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# Experimental Investigation of Metal Matrix Composite using Aluminium 7075

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***Abstract: Aluminium alloy-based MMC have proven to be an appropriate wear resistant material, particularly for sliding wear applications. It is found that there are many factors that contribute to wear and all of them are by no means degrading to the environment. Because of their exceptional mechanical and tribological properties such that MMC are widely utilized in automobile, aerospace, marine, sports, defense, etc. The current study concentrations on the invention of aluminium compounds (AA7075-T6) reinforced with a strong % of Titanium carbide and Biowaste eggshells particles for the standard Stir casting routes. The hardness value gets increased and the tribological properties of wear rate also reduced in the MMC AA7075. Machining character of AA7075, TiC & Es is analyzed and found minimum surface roughness obtained 0.417 microns. The minimum surface roughness has obtained by experimentally when low spindle speed, moderate feed rate & depth of cut. Alongside, the Taguchi process has found various machining characteristics and individual contributions through ANOVA for the metal matrix AA7075, TiC & Es.***
***Keywords: Metal Matric Composite, AA 7075, TIC, Egg shells, Hardness & Wear strength***

## I. INTRODUCTION

The aerospace and automotive industries improved request for light materials with high strength has improve the production & use of metal-matrix composites (MMCs). MMCs are widely utilized in industries, as they have outstanding mechanical properties & wear resistance. MMC has gradually replaced some of the less common metals such as several grades of alloys. For requests where low weight & energy saving are significant things but without losing strength. A metal matrix composite (MMC) is a metallic matrix with three-dimensional inclusions (generally an alloy of Al, Cu, Mg, Ti, Fe, or Pb). The ductility of the metallic alloy as the matrix content is preserved in these MMCs, while the modulus & strength of the composites are improved due to the reinforcement phases. MMCs can be tailored to have superior electrical, mechanical, & even chemical properties by using the perfect combination of matrix material & reinforcements.

## II. LITERATURE REVIEW

This review presents the available literature survey on the outcome of different types of reinforcement, size & fractional volume, the aging process with AMMC's. Elumalai et al., [1] were experimentally analysed composite mechanical properties such as tensile, impact, & shear strength of double protects are greatly enhanced until the two formations are then reduced due to the high fly ash content. The presence of TiC & fly-ash has caused in improved impact & tensile strength in the 2$^{nd}$ sample. As the reinforcement volume increases the stiffness of the combined increase. The increase in the % of TiC & fly-ash weight leads to the formation of porosity & the creation of clusters. Pradeep Devaneyan et al., [2] The highest micro hardness value was 52.12 HV, which was obtained using Al 7075 90%, SiC 4%, & TiC 4%. The sample density has the lowest coefficient of friction related to the other samples, according to the ring compression test. This is due to the addition of SiC & TiC to the MMC, which results in an improvement in wear resistance. The highest value of coefficient of friction was achieved in the study, which contained 100% Al 7075, 0% SiC, & 0% TiC, as well as the lowest micro hardness. Ramakoteswara Rao et al., [3] & [4] It was also discovered that composites have a lower wear rate than matrix metal. Furthermore, the wear rate reductions as the weight fraction of TiC growths, while the coefficient of friction decreases as the sliding velocity and weight fraction of TiC increase. The existence of TiC and other phases was discovered using SEM-XRD analysis. As compared to other composites & matrix metal, 8 wt% TiC composites had better wear properties. To prepared by stir casting procedure and optimized volumetric wear at different parameters such as particle percentage of TiC, sliding speed and sliding distance. The specimens were examined Scanning Electron Microscope (SEM). Through Taguchi's technique, a plan of experiment generated and it is used to behaviour researches based on $L_{27}$ orthogonal array. The established ANOVA used to find the optimum wear under the influence of percentage of TiC, sliding speed, sliding distance. In all the cases, matrix material shows a higher volumetric wear rate than composites. 8 wt % of TiC composites show a lower volumetric wear rate (535.58 mm$^3$/sec) at minimum sliding distance and maximum sliding velocity of 1Km 2.61m/s, respectively.

