MICROMACHINING

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Abstract- Micro level machining of metals is a direct operation to manufacture miniature parts. The current article a comprehensive review on micro machining has been carried out for metal cutting process. The key role in manufacturing of parties is good understanding of mechanic behavior of given material. Material removal mechanism of micro machining and conventional machining have significant differences due to the scaling effects associated with tool-geometry, tool material and work piece material characteristics. To explore the significance of range of cutting parameters on cutting force, surface roughness, temperature, tool life, vibration and tool wear, machining tests were conducted in literature. As a result, micro machining is a developing field which has shown to be a prospective approach to produce features on the parts in the range of a few to a few hundred microns with acceptable machining quality.

Keywords- machining, micro machining, micro fabrication, mechanic behavior.

I. INTRODUCTION

Micro level devices are today demanding the production of mechanical components with manufactured features in the range of a few to a few hundred microns in fields that include optics, electronics, medicine, biotechnology, communications, and avionics, to name a few. There is a growing need for fast, direct, and mass manufacturing of miniaturized functional products from metals, polymers, composites and ceramics [1,2]. Size and quality of the micro-products depend on the properties of the used machine tools to manufacture them, including the overall accuracy and dynamic performance. Microscale fuel cells, fluidic microchemical reactors requiring microscale pumps, valves and mixing devices, micro fluidic systems, microholes for fiber optics, micronozzles for high-temperature jets, micromolds, deep X-ray lithography masks, etc, have specific micro level manufacturing applications.

Recently new category of micro manufacturing techniques have been developed, known as non-MEMS or non-lithography-based micro manufacturing. Non-lithography-based micro manufacturing include techniques such as micro EDM, micro mechanical cutting, micro laser cutting/patting/drilling, micro extrusion, micro embossing, micro stamping and micro injection moulding as shown Fig.1. These manufacturing techniques are fundamentally different from MEMS micro manufacturing in many aspects [3].

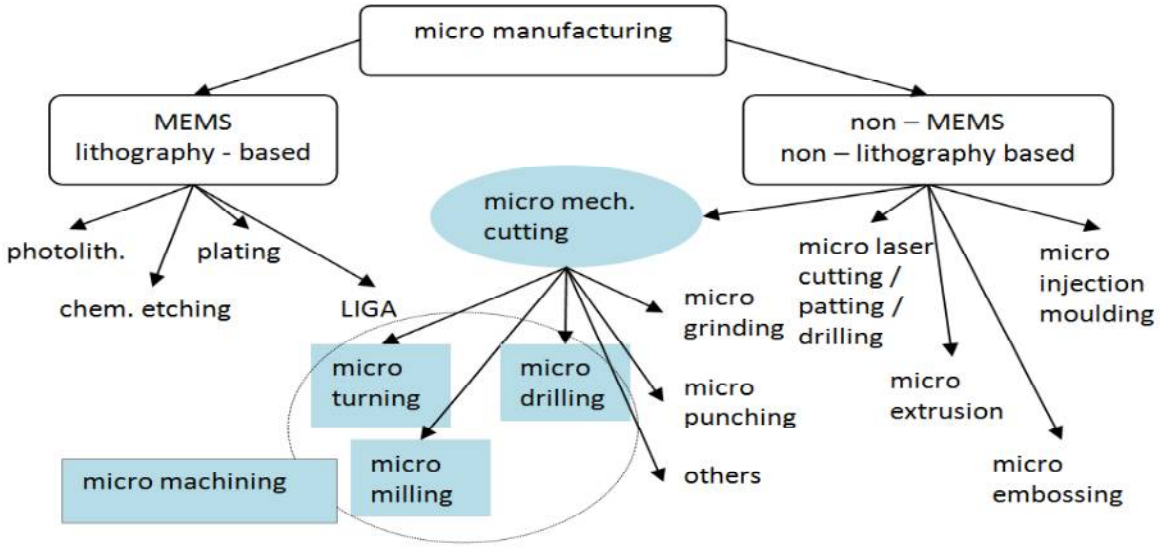


Figure 1. Classification of micro manufacturing techniques [3].

