Effects and Challenges of Tool Wears in Micro Milling by Using Different Tool Coated Materials

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Abstract
This paper which determines the effects and challenges of wear occurred in coated tool material after micro milling. In micro milling process the main challenges is tool failure and burr formation. Both will effects surface finish and surface accuracy. Here Stavax (modified AISI 420) stainless steel and Austenitic stainless steel (X5CrNi18-10) is used with coated TiAlN, CrN, TiN, AlCrN for experimental analysis study. The application of a TiAlN and AlCrN coating generated very good results regarding the tool wear. Relating to the surface quality, the AlTiN coating provided the best results.

Keywords
Micro Milling, Tool Wear, Micromachining, Surface Finish, Tool Coating

I. Introduction

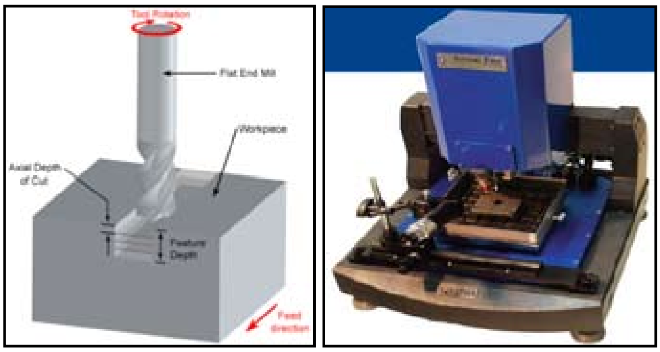
More of application of micro machining is mainly in the field of medicine, biological equipments, defense; telecommunication requires small sized miniature components with miniature features. It is because of high precision and high accuracy. Mechanical micro milling. Micro machining, micro laser machining are the common techniques used for manufacturing micro parts. High ductility austenitic stainless steel is mainly used due to its favorable properties like high resistance to corrosion, high strength due favorable properties like high resistance against corrosion, high strength. Contrary to these positive properties machining austenitic stainless is challenging. Due to its high toughness the formation of burrs is promoted.

Burr formation due to tool and increased tool wear are two major issues. In burr formation, it can be controlled by proper tool geometry and cutting conditions (feed per tool, depth of cut, speed). But tool wear is reduced, only by applying proper coating of tool and application of coolant. The main purpose of present the paper is to evaluate the tool wear with different coating materials. When complicate parts are machined, cutting tool radius immediately chip-off due to tool wear. This tool wear causes increased surface roughness and increases micro milling force. It's a challenging problem for analysis the micro milling tool wear effects. Three different coated materials were used by Biermann et al [2] for analyzing the machinability of coated tool. Where axial depth of cut, radial depth of cut and feed per tooth parameters were taken as process variable. All these challenges are summarized as follows,

1. Availability of ultra-miniature tools with appropriate cutting edge geometry.
2. Tool stiffness and sufficient wear resistance
3. Identification of suitable coated materials for reduce the wear of cutting tool.

II. Principle

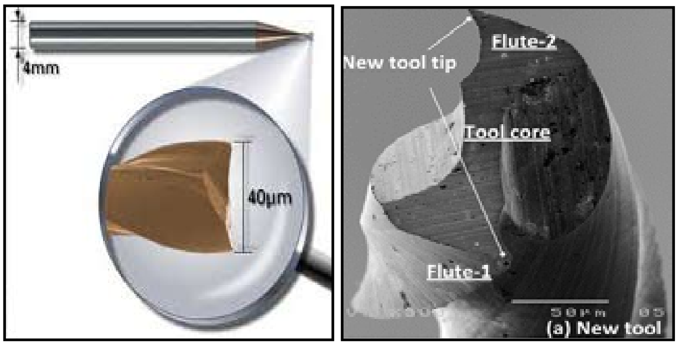
The general principle used for micromachining is discussed and which identifies the reliability of micromilling technology which employed for machining micro components. Fig. 1 shows the basic cutting operation of end milling.



(a) (b)

Fig. 1: (a). Basic End Milling Operation, (b). Three Axis-Vertical-Micromilling Machine -53725-2505939 [6]

Here the basic features are incorporated to machining operation and initially milling operation programmed manually, after CAM module was developed for their automatic generation. Fig. 2(b) represent A three axis micro machining center (Mikrotools (DT-110) [3], which provide 200×100×100mm X,Y,Z respectively AND +/-1 µm, with a resolution of 100 nm. This micro machine equipped with speed 70,000rpm, max power 1.4 kW. 2-3 µm cutting edge radius is measured.). All experiments are performed under dry machining conditions with a micrometer to provide the desired axial depth of cut. A personal computer with Lab view control software was used to control the X-Y motion of the stage.