Mahesh et al., [5] $TiO_2$ reinforced AMMC with a wt.% of 5 to 15 $TiO_2$ were manufactured using a powder metallurgy method with little or no pressure sintering. The impact of reinforcement on composite density, porosity, hardness, strength, & microstructure was studied. The Al-$TiO_2$ composites all increased as the weight percent $TiO_2$ was increased from 5 to 15%. The microstructure reveals that the reinforcement particles are distributed uniformly. Sivananth et al., [6] In this research, the wear & corrosion conduct of an Al-Si alloy with TiC was studied. Initially, stir casting was used to manufacture passenger car brake discs. The results revealed that TiC reinforced MMC has a higher wear resistance and friction coefficient than iron.

Azeem Dafedar et al., [7] We can increase the hardness by increasing compaction pressure while maintaining the sintering temperature constant. Each reinforcement should be 2%, 4%, 6%, or 8% of the total. The hardness of a metal matrix increases up to a certain point when reinforcement is included. Al is very light weight, & adding a small quantity of reinforcement increases its stiffness, which is very useful in applications where low weight and high strength properties are needed, such as aerospace and automobiles. Tong et al., [8] Al-Si/TiC composites outperform aluminum-based composites in terms of strength and ductility. As compared to rapidly solidified alloys & traditional composites, the RS Al/TiC & Al-Fe-V-Si/TiC show high Young's module & considerable changes in room & higher temperature properties. Because of the good interfacial bonding, the Young's modulus values of RS Al/TiC & Al-Fe-V-Si/TiC composites are well within Hashin-Shtrikman parameters. In this study, the RS technique was used to improve strength and ductility for a specific volume fraction.

Venkateshwar Reddy et al., [9] In the current analysis, three different reinforcement ratios (5, 10 and 15) were considered in the stir casting process. The fabricated samples were exposed to hardness & tensile tests. The results of the mechanical tests revealed that raising the reinforcement weight percent improved the tensile strength & hardness of the material. Pinon-disk tests were used to determine the tribological behaviour of the fabricated composites. The process variables were reinforcement weight %, load, & sliding speed, each with three levels, & the reply was the individual wear rate. The experiments were carried out and the findings were analysed using the Box–Behnken design. Shashi Prakash Dwivedi et al., [10] The metal matrix composite's high strength indicates that the SiC elements are evenly spread in the matrix C355. The tensile strength of (C355+5% SiC) AA decrease as the temperature rises.

Utilizing liquid metallurgy techniques, cast balanced (Al + 4% Cu + 5% SiC) composites were successfully developed (stir rout). The composites' hardness, impact, and tensile strength all improved as the grit size of SiC was increased. The best maximum value of hardness, impact strength, as well as ultimate tensile strength was obtained by pouring at 725°C. Once the pouring rate for all composites was kept steady at 2.5cm/s to say a Shubham Mathur & Alok Barnawal [11]. Sadi et al., [12] including satisfied of SiC from 0 - 15 wt. % with grain sized SiC of 400 mesh on stir casting process can decrease wear of Al-SiC composites about 90.08%. The same composites stir casting process, increase temperature of melt from 680 to 740$^{o}$C, it can decrease specific wear of 28.23%. Increasing rotation speed from 100 to 300 rpm can decrease specific wear of 14.07 %, but increasing rotation speed from 300 to 400 rpm will increase specific wear of 1.72 %. Increasing stirring duration from 10 to 40 minutes will increase specific wear of 10.28 %. Stir casting is the modest & greatest cost-effective process among the many available. The major negatives of stir cast Al-SiC MMC are the non-homogeneous distribution of SiC reinforcement in the matrix and the SiC ceramic particle's lower wettability with the molten Al matrix. The ratio of reinforcement, particle size, and fabrication route have the greatest impact on this parameter, its discussed by Yogesh Patel & Patel [13]. Suman Kant & Ajay Singh Verma [14] The majority of the researchers used a stir casting method to make the composite with various reinforcements such as SiC, $Al_2O_3$, fly ash, ground nut, as well as rice husk ash. The stir casting method, according to the authors, is the easiest & most cost-effective way to fabricate particulate form MMC.

