Flank Wear Measurement of Al-based Metal Matrix Composite Materials (MMC)

Anand Pandey (Corresponding author)
Department of Mechanical Engineering, Anand Engineering College, Kheetam,Agra,India
Tel: -09452598594 E-mail: pandey.anand.aec@gmail.com
Shailendra Singh
Department of Mechanical Engineering, Anand Engineering College, Kheetam,Agra,India
E-mail: shailendra201@rediffmail.com

Abstract
Metal based Composite's are the advanced materials possessing properties that make them useful in applications where high strength to weight ratio and ability to operate at elevated temperatures are required. MMC's are difficult to machine, however, consisting of hard abrasive reinforcing medium set within a more ductile matrix material. This paper results from a series of turning tests in which a number of different cutting tool materials were used to machine an Al(6063)/5 vol% SiCp Metal Matrix Composite. The influence of the cutting speed on tool wear was established for each tool material. It was found that carbide tools, both coated and uncoated sustained significant levels of tool wear after a short period of machining. The best overall performance was achieved using a titanium coated carbide insert.
Keywords: Metal matrix composite, MMC's

1 Introduction

The demand for a material to have high strength and high toughness and capable of operating effectively under adverse conditions has led to the developement of new generations of materials known as metal matrix composites(MMC).These are the advance materials generally reinforced with SiCp or Al_2O3 in the form of continious or discontinious fibers,whiskers or particulates of the ceramic material. The matrix can be any suitable material,but aluminium,magnesium,titanium, and some super alloys are the most popular.These advance composites are considered excellent canditates for high temperature applications **[1-5].** The density of most MMC's is about one third that of steel,so that the specific strength and stiffness of these materials is high.These properties are important in automotive and aerospace industries because of potential for large reductions in weight upto 25%. The presence of hard SiCp led to rapid tool wear, which is not surprising given that SiCp form the basis of many cutting tool materials. The machining of MMC's using these conventional methods often involves frequent and expensive tool changes and there for increased job completion time.Machining processes such as turning,milling and drilling of MMC'S ,therefore,require the use of carbide,diamond or hard nitride coated tools. Even then machining times tend to be 2-4 times greater than for the unreinforced matrix matrial because of increased tool wear ,the necessatity to use reduced feed rates ,and the need to achieve good surface finish : the latter is necessary because of fracture behavior of matrix material composite is sensative to surface finish.In particular ,a poor finish on a continious –fibre reinforced MMC's component can led tolongitudinal fibre fracture and delamination.The result outlinesd in this paper are based on an investigation involving the machining of an aluminium /silicon MMC by conventional turning on a lathe machine

2. Past work

times for potential applications in aerospace and automotive industries owing to their superior strength to weight ratio and high temperature strength in the automotive industries. 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. **O.Quigley** et al. **[6]** studied on factors affecting mach inability of an Al/ SiCp metal matrix composites. The influence of cutting tool coatings on flank wear and surface finish was investigated and it was found that a triple coated carbide, having a top layer of TiN, Performed best of in terms of flank wear but gave the poorest surface**.**

Gupta et al. in 1997 investigated the interfacial behavior in a SiCp reinforced 6061 alloy synthesized using the conventional casting route. Micro structural characterization studies carried out on sample subjected three different control heat treatment cycles revealed the presence of Mg-rich intermetallics & SiCp particulates as the two predominant secondary phased distributed in the metallic matrix. The result of scanning electron microscopic revealed the presence of solute-rich zones in the near vicinity of the interface formed between the

metallic matrix & the SiCp **[7].** **Lin** et al. in 1998 investigated Aluminum –matrix composites are widely used for their favorable specific strength /stiffness and corrosion résistance properties [**8**].
Shen et al**.** investigated the correlation between tensile strength and hardness, tensile strength and indentation in particle reinforced metal matrix composite. Experimentally It was found that as compared to monolithic materials, a simple relation between hardness and tensile strength does not exist for MMCs **[9]**. **Hunjg** et al. studied the diamond turning of Al matrix composite with four possible encounter of the tool with the MMC's using finite element method. Experimental data shows that flank wear of a cutting tool does not depend on the order of different cutting speeds, since abrasive wear dominates the wear mechanism **[10].**

3. EXPERIMENTATION

A range of cutting tool materials were used for the turning test on different 5 vol% of SiCp reinforced in aliminium(6063) and measurement were made of tool wear .Test were performed over a range of cutting speed and at two feed rates using tools having two different nose radius.The result obtained have enabled an assesment to be made of the influence of each cutting tool materials on the machinabilty of the Al/SiCp metal matrix composite.