(a) (b)

Fig. 2: (a). End Milling Cutter With 4mm Dia. [1] (b) SEM Image of End Cutter [2]

Failure of cutting edge is mainly depends on feed per tooth increased tool wear rate. In this study, Stavax ESR (modified AISI 420 stainless steel) is used which is widely coated with TiAlN, TiN, and AlCrN. Normal coating thickness is 2.5 to 3 µm. High hardness is the main advantage by using this as a coating material. For wear resistance, hardness of coating is an important factor. All these coating were monotype layer coated with PVD technique.

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III. Methodology

For any conventional machining or precision machining cutting speed, feed per tooth, axial depth of cut are the process parameters.

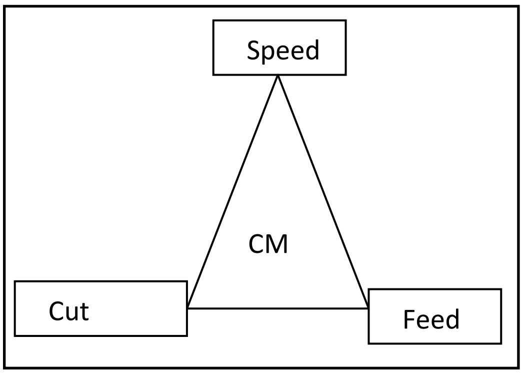
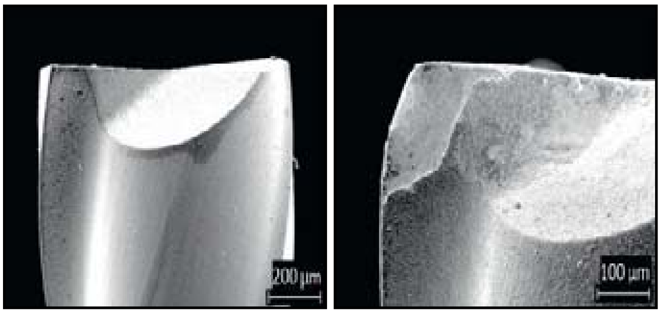


Fig. 3: Conventional Machining Parameters

Fig. 3 shows conventional machining parameters and corresponding micromachining parameters are tool wear, surface roughness and milling forces. But increased level of miniature level machining which increases control parameters. Two series of experiments were carried out. One is based on Tool wear and other is based on surface quality. The test were stopped as soon as tool breakage occurred. Experiments with coated tools were performed until significant delamination of the coating was observed. Three series of experiments were carried out. With the TiN, TiAlN and AlCrN.

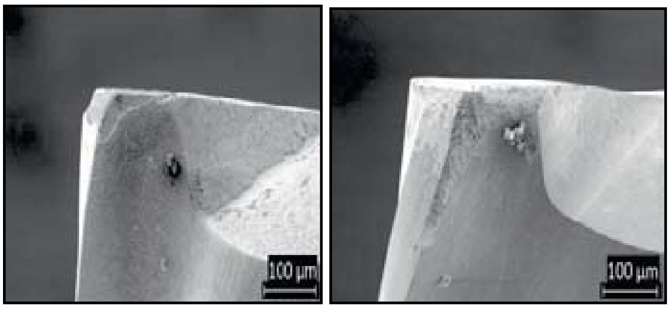
IV. Result and Discussion

Sudden tool failure is mainly due to small diameter of micro milling tool as compared to macro machining. So increased tool wear resistance is needed only by coated with different wear resistant materials. Fig 4(b) is the coated AlCrN and (c), (d) with TiN and TiAlN respectively.



(a) (b)

Fig. 4: (a). New Cutting Tool, (b) AlCrN Coated Tool After Machining of 2mm Depth of Cut [4]



(c) (d)

Fig. 4: (c). TiN Coated Tool, (d) TiAlN Coated Material After 2mm Depth of Cut [4]

Here they were experimentally identified three different coated material posses with different cutting wear resistant conditions. AlCrN coated tools exhibit more chance to delamination and poor adhesion property. But lack chance for side chipping of titanium coated cutting tool. TiN and TiAlN exhibit