## III. OBJECTIVES OF PRESENT WORK

Due to their various properties such as low density, good wear resistance, as well as surface finish, composite materials have become increasingly common in recent years. Titanium carbide (TiC) is a high-cost, low-density reinforcement that is easily obtainable as a solid waste by-product in ceramic plants. The strength of the hardness will also be calculated. To execute the above, an experimental

setup is created in which all of the required inputs are made. In this research, a composite material of aluminium reinforced with titanium carbide is developed by weight ratio of various percentages by Stir casting technique. The mechanical behaviour of hardness and wear has tobe analysed and consider surface roughness for turning operation by Taguchi design. This experimental study has processed based on flow chart (figure 1) as follows:

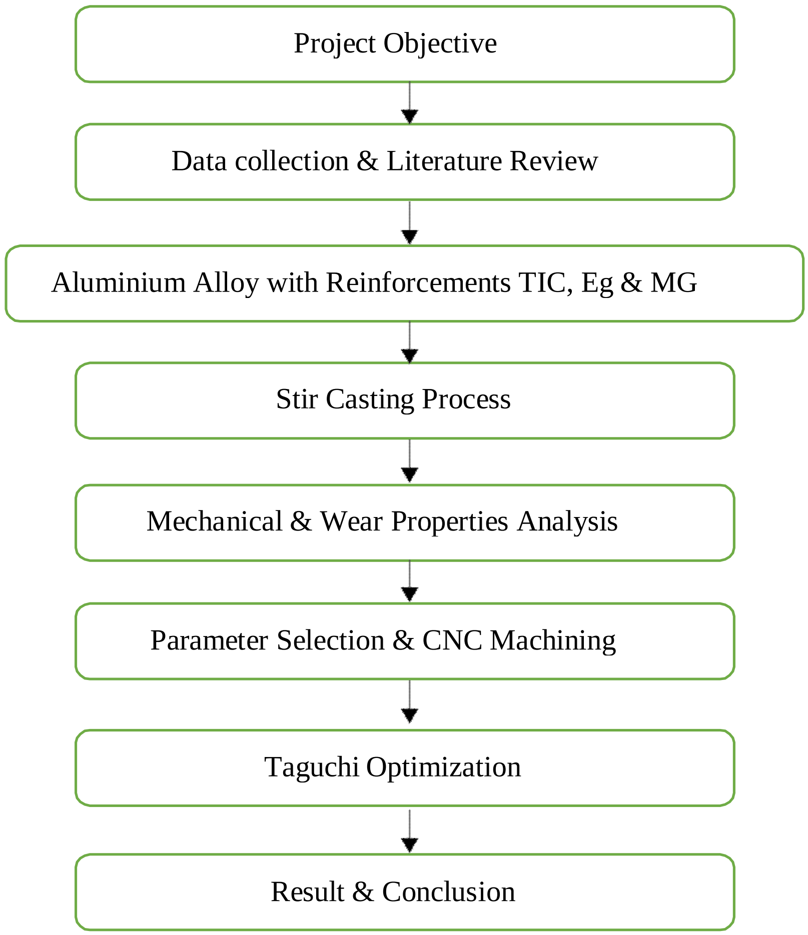


Figure 1 Process Plan

## IV. MATERIALS & PROPERTIES

Al 7075 has a respectable surface finish; high corrosion resistance is suitable for welding & can be simply made with anodized. Furthermost generally found as T6 temper, in the case of T4, it has respectable stability. The composition of Aluminium 7075 probably includes zinc, magnesium, copper, & less than half the percentage of silicon, manganese, titanium, iron, chromium, & other metals are shown in Table 1 & the mechanical properties tabulated below Table 2

Table 1. Typical Chemical Compositions for AA-7075

| Element | % Present | |
|---|---|---|
| | min | max |
| | | |
| Si | - | 0.40 |
| Fe | - | 0.50 |
| Cu | 1.2 | 2.0 |
| Mn | | 0.30 |
| Mg | 2.1 | 2.9 |
| Zn | 5.1 | 6.1 |
| Ti | - | 0.20 |
| Cr | - | 0.28 |
| Al | - | - |

Table 2. Al 7075 Mechanical Properties

| Description | Properties |
|---|---|
| Density | 2.8 g/cm3 |
| Melting Point | 660.2 °C |
| Modulus of Elasticity | 68.3 GPa |
| Thermal conductivity | 0.57cal/Cms°C |
| Crystal Structure | Fcc |
| Electrical resistivity | 2.69 |

TiC and Eggshell reinforcement particles have been used to produce MMCs aluminium hybrid. A TiC with a mass of 4.93g/cm$^3$ and an ES weighing 2.50g/cm$^3$ are used to produce the composite. The melting point of the TiC is 2730°C and 825°C respectively. TiC and Es have very low recurrence of molten aluminium metal and very low cost. The solid particles of the eggshell will improve the composite properties such as strength, wear, rust, and toughness.