3.1 Fabrication of MMC

The matrix material used is an Al-Mg-Si wrought alloy matrix reinforced with SiCp of size 100µm. commercial Al (6063) alloy reinforced with 5 vol% SiCp .The matrix alloy was first melted in a graphite crucible in electric furnace. The matrix alloy was preheated at 300°c for 1-2 hours before melting and before mixing the SiCp was preheated at 300°c for 1 hour to make the surface of SiCp oxidized. The furnace temperature was raised above the liquidus temperature to melt the alloy completely at 750°c and was then cooled down just below the liquidus temperature to keep the slurry in a semi solid state .At this stage the preheated SiCp were added and mixed manually. The mixing was done for a short time period of 1-1.5 minutes. The composite slurry was reheated to a fully liquid state and then automatic mechanical mixing was done for 30 minutes at a stirring rate of 220 rpm..In this experiment, the molten composite was transferred from the crucible into the mild steel mould with diameter 50mm and length 250mm.

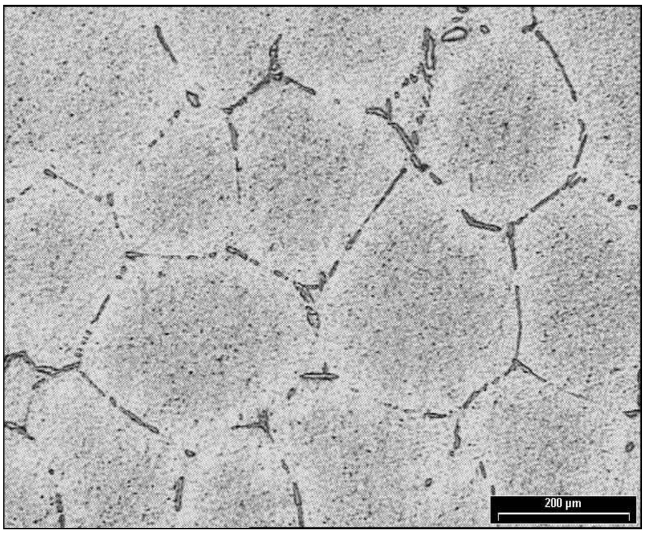

Fig .1 Microstructure of Al/SiCp 5 Vol. % MMC

3.1.1 Tuning tests: Measurement of Tool wear

The turning tests was performed on a Centre Lathe machine using a range of spindle speeds 252-600 rev/min. Feed rate of 0.071 & 0.2 mm/rev were used for the tests. Each experiment was repeated three times & three measurement of flank wear and 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. After each tests the worn cutting edge was measured with the aid of a Tool makers microscope to determine the flank wear.

4. RESULTS AND DISCUSSION

4.1 Flank Wear

The relationship between tool flank wear and the cutting speed is shown in for each of the tool material tested. It should be noted that these curves of flank wear/cutting speed show the magnitude of the wear sustained after machining a fixed length of the work piece at various speed

ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online)
Vol.4, No.7, 2013 - National Conference on Emerging Trends in Electrical, Instrumentation & Communication Engineering

