Investigation of Machining Behavior of Metal Matrix Composite: A Review

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Abstract:-Machining converts raw material into the required component as per dimensions by the removal of material, the utilization of MMC in different industries are not generalized as expected due to difficulty in machining MMC materials. There must be a combination of properties in a material for specific purpose, now a days the component having modern technology works in an environment that are special, like very high temperature, vacuum, high hydrostatic pressure like deep sea, etc. Conventional materials are not meeting such requirements for such requirements metal matrix composite (MMC) is the right choice. Metal matrix composites (MMCs) generally consist of lightweight metal alloys of aluminum, magnesium, or titanium, reinforced with ceramic particulate, whiskers, or fibers. The reinforcement is very important because it determines the mechanical properties, cost, and performance of a given composite.

Keywords:- *Composite; MMC; Reinforce; Cutting Tools*

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I. Introduction

A composite material is composed of reinforcement (fibers, particles, flakes, and/ or fillers) embedded in a matrix (polymers, metals, or ceramics). The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material show better strength than each individual part.

[1]Composite materials are continuously displacing traditional engineering materials because of their advantages of high stiffness and strength over homogeneous materials formulations.

Composites may have metal or polymer matrices and may be reinforced with continuous fibers, discontinuous fibers, or particles [1]. The term “composite” broadly refers to a material system which is composed of a discrete constituent (the reinforcement) distributed in a continuous phase (the matrix), and which derives its distinguishing characteristics from the properties of its constituents, from the geometry and architecture of the constituents, and from the properties of the boundaries (interfaces) between different constituents. Composite materials are usually classified on the basis of the physical or chemical nature of the matrix phase, e.g., polymer matrix, metal-matrix and ceramic composites [2]. Composites based on metals and their alloys, known as metal matrix composites (MMC) have become one of the most important advanced materials used for aerospace, automotive, defense and general engineering applications. They can be tailored to have superior properties such as high specific strength and stiffness, increased

wear resistance, enhanced high temperature performance, better thermal and mechanical fatigue and creep resistance than those of monolithic aIloys[3]. [4-5] MMCs have an edge over polymer matrix composites because of their capability to withstand high temperatures, better transverse mechanical properties, superior electrical and thermal conductivities, excellent resistance to moisture, flame and radiation and zero out - gassing at vacuum.

The major constituents of the MMC are the matrix and the reinforcement, the interface between the matrix and the reinforcement is also considered as one of the constituents as it plays the crucial role in determining the properties of composite. The main problem when machining MMC is the extensive tool wear caused by the very hard and abrasive reinforcement.

II. Earlier Research

[6]Machining characteristics depends on the reinforcement material, type of reinforcement (particle or whisker), distribution of reinforcement in the matrix, and volume fraction of the reinforcement and matrix. Machining results of MMC are different than metal machining due to presence of hard and brittle reinforcements. While machining tool encounters matrix and reinforcement materials alternatively, whose response to machining is entirely different. The main problem in machining MMC is the high tool wear, which leads to an uneconomical production process or makes the process impossible. Thus, machining of composite materials imposes special demands on the geometry and wear resistance of the cutting tools. In any conventional machining operation the primary machining parameters are cutting speed, feed, depth of cut etc. Properties of AMMC depend on matrix & reinforcement. Hence to assess the the machining behavior of AMMC parameters like reinforcement orientation and tooling are also considered. [6]

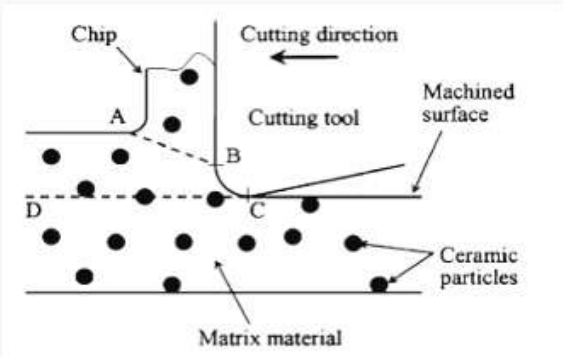

Fig 1. Machining of Metal Matrix Composites [6]

C.R Prakash Rao et al (2014) [7] observed that the hardness values of the composites is greater than that of its cast Al606l alloy and increased % fly- ash in the composite improves the hardness of the composite they also observed that while machining aluminum fly ash MMC having 15 % filler material at cutting speed of 300 m/min and feed of 0.3 mm/rev there is less Built up edge.