## V. CASTING PROCESS

Combined materials of the aluminium metal matrix are a mixture of two or additional elements where one is a matrix & the other is a reinforcement. The AMMC may be composed of sheets, fibers, or particle components. These materials are generally handled through P/M, metal technology, or through a manufacturing development. Processing of an obsolete metal matrix material involves two main developments (1) metallurgy powder route (2) liquid cast metal technology. The process of powdered iron has its limitations such as processing costs and material sizes. Therefore, the only artificial scattering method should be considered as the most efficient and cost-effective method of processing aluminium composite materials. To improve the mixture, an aluminium 7075 rod and Titanium carbide (TiC) average of 200µm particles were purchased at the local market. The aluminium rod was melted by the magnesium movement and combined with the required amount of reinforcement.

### *A. Stir Casting*

Stirrers are used for imitation to regenerate a molten metal matrix. The stimulus is usually made of a material that can endure melting temperatures developed than the matrix temperature range. Typically, a graphite stirrer is used for imitation. The consists mainly of two parts of a rod & an impeller. One end of the rod is related to the impeller & the other end is related to the engine shaft. The stimulus is usually detained in the exact location stated in Figure 2 & is interchanged by the car at several speeds. The following molten metal is discharged into the die for use. Combine streaming is appropriate for producing mixtures with volumes of up to 30% solidification. The casting route is suitable for low volume components <20%, while the entry routes are most suitable for a high-volume component > 40%.

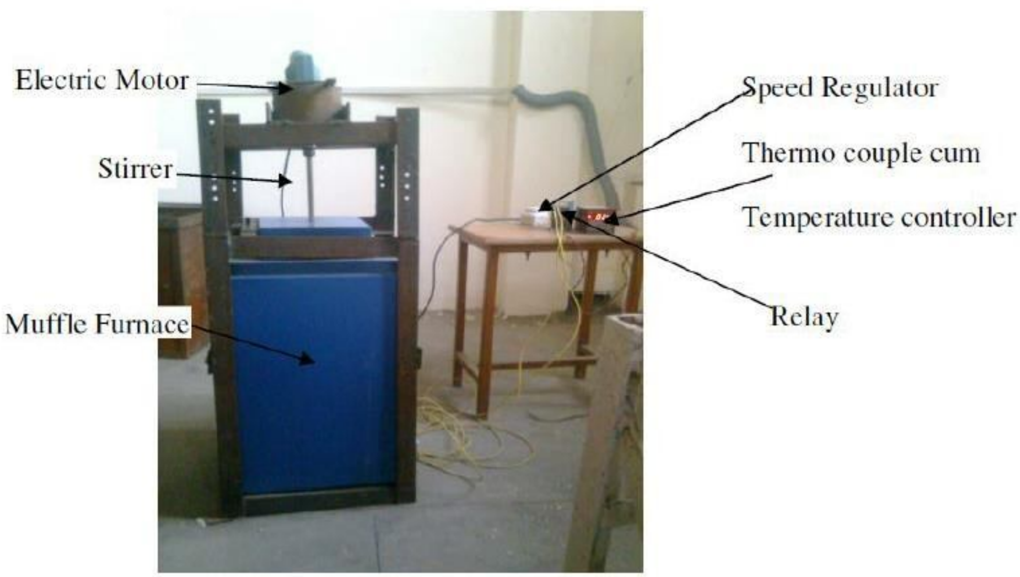


Figure 2 Stir Casting Setup

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The separation of reinforcement particles caused by different processing parameters & material properties results in a non-homogeneous metal distribution, which is a major concern identified with stir casting. The wetting state of metal particles, relative density, settling velocity, as well as other process parameters are among them. The velocity of the stirrer, angle of the stirrer, vortices cone, as well as other factors influence particle size distribution in the molten metal matrix. The MMC is heated above its liquid temperature in this process so that it is fully molten. The preheated reinforcement particles are then applied to the molten matrix & heated again until completely liquid, ensuring that they are thoroughly mixed. As a result, the MMC sample is prepared by the stir casting process, and the required samples are listed in Table 3.

