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Tool Optimization for Matrix Composite Turning using Coated and Uncoated Cutting Tools

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A B S T R A C T

Industries usually want to make a profit; this includes everything from materials to equipment to deep-cutting tools to work materials, and one product that fits the bill is metal matrix composite. Due to its low cost, metal matrix composites are increasingly being used more and more in a variety of industries, including aerospace and automotive. However, because of their anisotropic and non-homogeneous structure, as well as the high abrasiveness of their reinforcing elements, metal matrix composite materials are difficult to machine. Even so, these industries are compelled to move with MMC because damage is frequently introduced into the work piece as well as very quick wear development in the cutting tool. When milling MMC, the cutting tool is said to be the most important component. A good cutting tool that doesn't break while milling MMC will undoubtedly produce good results and find widespread application. Although cutting speed has been found to be more efficient, the wear rate of the cutting tool significantly dropped as cutting parameters like feed and depth of cut were increased. High cutting speeds caused tool inserts to break suddenly. Tool life has been greatly increased using coated carbide tools. Compared to uncoated tools, coated tools produce better outcomes. Consequently, this research highlights a crucial feature in areas like optimization and design. Using coated and uncoated tools, Minitab software is used to analyze the tool's break even point during turning operations on Metal matrix composites while comparing the graph of the material removal rate in MMC.

Keywords: Tool Optimization, Cutting Tools, Matrix Composite Turning

1. Introduction

Modern applications of metal matrix composite include the space shuttle, commercial airliners, electronic substrates, bicycles, cars, golf clubs, and more. The term "metal matrix composite" refers to a wide variety of systems, scales, and microstructures. According to whether the reinforcement is in the form of a) particles that are at least somewhat equiaxed, b) short fibers (with or without a degree of alignment), or c) long aligned fiber matrix and reinforcement, MMC kinds are frequently differentiated. MMCs have superior elevated temperature characteristics (such as high strength and low creep rate), better fatigue resistance, lower coefficients of thermal expansion, higher thermal conductivity, better damping characteristics, superior wear properties, and flexibility in design attributes when compared to monolithic metals. Due to challenges with the machining of MMC Materials, however, the use of MMC in various industries is not as widespread as anticipated. The machinability of this class of materials has not been thoroughly studied in terms of cost-effective machining of MMC. The results of previous tests indicate the effects of reinforcement materials on tool wear and the surface integrity of MMC, but they did not establish the ideal tooling conditions for machining the MMC material. The reinforcements are broken when the work piece was machined using worn cutting tools. Studies show that the optimum tools for machining MMC are coated PCD tools. The sort of coating put on the cutting instrument determines the type of cutting. The Taguchi Method can clearly identify the type of coating to be used for the type of tool used, according to studies proving that coating is the best method for machining an MMC. It is also very important to study the cutting tool's optimum performance or the point at which the cutting tool breaks while machining the optimum cutting condition. This experiment mainly verifies the use of cutting tools, and the work piece's surface finish or any other criteria are not examined.

A composite material that has at least two basic pieces, one of which is a metal, is known as a metal matrix composite (MMC). The additional substance could be a different metal or an other substance altogether, like ceramic or an organic component. A hybrid composite is one that contains at

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least three different materials. A cermets' complement is an MMC. Metal composite materials have been used for a long time in numerous aspects of daily life. It is frequently overlooked that the application uses composite materials. These materials are created on-site using the usual methods for producing and processing metals. The Dalmatian sword, which has a meander structure created by repeatedly forging two different types of steel together, can be referenced in this context [19] [20] [21] [22]. Materials such as cast iron with pistons that have been commercially reinforced with fiber, aluminum crankcases with strengthened cylinder surfaces, and brake disks that have been stiffened with particles Modern material science and development now have limitless possibilities because to these novel materials, which allow for tailor-made materials with MMC properties according on the intended use. Metal matrix composites are able to realize all of the designer's ideal thoughts from this potential. If the property profile of conventional materials either cannot meet the higher requirements of specific needs or is the solution to the issue, then this material group becomes interesting for usage as building and functional materials. However, other contemporary material technologies, like as powder metallurgy, compete with MMC technology. Only when there is a reasonable cost-performance ratio in the component manufacture are the benefits of composite materials realized. If a specific property profile can only be achieved by using these materials, then using a composite material is required.