A. Fathy et al (2012) [8] observed that wear rate increased rapidly with increasing cutting speed, feed and depth of cut while turning MMCs on simple lathe using cutting tool as carbide inserts with and without coating and also observed that uncoated tool produce better surface finish than coated cutting tools and coated tools performed better than uncoated tools in terms of flank wear. N. Muthu Krishnan et al (2005) [9] observed that while machining Al – SiC MMC on self- centering lathe with the use of Poly crystalline diamond (PCD 1600) inserts cutting tool show good metal removal rate at high depth of cut and also the surface finish found good at lower feed and worsens as the feed increases. Gurpreet Singh et al (2013) [10] observe while experimental investigation of turning of Al/SiC//Gr MMC components shows increased surface roughness with increased feed rate and depth of cut. Manna et al (2003) [11] study the chip formation and observed that during machining the propagation of crack under the tool effect is accelerated by the upward and side curling action of the chip, which helps to produce a small or discontinuous chips as shown in (a). They also observed that during machining when the material undergone its shear limit by the cutting tool the imitation of cracks forms the outside free surface of the chip and separation of SiC particles and Al- matrix within the chip forms some small voids and when it is sheared further fracture takes place and sliding of material formed wavy or toothed chips as shown in (b)

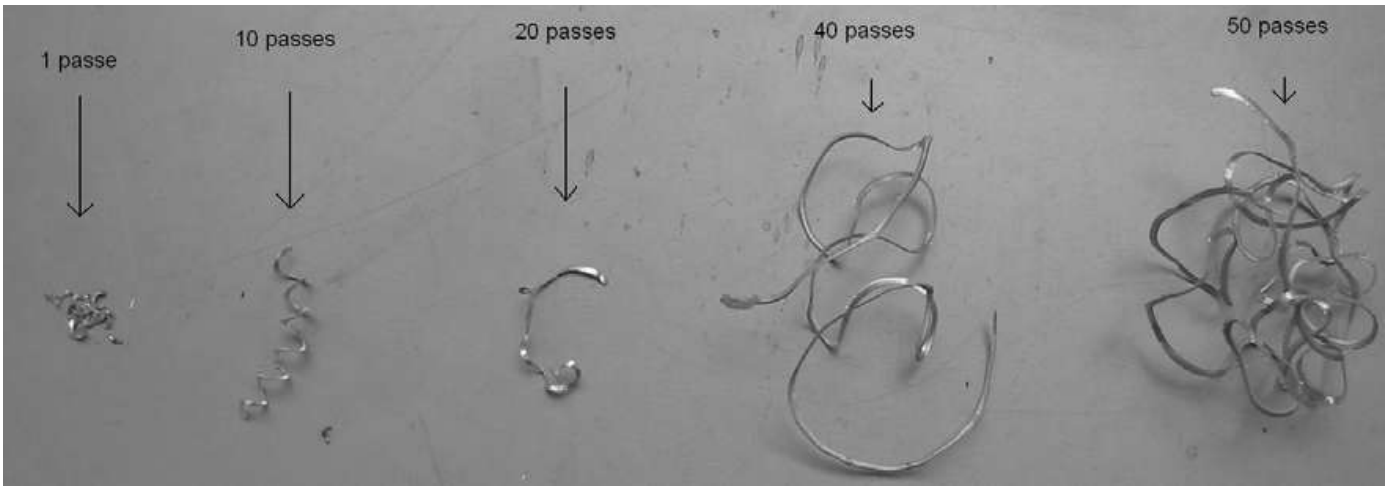

Fig. 2 Chip formation of 15% vol – SiCp reinforced MMC at different stages of cutting [11]

III. Conclusion

Following conclusion has been made from the literature review.

1. It has been concluded that the physical property of matrix and reinforcement, percentage of reinforcement and its distribution in composite and also manufacturing method of composite plays an important role in the performance of cutting tools.
2. Limited research has been done on machining of metal matrix composite.
3. In machining MMC selection of cutting tool plays a major role, it is clear that MMC is difficult to machine because of the presence of a hard ceramic phase within a softer metallic matrix.
4. Researchers shows that coated and uncoated cemented carbide and polycrystalline diamond tools (PCD) are suitable for machining MMC.

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