Performance of machining parameters on powder metals by using PCBN tool and carbide tool

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Abstract - *Present work includes understanding the effects of various milling parameters such as spindle speed, feed rate, and depth of cut on the surface roughness (Ra) of finished products. The experimental plan was based on Taguchi's technique on surface roughness. Powder metals are becoming mostly used metals in the automotive and other manufacturing industries because they are widely using product functional requirements without compromising the performance of the product. They give various advantages, including weight reduction, near net-shape processing capability, and their ability to be sintered to achieve desired properties in the end-product. Machining of powder metals is quite different to machining of traditional metals because of their specific properties, including porosity.*

The experiments were conducted on powder metal steel material on CNC vertical milling machine using PCBN and carbide tools. The analysis of mean and variance technique is employed to study the significance of each machining parameter on the surface roughness. This experimental work deals with the finish machining of powder metal steels in automotive applications, for increased tool-life/reduced tool-wear. Tool-life is affected by a various factors such as cutting conditions and tool geometry.

Keywords- Powder metals, PCBN tool, carbide inserts, CNC vertical milling machine, tool parameters .

1.INTRODUCTION

The theme of this thesis study is to obtain optimum cutting conditions for maximum tool-life in boring and plunge cutting of powder metal steels using PCBN and carbide tools. Powder metals have been around in the market for quite some time now. However, their potential use in the area of automotive manufacturing is beginning to be appreciated lately. With the automotive industries moving toward addressing the sustainability issues involving reduction in energy consumption, pollution reduction, etc., powder metal components offer a highly attractive light weight property with the additional advantage that they can be easily shaped into various complex parts. Powder metals, unlike conventional metals are considered to be 'difficult to machine' materials, due to their inherent porous properties. From the review of the published literature in the area of powder metal machining, there appears to be lack of fundamental studies in the mechanics and the cutting action of sintered powder metal parts. It has been estimated that about 30% of powder metallurgy structural components made for automotive industries require some form of machining (Holzki, 1996). This high proportion of machining involved with powder metals in the automotive industries and the lack of fundamental knowledge in machining of porous powder metals inspired this thesis work.

MACHINING OF POWDER METALS

This chapter reviews the recent and relevant published work in the area of powder metal machining using PCBN and carbide tools. It has been noted that only limited published work exists on machining of powder metals. This chapter covers only a summary of reviews from these papers. The subsequent chapters of this thesis cover reviews of other relevant topics such as modeling of tool-wear and machining optimization. The major variables that influence the mach inability of powder metals are:

(a) powder metal material and properties,

(b) cutting tool materials,

(c) cutting conditions,

(d) cutting tool geometry,

(e) coolant application and

(f) Type of machining operation.

In what follows, a brief review of these influencing variables and how they affect machining of powder metals will be presented.

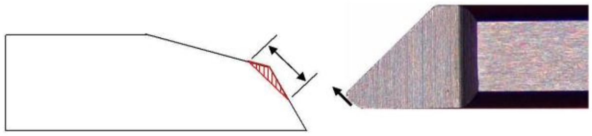
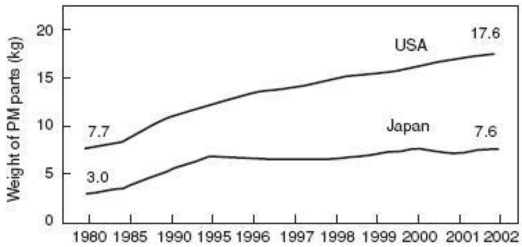


Figure 3. Material Removed in Machining by Plunge Cutting and Boring Tools



FIgNo.1Weight of Powder Metal Parts Installed in an Automobile

EXPERIMENTAL WORK

In the present investigation, extensive experimental work in machining of powder metal steel was carried out to establish an interrelationship between a major machining performance measure (tool-life) and the cutting parameters (cutting speed and feed). This interrelationship was developed for plunge cutting and boring operations under flood-cooling conditions. This chapter describes the experimental setup and the experiment design used for this investigation. The observations made during the experimentation and the practical problems experienced are also highlighted in this chapter.

Figure 2: Powder Metal Rings A and B.

The tooling head can be compared with a milling cutter in some ways, even though the functions This chapter reviews the recent and relevant published work in of both are completely different. The 30° and the 75° surfaces are cut by plunge cutting operation, whereas the 45° surface is generated by the boring operation. A special attachment on the tooling head facilitates the movement of the boring tool in the traverse manner, while the tooling head rotates.

