Analysis of performance characteristic's during turning of Al-based hybrid composite using Taguchi's method

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Abstract—**Hybrid-composites are the advanced-materialspossessing properties, that make them useful in applications where high strength-to-weight ratio and ability to operate atelevated temperatures are required. These consisting of hard abrasive reinforcing medium set withina more ductile matrix material. This paper results for afabricationof Al/SiCp/Al_2O_3hybrid metalmatrix composite using stir castingtechnique and experimentation results analyzed using taguchi's methodology.**

Index Terms— **Metal matrix composite, MMC's**

I. Introduction

Metal based composites are the engineered material having the combination of two or more materials in which the tailored properties are achieved**[1].** In the past decade, the need for lighter materials with high specific strength coupled with major advances in processing, has led to the development of numerous composite materials as a serious competitor to traditional engineering alloy of particular interest in aerospace and defense industry**[2].**The matrix alloy, the reinforcement material, the volume and shape of the reinforcement, the location of the reinforcement, and the fabrication method can all be varied to achieve required properties. Researchers have fabricated Al- based metal composite for industrial applications **[3-5].**

II. Past work

Aluminum-based composite have evoked a keen interest in recent times for potential applications in aerospace and automotive industries, owing to their superior strength-to-weight ratio and high temperature strength [**3**]. These materials have been evaluated for applications such as pistons, pistons ring inserts, cylinder liners, brake rotors, brake pads and connecting rods. Manufacturing of composite for their application in industry has always been an area of interest to the investigators. Some of research has been done as regards to manufacturing, property analysis and machining of metal matrix composites[**4-5**].It wasstudied on important factors affecting machinability of an Al/SiCp metal matrix composites**[6].**

Micro-structural characterization studies carried out on sample subjected three different control heat treatment cycles revealed the presence of Mg-rich inter-metallic&SiCp particulates as the two predominant secondary phased distributed in the metallic matrix. **[7].**In the year, 1998 researchers investigated an investigation, which was carried out on aluminum –matrix composites [**8**].A correlation study between tensile strength and hardness/ tensile strength and indentation in particle reinforced metal composite was experimentally studied. **[9]**.Researchers studied, some important facts during, diamond turning of Al matrix composite with four possible encounter of the tool with the MMC's using finite element method. **[10].**

Al-MMC's containing reinforcing particles of B_4C, SiC and Al_2O_3 (0–20 vol. %) were processed. **[11].**Optimization on some of the parameters for uniform particle distribution for batch compo casting the simulation studies has been conducted. The simulation involves visualization experiments **[12].** Astudy was done on MMC'S containing two levels of SiC particles. It was found that coated carbide cutting tools performed better than uncoated carbide cutting tools for all materials machined in terms of tool wear [**13**].Further, a study on3 D thermo–mechanical finite element model of the machined composite work- piece material **[14]**.

Experimentation analysis were carried out to study the performance of various type of polycrystalline cubic boron nitride (PCBN) and polycrystalline diamond (PCD) cutting tools during machining of Al- alloy reinforced/SiC composite. Different wear modes were observed on the surfaces of the cutting tools and the surface finish was found to be governed by the notch wear formed on the flank face [**15**]. A homogenized 5% SiCp aluminum MMC material was selected for experimental investigation of tool wear and surface roughness **[16].** By reviewing the past literature, it was found by the researchers, that little researchhas been performed on hybrid-metal composites.

III. Experimental details

A. Specimen Preparation

In the present investigation Al-6061 alloy is taken as the matrix material and SiCp and alumina (Al_20_3) of size 20µm each were considered as a reinforcement materials from "The shind chemicals Company" New Delhi.

B. Matrix Alloy

Al (6061) alloy is extensively used for the manufacturing of various types of castings in the automobile sector. The chemical composition of Al (6061) alloy is shown in table I –

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TABLE I: Chemical composition of Al (6061)

[1] Elements	[2] Composition
[3] Si	[4] 0.42
[5] Mn	[6] 0.045
[7] Mg	[8] 0.7
[9] Cu	[10] 0.018
[11] Fe	[12] 0.19
[13] Ti	[14] 0.004
[15] Al	[16] Rest

C. Tool Material

In the investigation carbide tool insert was fixed on a PCLNR tool holder for machining of Hybrid MMC as shown in Fig.1

Fig.1 PC LNR 2525 M15 Tool holder

IV. DESIGN OF EXPERIMENTS (TAGUCHI'S METHOD)

Taguchi technique is recommended for analysis of problems in which the responsevariables are influenced by several turning parameters. The objective in the investigation was to find the correlation between the response's and the variables and can be used for optimizing the response **[17].**In the present investigation Taguchi's Orthogonal Array (2^3) have been used as an experimental design, as shown in Table II.