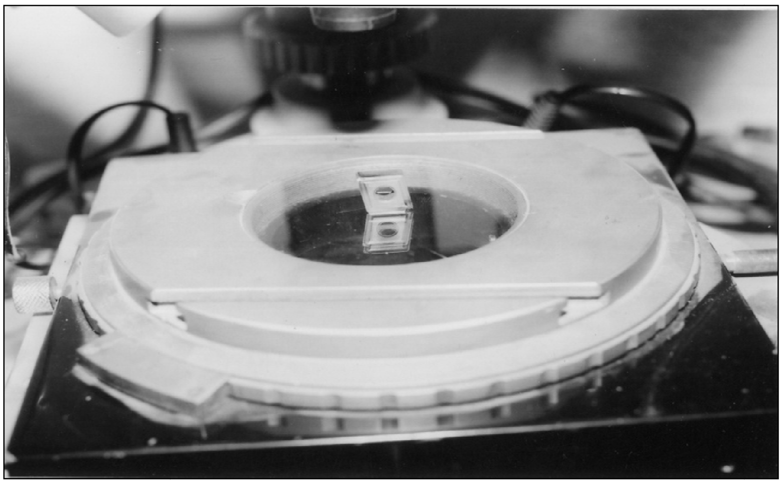

Fig. 2 Tool maker's microscope for flank wear

Fig. 3 PC LNR 2525 M15 Tool holder

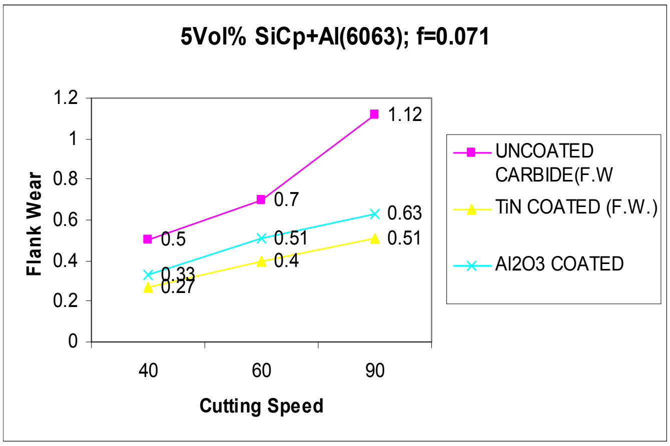

Fig. 4 Effect of Cutting Speed on Flank Wear of 5 Vol% Sicp reinforced

From fig.5 it was ,in general noted that the increasing cutting speed produces a faster tool wear , when cutting speed was increased from 60 to 90 m/min. Tool wear value was nearly doubled in case of turning by uncoated carbide H1F. This was similar to machining any material, that the cutting tool worn faster with using higher cutting speed.TiN coated cutting tool 150T results a lower value of flank wear in comparison to uncoated carbide and coated carbide 375T. This indicate that coating of TiN helped in reducing wear on flank face.

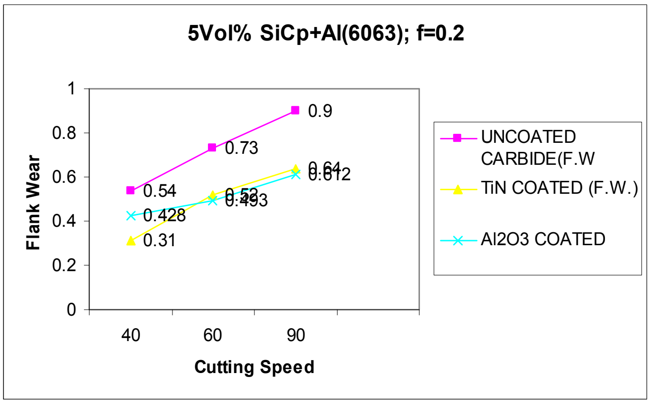

Fig. 5 Effect of Cutting Speed on Flank Wear of 5 Vol% Sicp reinforced

5. Conclusions

The results from the flank wear tests indicate that the uncoated carbide tools are unsuitable for machining the MMC's because of its high volume fraction of ceramic reinforcement.

The Vol. % together with the cutting speed were found to be the major factors affecting the flank wear This may be due to considerable increase in cutting force and change in slip direction. At the interface of particulate and matrix, there is a coordinate deformation which causes increase in shear angle and reduction in chip thickness. Coated cutting tools performed better than uncoated cutting tools in terms of tool wear for all material machined.

References:

C.R.A.Inc.Noyes, "Advanced ceramic materials, technological and economic assessment", New Jersey, 1985, Publications.

J.R. Colemen(Ed.), Proc.5th International ,Symp. automotive PropulsionSysems,Vol.1,Dearborn,MI,October,SME,1980.

R.Snoeys and F.Stalens,CIRP Ann., 35(1986) 467-480

Caroline.J.E.Andrews, His-Yung & W.M.Lau "Machining of an aluminium/SiC composite using diamond insert" Journal of Materials Processing Technology;Vol.102,2000,pp.25-29.

A.Manna and B.Bhattacharya, " Investigation for optimal parametric combination for achieving better surface finish during turning of Al/SiC MMC" Journal of Advanced Manufacturing Technology;Vol.23,2004,pp.658-665.

O.Quigley and J.Managhan, " Factors affecting the mach inability of an Al/SiC MMC" Journal of Material processing Technology; Vol.43,1994,pp.21-36.

M.Gupta and M.K.Surappa, " Effect of interfacial characteristic on the failure mechanism mode pf SiC reinforced aluminum based MMC" Journal of Material Processing Technology; Vol.67,1997,pp.94-99.

T.Lin, D.Bhattacharya and W.G.Ferguson, " Chip formation in the machining of SiC particle reinforced Aluminum-matrix composite" Journal of Composite Science and Technology; Vol.58,Issue 2,1998,pp. 285-291.

Y.L.Shen, "Correlation between tensile strength and indentation in particle reinforced MMC" Journal of Materials Processing Technology; Vol.118, 2001, pp.25-36.

N.P.Hunjg and C.H.Zhong, " Cumulative tool wear in machining MMC : Part1:modeling" Journal of Materials Processing Technology;Vol.58,Issue 1,march1996,pp.109-113.