DEVELOPMENT OF TOOL-LIFE MODEL FOR PLUNGE CUTTING AND BORING OPERATIONS

The primary goal of modeling of machining operations is to be able to quantitatively predict the performance of machining operations accurately. Modeling can facilitate effective planning of machining operations to achieve optimum productivity, quality and cost. According to Armarego et al. (2000), modeling can be classified into two distinct categories depending on the approach to study the process of machining, namely:a direct experimental or 'empirical' approach to study and estimate the various technological performance measures and the effect of the influencing variables on the complex machining operations; and a fundamental or theoretical approach to study the scientific phenomena involved in the cutting process and develop mechanics of cutting models and analyses for the various technological performance measures for the highly simplified machining operations. The machining performance can be classified as 'technological' and' commercial'. The technological machining performance covers the aspects such as accuracy of shape, dimensions, surface roughness, surface integrity, etc.; whereas, the commercial machining performance covers the aspects such as machining time, cost, throughput time, defects, etc.

Results and Discussion

The results obtained from the performances of cutting conditions for boring and plunge cutting of powder metal steel rings, machined using PCBN and carbide tools, under flood-cooling condition. An increase in tool-life in the range of 5-27 % is obtained just by changing the cutting conditions to optimum values, without upsetting the cycle time of the machining line. A general trend can be observed for PCBN and carbide tools, in terms of tool-life. For PCBN 75° and 45° tools, an increase in tool-life is achieved at lesser speed and higher feed. This trend is consistent.

SUMMARY AND CONCLUSIONS

This thesis work focused on developing an optimization method for maximizing tool-life in machining of powder metal automotive components. This new methodology was applied to plunge cutting and boring of ferrous powder metals using PCBN and carbide tools under flood-cooling conditions. The process considered in this study is a niche application, but the Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

3. CONCLUSIONS

methodology developed through the investigation can be applied to broader range of applications. A systematic approach to optimizing the cutting conditions for machining operations has been carried out. The following major conclusions can be drawn from this research work: 1. the effects of cutting conditions (cutting speed and feed) on tool-life performance measure were established for both PCBN and carbide tools. Flank wear criterion was selected as the tool-wear criterion, since the change of tools was governed by the dimensional change in the width of the critical, 45° surface. Increased feed rate is found to have a positive impact on the life of the PCBN tools,. ,. Increased feed rate improves stability of the process. Whereas, for carbide tools reducing the feed rate led to an improvement in the tool-life performance. However, the optimized feed rate was found to be higher than the current feed rate, owing to the cycle time constraint. Reduced cutting speed was found to be favorable to improved tool-life, both for PCBN and carbide tools. 2. Given the very small window of cycle time to work within, the achieved improvement in the tool-life, in the range of 5-27%, is dramatic.3.The technique for assessing the tool-life is unique and can be applied for tools that have longer tool-life with a linear wear progression curve. This methodology can be useful for tools that require large quantity of parts to be machined in order to obtain the relation between the tool-wear and number of parts machined. The tool-life tests in such cases can require insurmountable amount of time and resources. This is usually true in the cases where a tool-life analysis is to be conducted for the components with higher tool-life and which are machined in a production environment. With the methodology presented in this thesis work, offline tests can be simulated in a lab environment, giving manufacturers (project sponsors) an opportunity to take advantage of offline lab facilities without disrupting their production lines. 4. Although a limited number of tests were conducted due to the limitation of time and resources, these tests give a good idea of the effect of cutting conditions on tool-life performance of PCBN and carbide tools. Due to the tight cycle time constraint, the improvement gained in tool-life is quantitatively less. However, qualitatively this work provides a fair idea of the behavior of PCBN and carbide tools for a lesser known work material, which is fast gaining popularity in the automotive and manufacturing industries. The work presented here can serve as a good foundation for future research work involving machining of powder metals.5. A baseline for the current production practice was established through this work, serving as a reference to judge any future improvements made on the powder metal machining station. 6. The production line machining operation was successfully simulated in the lab environment, encouraging the industry groups to work closely with the university research labs and promote research activities, mutually beneficial to both the parties.

Future scope

Further research work in machining of powder metals could include the effects of tool Grades and coatings on tool-life and other machining performance measures, effect of lubricants/coolants (including cryogenic cooling) on mach inability of powder metals and machining performance measures, surface integrity analysis of the machined product for sustainable functional performance of the product, etc.

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