1) *Factors Affecting Process:* Based on the review of various authors show that the following factors which affects most in the stir casting development. They are
a) Speed
b) Time duration
c) Temperature

Table 3. List of Sample by Stir Casting

| Sample ID | Material Composition |
|---|---|
| R1 | Aluminium Alloy 7075 |
| R2 | TiC -5% + Eg-2.5% & Mg- 1% -Remaining Al-7075 |

## VI. MECHANICAL TEST

### A. *Rockwell Hardness Test*

Rockwell's tough test technique involves depressing the test content with a diamond cone or sharp metal indenter. The indenter is required into the trial material further down the first small load $F_0$ generally 10 kgf. When symmetry is detected, the identification system that follows the indent movement and thus replies to deviations in the indent depth of penetration is set in the data area. While the first small load was used, another large load was used with the increase that led to the penetration. When the stability is reached once more, the additional load is unconcerned but the original load is still retained. The removal of the additional heavy load permits limited recapture, thus falling the depth of the penetration. A permanent growth in the depth of penetration, resulting from the use & discharge of the extra load is used to compute the amount of hardness referred to in Table 4.

Table 4. Results of Rockwell Hardness Test

| Sample ID | Material Combination | HRB |
|---|---|---|
| R1 | Al-7075 | 64 |
| R2 | TiC -5% + Eg-2.5% & Mg- 1% + Al-7075 | 73 |

### B. *Wear Test*

A tribometer is a tool that measures tribological values, such as the coefficient of friction, force friction, & volume wear, between the two contact points. A tribotester is a common term given to a machine or device used to perform tests and simulations of dress, collision, and anointing that is the subject of a tribology course.

1) *Technical Specification of Wear Machine*
a) *Test Speed:* 600RPM
b) *Normal Load:* 40N
c) *Pin Diameter:* 10mm
d) *Track Radius:* 30mm

The vertical pin is pushed compared to the revolving disk under a specified load. The pin can be any shape; however, the greatest general shape is a circle (ball or lens) or cylindrical due to the ease of arrangement of these anchors. Throughout the trial, the dressing is considered continuously. The typical wear rate vs time curve recorded pin on disc items is shown in the Figure below 3 & 4.

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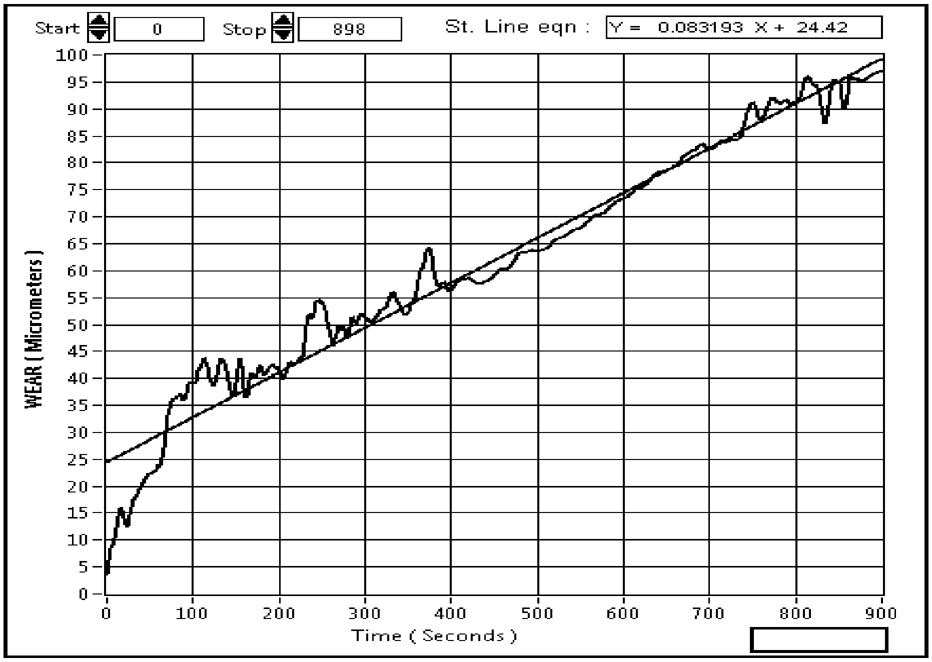