A reinforcing substance is dispersed across a metal matrix to create MMCs. To stop a chemical reaction with the matrix, the reinforcing surface might be coated. For instance, carbon fibers are frequently incorporated into an aluminum matrix to create composite materials with a low density and great strength. These composite materials also include tungsten carbides, which are composed of carbides and metallic binders, as well as carbon-reacting graphite or steel with a high carbide concentration. The terms "metal matrix composites" and "light metal matrix composites" are frequently used interchangeably by researchers (MMCs). Light metal matrix composites have made significant advancements in recent years, allowing for its introduction into the most critical applications. MMCs have been employed in traffic engineering, particularly in the automotive industry. [14]15][16][17] [18].

2. METHODOLOGY

The machining of the Metal Matrix composite using a typical tool is influenced by a variety of variables, including cutting speed, depth of cut, feed rate, and others. A.Fathy et al. make apparent that several attempts and studies have been undertaken to compare the types of tools, such as coated and uncoated tools, in order to determine performance. In addition to tool coatings, according to A. Fathy et al, there hasn't been any optimization of how the tool is presented to the material. When machining MMC, the fundamental issue is the considerable tool wear brought on by the extremely tough and abrasive reinforcements. The findings of the aforementioned investigations show that more research is required to fully understand the impact of the cutting tool when it comes into contact with the work piece. Here, I use both coated and uncoated cutting tools to examine the ideal machining parameters for a cutting tool. In terms of flank wear, coated tools can outperform uncoated tools, but uncoated tools produce a better surface polish. In order to assess the performance of coated and uncoated tools without causing an unintended chemical reaction between actual diamond and iron, this research conducts a break-even analysis for the machining of a metal matrix composite.)

The majority of coatings tend to make tools harder and/or more lubricious. With the aid of a coating, a tool's cutting edge can easily cut through a substance without the substance adhering (galling) to it. Additionally, the coating lengthens the life of the tool and lowers the temperature linked to cutting. Typically, the coating is applied via thermal CVD, while mechanical PVD may also be used in some circumstances. The coating may fail to adhere if the deposition is carried out at a temperature that is too high because an eta phase of a Co6W6C tertiary carbide occurs at the interface between the carbide and the cobalt phase. According to A. Fathy et al. and M. Wieland et al., coated tools are superior and can extend tool life by more than 3.3 times compared to uncoated tools. Additionally, coated tools have superior cutting performance than uncoated tools, but coated tools have a better surface polish. Tools made of coated and uncoated carbide are frequently used in the metalworking sector. In terms of surface roughness, this study compares the effectiveness of coated and uncoated carbide tools for dry machining MMC. The performance of the cutting tool is influenced by a variety of parameters, particularly when dry machining. Today, manufacturing engineers have developed a wide variety of cutting tools to address the issue. The coated and uncoated carbide cutting tools are two examples. Both of these cutting instruments have benefits and drawbacks. We attempt to determine which type of carbide cutting tool—coated or uncoated—is optimal forwith aluminum to generate a brittle and water-soluble compound Al_4C_3 on the surface of the fiber. To prevent this reaction, the carbon fibers are coated with nickel or titanium boride. The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. This means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together. In structural applications, the matrix is usually a lighter metal such as aluminium, magnesium, or titanium, and provides a compliant support for the reinforcement. In high temperature applications, cobalt and cobalt-nickel alloy matrices are common.

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3.RESULTS

.The goal of this study is to forecast the effects of machining parameters on coated and uncoated cutting tools. In contrast to cutting speed or Fig. 6.1 Tool Wear VS Cutting Speed, Depth of Cut, and FeedRate, material removal rate, which depends on time, had a significant impact on the cutting parameters. The graph shows that tool wear increases with cutting speed, leading to higher levels of wear in cutting tools when compared to feed rate and depth of cut, but when comparing the graph at one point, the wear is too low, while at feed rate, the tool wear is more or less constant, and for depth of cut, the tool wear increases.

4.CONCLUSION

The design of experiments (DOE) method has been discussed in this study's description of how to perform experiments. The following findings were attained during straightforward lathe turning tests following machining tests to MMCs utilizing carbide inserts as cutting tools with and without coating.

- The wear rate increased quickly as the cutting parameters (cutting speed, feed, and depth of cut) were raised, yet cutting speed has been found to be more efficient.
- Tools with coatings can last longer and show less wear than tools without coatings.
- Cutting speed affects material removal rate in a manner similar to how it affects material removal rate.[13] [14] 15] [16] [17] [18] .

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