Micromachining refers to mechanical micro cutting using geometrically determined cutting edge(s) (micro turning, micro milling and micro drilling, etc.) performed on conventional precision machines or micromachines. Although lithography-based manufacturing can achieve smaller feature size, micromachining has many advantages in terms of material choices, relative accuracy and complexity of produced geometry. Although micromachining techniques are similar to conventional (macro)

machining manufacturing techniques, simple scaling of parameters or process model cannot be applied due to size effects. There are two research approaches taken to deal with size effects. These two approaches overlap in some areas and attempt to address similar issues, such as cutting tool edge, size effect, minimum chip thickness, etc. [3].

II. CHARACTERISTICS OF MICROMACHINING

The fundamental difference between micromilling and conventionalmilling arises due to scale of the operation, in spite of being kinematically the same. However, the ratio of feed per tooth to radius of the cutter is much greater in micromilling than conventional milling, which often leads to an error in predicting cutting forces.

Micro-milling is associated with sudden tool failure due to its highly unpredictable cutting action. The chip formation in the micro-milling depends upon a minimum chip thickness and hence the chip is not always formed whenever tool and workpiece is engaged as opposed to conventional milling. The tool deflection in the micro-milling greatly affects the chip formation and accuracy of the desired surface as compared to conventional milling. The tool edge radius (typically between 1–5 μm) and its uniformity along the cutting edge is highly important as the chip thickness becomes a comparable in size to the cutting edge radius. Since the chip load is small compared to the cutting edge radius, the size effect and ploughing forces become significant on both surface and force generation in micro-milling. Micro-milling may result in surface generation with burrs and increased roughness due to the ploughing-dominated cutting and side flow of the deformed material when the cutting edge becomes worn and blunter. The effects of the different parameters on micromilling as shown fig.2 [4].

Precision cutting tools and machine tools are critical to micro-mechanical cutting processes, since the surface quality and feature size of the microstructures are dependent on them.