Figure 3 Wear Test on Sample 1

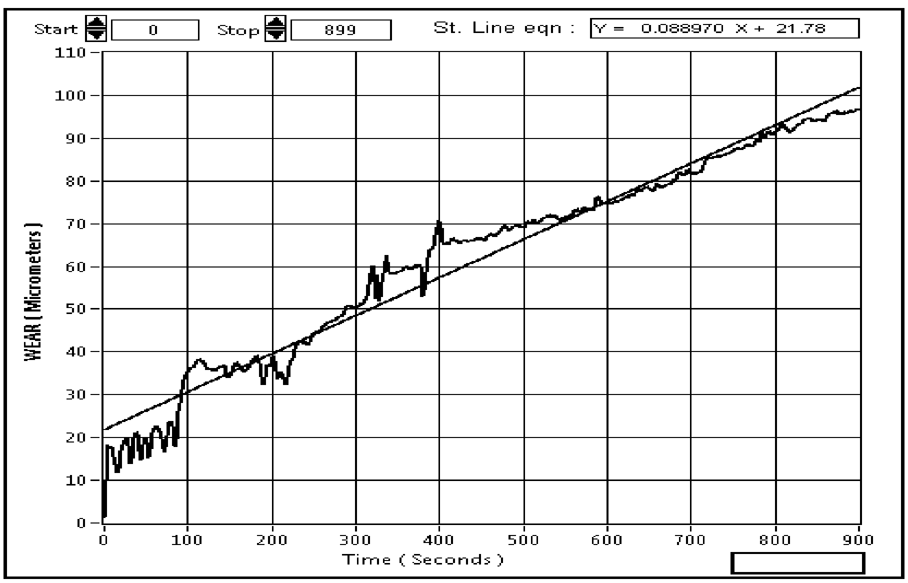


Figure 4 Wear Test on Sample 2

According to the wear test were found the wear rate ofAA7075 is higher than metal matrix combination (TiC -5% + Eg-2.5% & Mg- 1% + Al-7075) comparatively. The weight difference of the specimen has found in before and after testing is tabulated below Table 5.

Table 5. Weight Measurement Before and After Wear Test

| MATERIAL RATIO | WEIGHT BEFORE TEST | WEIGHT AFTER TEST | DIFFERENCE |
|---|---|---|---|
| Al-7075 | 6.5979 | 6.5821 | 0.016 |
| TiC -5% + Eg-2.5% & Mg- 1% + Al-7075 | 6.2458 | 6.2314 | 0.014 |

## VII. TAGUCHI DESIGN

Basically, the Design Experiment methods were developed to get the original equipment. However, test approaches are very difficult & not relaxed to use. In addition, a great number of tests should be performed when the quantity of development parameters rises, to resolve this problematic, the Taguchi technique uses a structure of the same orthogonal members to research the whole limitation area with only a minor number of tests. In the parameter design phase of the Taguchi technique, the first stage is to set and choice the suitable orthogonal array (OA). To adopt the three control elements in the experimental study, the experimental design based on Taguchi, L9 ($3^3$) was selected for use in this study and is shown in Table 6 and the CNC machine exhibition in Fig. 5.

Table 6. Process Parameters and Variables

| S.No | Spindle Speed (N) (RPM) | Feed (mm/Rev) | Depth of Cut |
|---|---|---|---|
| 1 | 1200 | 0.08 | 0.4 |
| 2 | 1200 | 0.10 | 0.6 |
| 3 | 1200 | 0.12 | 0.8 |
| 4 | 1300 | 0.08 | 0.6 |
| 5 | 1300 | 0.10 | 0.8 |
| 6 | 1300 | 0.12 | 0.4 |
| 7 | 1350 | 0.08 | 0.8 |
| 8 | 1350 | 0.10 | 0.4 |
| 9 | 1350 | 0.12 | 0.6 |

### *A. Experimental Arrangement and Process Parameters Levels*

1) *Machine Tool:* Batliboi smarturn CNC lathe.
2) *Work Specimen Material:* TiC -5% + Eg-2.5% & Mg- 1% + Al-7075
3) *Size of Material:* Φ32mm X 60 mm.
4) *Tool Material:* Carbide-TAEGUTEC-TT-5100-04 inserts.
5) *Environment:* Coolant not used.
6) *Metal removal rate Calculation:* Through weight.
7) *Machining time Measurement:* From CNC machine.


