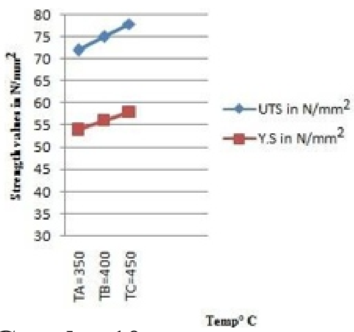
Table - 9



Graph - 9

S. No	% Cow urine	Quenching Temp°C	Time of Quenching	UTS in N/mm2	Y.S in N/mm^2
1	30	350	90	72	54
2	30	400	90	75	56
3	30	450	90	78	58

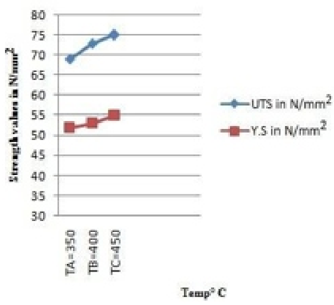
Table - 10



Graph - 10

S. No	% Cow urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm2	Y.S in N/mm^2
1	40	350	90	69	52
2	40	400	90	73	53
3	40	450	90	75	55

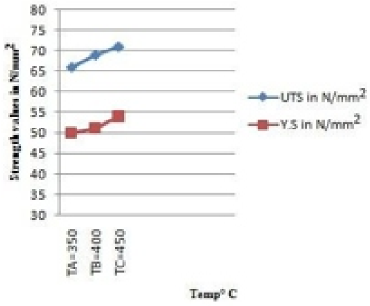
Table - 11



Graph - 11

S. No	% Cow urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm^2	Y.S in N/mm^2
1	50	350	90	66	50
2	50	400	90	69	51
3	50	450	90	71	54

Table - 12

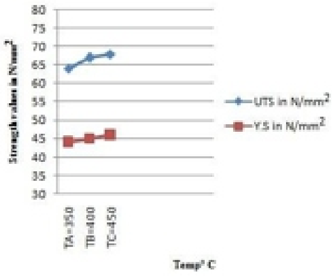


Graph - 12

E. Different Temperatures with Fixed %Sheep urine

S. No	% Sheep urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm^2	Y.S in N/mm^2
1	10	350	90	64	44
2	10	400	90	67	45
3	10	450	90	68	46

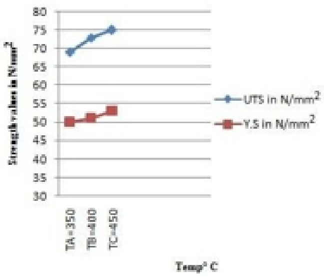
Table - 13



Graph – 13

S. No	% Sheep urine	Quenching Temp°C	Time of Quenching mins.	UTSin N/mm^2	Y.S in N/mm^2
1	20	350	90	69	50
2	20	400	90	73	51
3	20	450	90	75	53

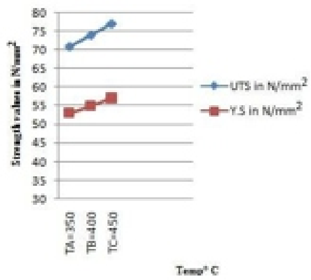
Table - 14



Graph – 14

S. No	% Sheep urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm^2	Y.S in N/mm^2
1	30	350	90	71	53
2	30	400	90	74	55
3	30	450	90	77	57

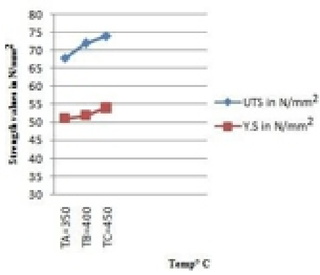
Table - 15



Graph – 15

S. No	% Sheep urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm^2	Y.S in N/mm^2
1	40	350	90	68	51
2	40	400	90	72	52
3	40	450	90	74	54

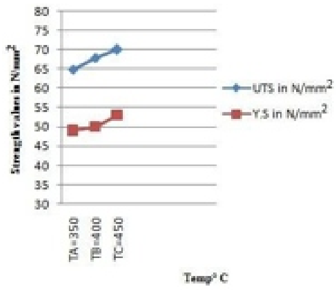
Table - 16



Graph – 16

S. No	% Sheep urine	Quenching Temp°C	Time of Quenching mins.	UTS in N/mm^2	Y.S in N/mm^2
1	50	350	90	65	49
2	50	400	90	68	50
3	50	450	90	70	53

Table - 17



Graph - 17

Summary of tables 1 to 17 and graphs 1 to 17.

Table 1 and Graph 1 correspond to temperature in °C and strength values using 100% water.

Table 2 and Graph 2 correspond to % variation of cow urine in water base quench media and strength values at 350°C.

Table 3 and Graph 3 correspond to % variation of cow urine in water base quench media and strength values at 400°C.

Table 4 and Graph 4 correspond to % variation of cow urine in water base quench media and strength values at 450°C.

Table 5 and Graph 5 correspond to % variation of sheep urine in water base quench media and strength values at 350°C.

Table 6 and Graph 6 correspond to % variation of sheep urine in water base quench media and strength values at 400°C.

Table 7 and Graph 7 correspond to % variation of sheep urine in water base quench media and strength values at 450°C.

Table 8 and Graph 8 correspond to variation of temperature for 10% cow urine with strength values.

Table 9 and Graph 9 correspond to variation of temperature for 20% cow urine with strength values.

Table 10 and Graph 10 correspond to variation of temperature for 30% cow urine with strength values.

Table 11 and Graph 11 correspond to variation of temperature for 40% cow urine with strength values.

Table 12 and Graph 12 correspond to variation of temperature for 50% cow urine with strength values.

Table 13 and Graph 13correspond to variation of temperature for 10% sheep urine with strength values.

Table 14 and Graph 14 correspond to variation of temperature for 20% sheep urine with strength values.

Table 15 and Graph 15 correspond to variation of temperature for 30% sheep urine with strength values.

Table 16 and Graph 16 correspond to variation of temperature for 40% sheep urine with strength values.

Table 17 and Graph 17 correspond to variation of temperature for 50% sheep urine with strength values.

9.0. CONCLUSIONS

The major contribution of the present work is to study the effect of adding cow and sheep urine with different percentages during quenching process and to note the mechanical properties and microstructure. It has been observed that there is an overall marginal improvement in the mechanical properties of the Al alloys and there is appreciable refinement in the grain boundaries, paving way for improved mechanical properties.

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