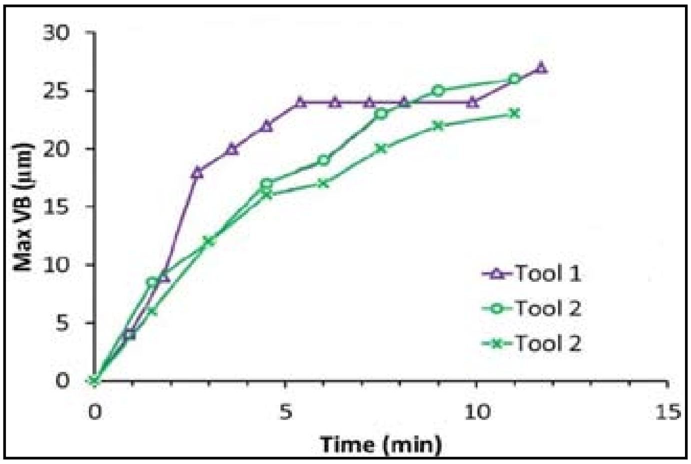


Fig. 5: Maximum Tool Wear Graph by Using Three Different Coated Tools [6]

small reduction in wear as compared to AlCrN coated material. The maximum flank wear is 30µm.

Since SEM image by using different coated material indicates increased wear resistance and surface quality. In micro milling, tool wear is known to be stochastic due to process uncertainties and this stochastic behavior becomes more dominant as tool diameter decreases.

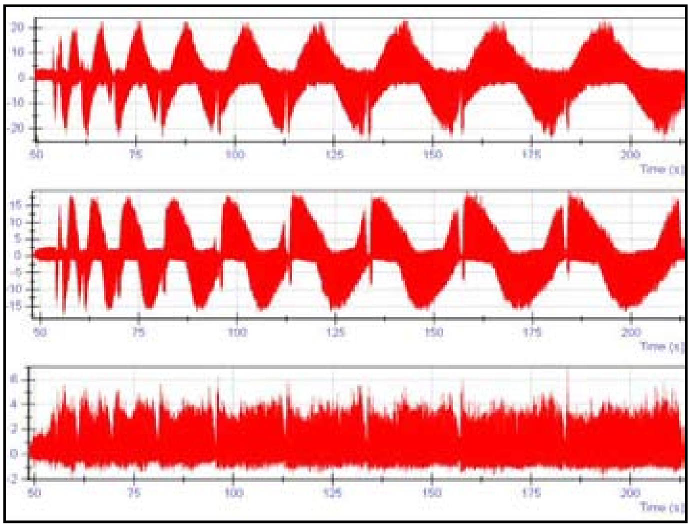


Fig. 6: Surface Roughness Due to TiAlN, TiN and AlCrN coated tool [3]

From fig. 6, which gives the corresponding surface roughness due to titanium and aluminum coated material. An important surface integrity attribute in micro machining is the potential for machining damage that can reduce the strength of machined components. The mean strength values and the standard deviations for the samples.

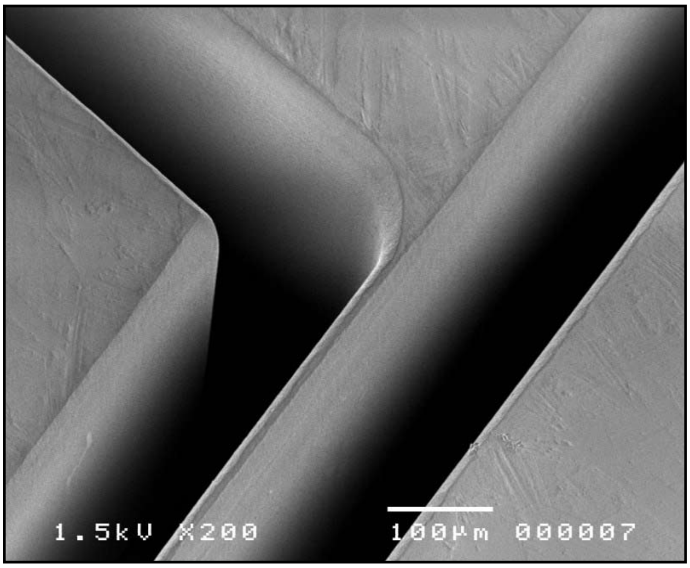


Fig. 7: Machined Micro Components With AlCrN Coated Cutting Tool [5]

The above results show that the hypothesis of ductile machining is only an indicative value. Bifano et al [4]. did not take into account the effects of geometry and phase transformations And Fig. 7 indicates the best surface finished micro component with accuracy of 10-20 µm.

V. Conclusion

We have reported the influence of process parameters is investigated and suitable process parameters for end micro milling. By analyzing different cases, most of them for their experimental study, Stavax stainless steel and austenitic stainless steel tool is used. The main conclusions of this work are:

1. Experimental results, the influence Of AlCrN provides strongest tool wear coating. But may chances delamination.
2. And titanium coated tool material exhibits side chipping. And which reduces the flank wear up to 30µm.
3. In terms of surface finish, AlCrN andAlTiN is the best coated material.

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