Figure 5. CNC Machine

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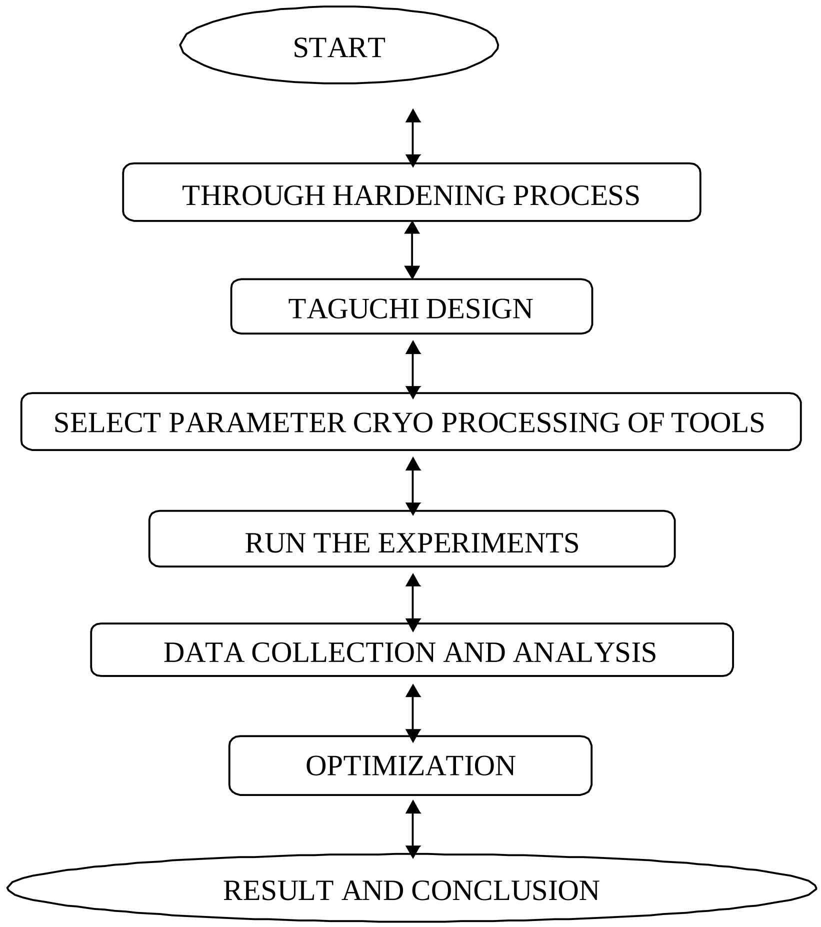
The proposed work approach and methodology has been elaborately shown in the flow chart as follows:




The MS bars (32 mm wide and 60 mm long) required for testing are pre-designed. Nine numbers of the same object and the same size are made. Subsequently, using various levels of boundary development 9 samples turned to CNC consequently. Afterward machining, surface roughness unrushed exactly with the help of a moveable stylus-type profilometer, Talysurf (Taylor Hobson, Surtronic 3+, UK). The consequences of the researches have been tabulated in Table 7. Study has been made based on investigational statistics in the resulting below. Taguchi improved the surface roughness and the rate of material removal.

Table 7. Results of Experiment by using Taguchi Method

| S.NO | SPEED (N) (RPM) | FEED (mm/Rev) | MT SEC | RA micron | MRR |
|---|---|---|---|---|---|
| 1 | 1200 | 0.08 | 107 | 0.537 | 0.027 |
| 2 | 1200 | 0.10 | 96 | 0.417 | 0.030 |
| 3 | 1200 | 0.12 | 83 | 0.814 | 0.034 |
| 4 | 1300 | 0.08 | 94 | 0.545 | 0.031 |
| 5 | 1300 | 0.10 | 76 | 0.847 | 0.038 |
| 6 | 1300 | 0.12 | 83 | 0.893 | 0.036 |
| 7 | 1350 | 0.08 | 88 | 0.632 | 0.034 |
| 8 | 1350 | 0.10 | 79 | 0.798 | 0.038 |
| 9 | 1350 | 0.12 | 89 | 0.858 | 0.034 |

## VIII. CONCLUSION

Titanium carbide and chicken eggshell (TiC & ES) were successfully incorporated into the Al7075 matrix alloy by the stir casting process. Composite materials mainly Aluminium 7075 and Titanium carbide and chicken egg and magnesium are a combination with good mechanical and comparable properties compared to conventional materials. Used in a variety of industrial applications these materials have low weight and high hardness. From the investigation, the amount of hardness increased and the affected areas wore a reduced and matrix steel AA7075 Composites.