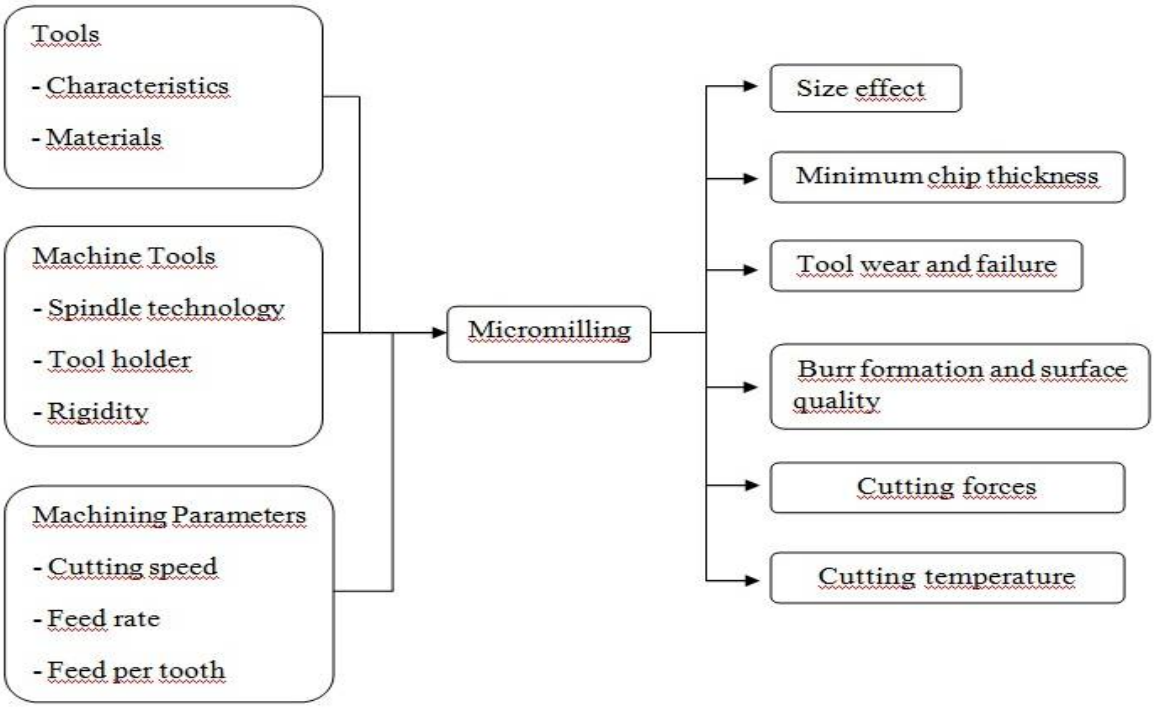


Fig.1. Inputs and influences in micromilling

Tungsten carbide cutting tools are generally used for the micro-mechanical cutting process, due to their hardness over a broad range of temperatures. In the early 1990s, use of coatings to reduce wear and friction became more common and most of these coatings are referred to by their chemical composition, such as TiN (TitaniumNitride), TiCN (Titanium CarboNitride), TiAlN (TitaniumAluminumNitride) or TiAlCrN (Titanium Aluminum Chromium Nitride), among others.

In 2006, Arumugam, et al. [5] investigated the performance of polished CVD diamond tool carbide inserts in comparison with unpolished CVD diamond coated carbide tool inserts in the dry turning of A390 aluminium, a silicon hypereutectic alloy and concluded that polished chemical vapour deposition (CVD) diamond tool inserts improve tool life and reduce the cutting forces.

The requirements on the coatings for micro machining tools are not only the desirable properties such as high hardness, high toughness and high chemical/erosive and abrasive wear resistance, but they must also be dense, have a fine microstructure and present a smooth surface to the work piece, with a reduced coefficient of friction compared to that of the uncoated tool [4-6].

In this part shows that many studies have been done to show up to which extent these parameters influence the quality of the machined parts and the consequences on the tool.

Weule et al. [7], explained the achievable surface roughness in terms of minimum depth of cut. They found that minimum chip thickness or minimum depth of cut depends primarily on sharpness of the tool and secondarily on material properties. Yuan et al. [8] found in their diamond turning experiments on aluminium alloys that the minimum chip thickness was estimated to be between 20 to 40 % of the cutting edge radius. Cardoso and Davim [9] in order to perform a comprehensive study on surface roughness of the machined surfaces, cutting parameters such as feed rate as well as machining strategies were varied to optimisation micromilling. In this research, Al 2011 aluminium alloy was used. The tool used to machine the workpiece was a cemented carbide K10, 0,8 mm diameter endmill. Sugawara and Inagaki [10] investigated the effect of drill diameter and crystal structure on burr formation in microdrilling. Dhanorker and Özel [4] experimental and modelling studies on meso/micromilling of Al 2024-T6 aluminium and AISI 4340 steel to predict chip formation and temperature fields. They also studied size effects and minimum chip thickness. Adams et al. [11] fabricated 13µm diameter microgrooving and microthreading cutting tools of high speed steel and tungsten carbide.

CONCLUSİONS

The multitude of input factors indicates the complexity of the analysis concerning their influence on the output parameters. The most relevant inputs in the micromachining process can be said to be the materials, spindle technology, tool holder, machining parameters (cutting speed, feed rate and depth of cut etc.). On the other hand, the issues addressed with micromachining are the minimum chip thickness and size effect, the cutting temperatures and cutting forces, which influence the tool wear and its failure, which, in turn, influence the burr formation and, consequently, surface quality. The micromilling process separates from other conventional processes because of high quality of the surface layer and by obtaining a high accuracy of surface.

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