TABLE II:Parameters with their levels for experimentation

ParametersLevels		
	1	*2*
Cutting speed (rpm)	40	60
Feed rate(mm) 0.070.2		
Depth of cut(mm)	0.5	1.0

The experimental observations are further transformed into a signal-to-noise (S/N) ratio. There are several (S/N) ratios available, depending on type of characteristics. The characteristic that has lower value represents better machining performance, such as tool wear rate (TWR) and surface roughness (SR). Therefore, "LB'' for the TWR and SR were selected for obtaining optimum machining performance characteristics is calculated as:

$$MSD_{LB} = \frac{1}{n}\sum_{i=1}^{n} Y_{I^2} \qquad \text{(i)}$$

V. ANALYSIS OF RESULT (TOOL WEAR)

The effect of cutting speed, feed rate and depth of cut on the response (TWR) has been shown in Fig.3. As from the fig.3 with respect to the increased of cutting speed of work-piece material (Hybrid MMC), the tool wear rate increased. This may be described as with increased speed from abrasion, friction and heat energy are generated within the machining zone. This increases the changes the occurrence of flank wear of the carbide insert.The increasing of cutting speed influences the cuttingtemperature, thus activated mechanism becomes more predominant. This includes diffusion, oxidation and chemical wear.Similarly, with increased feed rate (0.07-2.0 mm), the wear of tool increased. The increased feed rate increases the changes in wear.

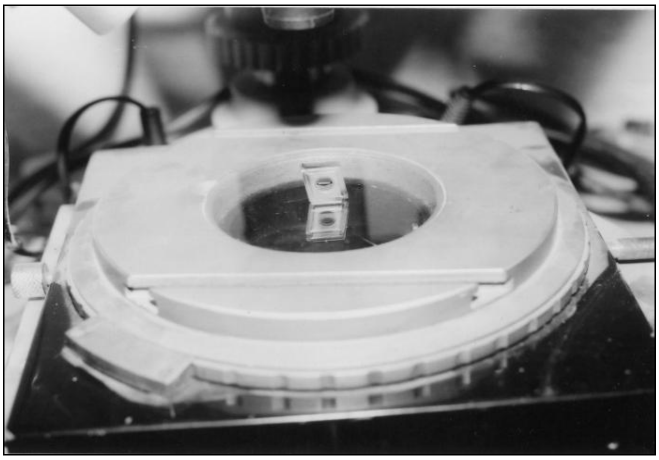

Fig.2 Tool maker's microscope for Tool wears

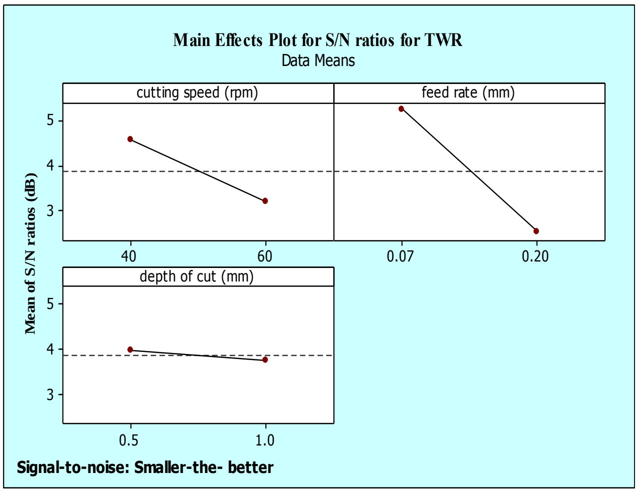

Fig.3 Main effect plots of S/N ratio for TWR

VI. Analysis of Result (Surface Roughness)

The turning tests wereperformed on a capstan lathe machine. Each experiment repeated three times & three measurement of surface roughness was taken. Surface roughness(R_a) measurement was performed on the machines section of the cylindrical billet with the aid of a SURFCODER SE 1200 stylus instrument using a meter cut off length of 0.8mm and sampling length of 4.0mm as shown in Fig.4.

The results were recorded for two value of feed rate 0.07 and 0.2. From fig.5 it is in general, noted that cutting speed and feed rate are the influential machining parameter on the surface roughness viz. increased.

Fig.4 Surface roughness testing device

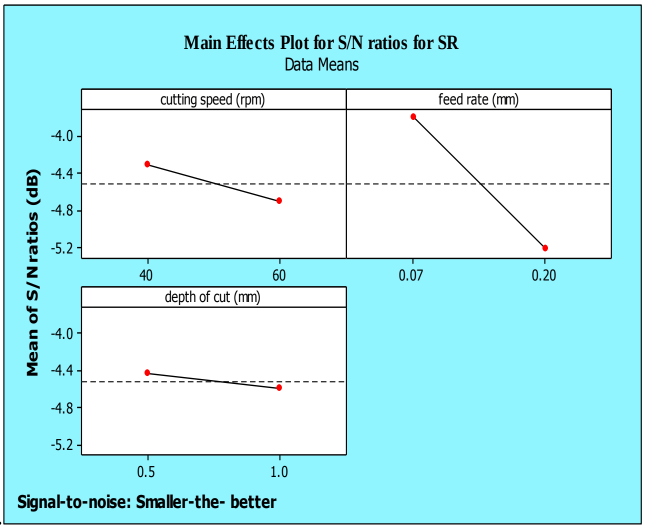

Fig. 5 Main effect plots of S/N ratio for TWR

VII. Conclusion

The resulted out responses using taguchi's methodology concludes that turning parameters have large impact on machinability. It has predicted after analysis that larger forces, friction, heat energy influences the quality of surface finish and increases the changes of rapid tool wear.

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