The present study also investigated and standardized of the metal matrix composites of the machining characteristics of CNC turning process.

1) Good surface quality of roughness about 0.417 microns is obtained during turning operation.
2) The minimum surface finish was obtained when Spindle speed was 1200 rpm, feed 0.10 mm/Rev & depth of cut of 0.6 mm.

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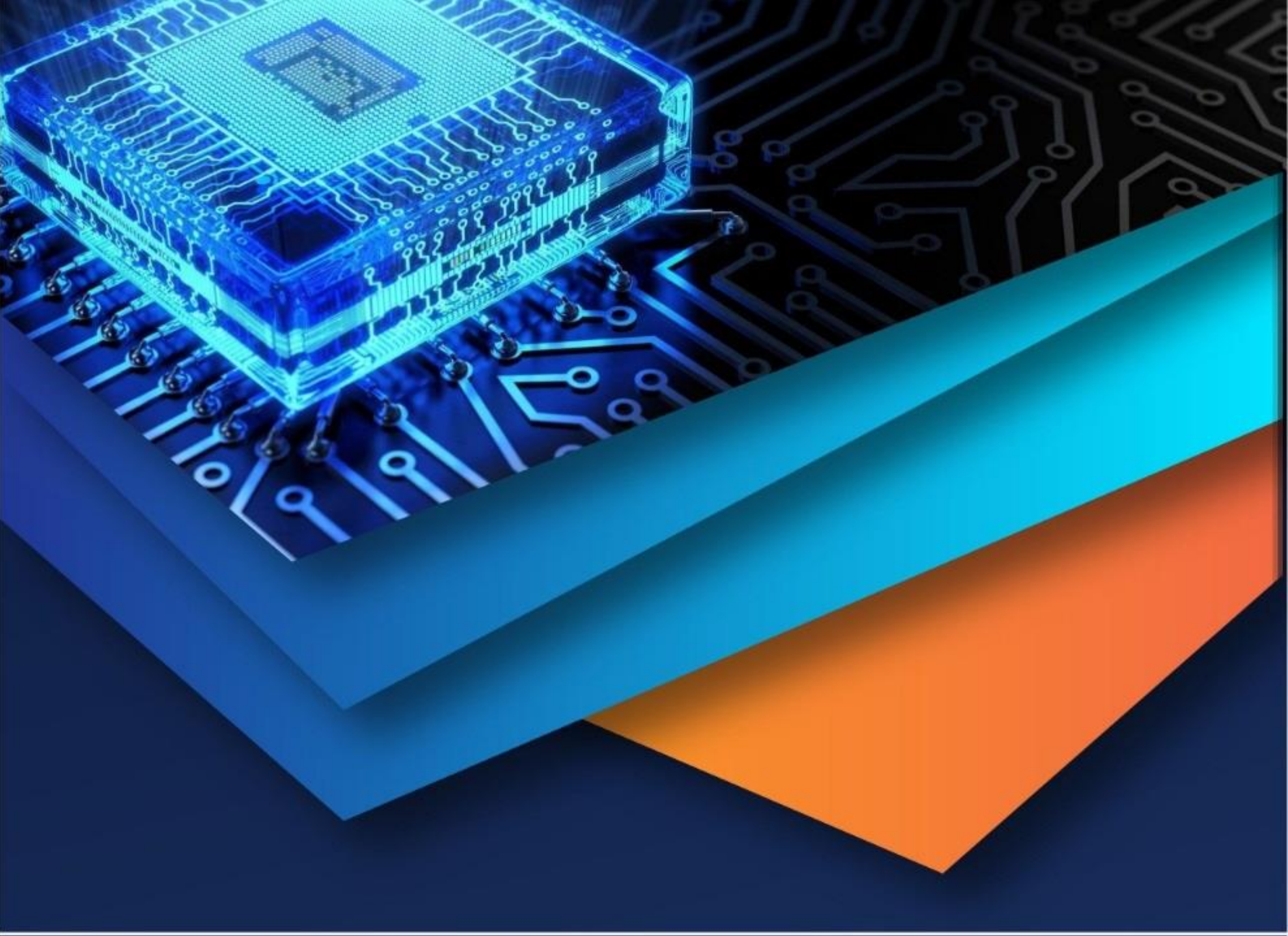

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