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Machining Stavax and XW-5 for Different Cutting Flute in Low Speed Machining

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ABSTRACT

This paper examines the capability of one type of cutting tool towards machining mould material that usually used in Injection Moulding Industries, the Tungsten Carbide Ball Nose. This study focuses on three components include tool wear, surface roughness and surface topography. The relationships of all these three properties respect to each other were also investigated. By machining the materials that usually used in the industries, Stavax and XW-5, a major wear occur on cutting tool which is called flank wear. Theoretically, the flank wear is increased by increasing the hardness of the material used. This fact is supported by the result obtained: the surface roughness increases when the material hardness is increased. The surface finish of the material also decreases when the tool wear is increased. Surface topography was described through wavy marks and surface tearing. For both 2 and 4-flute cutting tool, the waviness phenomena decrease when the material is increased. Meanwhile, for surface tearing, the rate of occurrence is proportional to the increment of the material hardness.

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INTRODUCTION

In the modern world of manufacturing industries, mould machining is one of the main manufacturing activities. Mould is making to produce a various type of products whether in automotive, aeronautic, and steel. Several products which encountered in our daily lives, ranging from metal spare part to automotive bodies are product of mould and die (A. O. Oke et al, 2011). To produce mould, it requires more than one type of materials; each material has different type of properties whether in mechanical, chemical or physical elements.

Usually, the tools used have different type of properties to machine the material involved to make the mould such as the Ball Nose endmill. Ball nose cutters are similar to slot drills, but the ends of the cutters are hemispherical. They are ideal for machining 3-dimensional contoured shapes in machining centers, for example in moulds and dies. They are also used to add a radius between perpendicular faces to reduce stress concentrations. There is also a term bull nose cutter, which refers to a cutter having a corner radius that is fairly large, although less than the spherical radius (half the cutter diameter) of a ball mill. In mould and die production, the ball-nose end milling process is a critical machining operation due to the complex geometry of work piece, high requirements on surface quality and high accuracy.

In injection Moulding Industries, the relationship between tool wear and surface finish can be categorize as important because the machining process' cost in making a mould can be reduce. Tool wear represents a major index of the performance criteria for a cutting tool. It occurs because of the rubbing action of the chip and work piece against the rake and clearance faces. The wear is the most important element in identifying whether a tool is good for machining or not. In order for the tool to successfully perform under the harsh environment of high temperatures and high force involved with the cutting process, it must sacrifice itself in term of wear. As the tool wears, eventually it will fail to perform its intended objective of cutting. A broad description of tool failure can be given within the context that the tool losses its capability to produce parts within specification. The main effect occurred when the tool wears are it degrades the surface finish, increase the tolerance and increase the cost of machining.

Measuring in machining and an effective parameter is one of the most common performances in the surface roughness. Surface roughness has been known as an important design feature in many situations such as parts subject to fatigue load, precision fits, fastener holes and esthetical requirements. Other than that, surface roughness imposes one of the most critical constraints for selection of machines and cutting parameters in process planning. The surface roughness of machined parts is a significant design specification that is known to

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have considerable influence on properties such as wear resistance and fatigue strength. It is one of the most important measures in finishing cutting operations.

In this paper, the study is done to investigate the possibilities for reducing the second process when machining mould material using low speed machine with 2 or 4-flute cutting tool. Furthermore the study also conducted to determine the effects of material properties on the cutting tool and workpiece's surface used in machining for those materials.

RESULT AND DISCUSSION

The results of experiments performed are shown below. The relationship between hardness of material, tool wear and surface roughness contribute a major part in studying the tools capabilities in moulding industries. The analysis for tool wear, surface roughness and the tools capability has been issued based on the assessment that has been found. All of the results produced show that this experiment has run successfully and achieved the objectives.

Tool Wear:

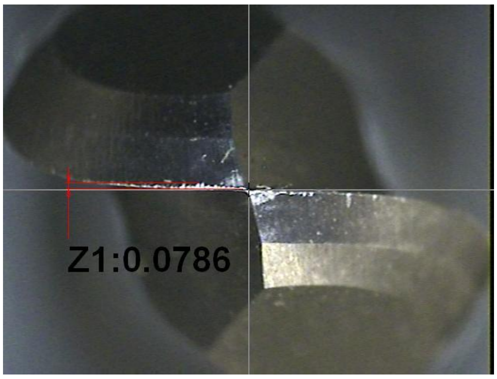

Fig. 1: Flank wears for Stavax.

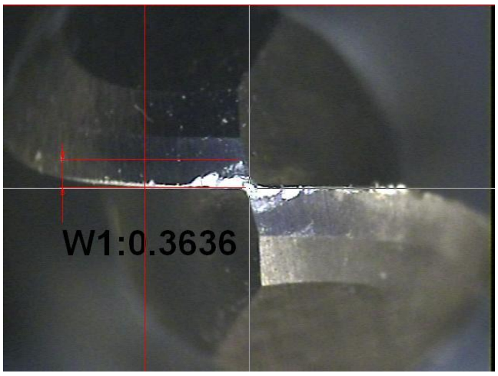

Fig. 2: Flank wears for XW-5.

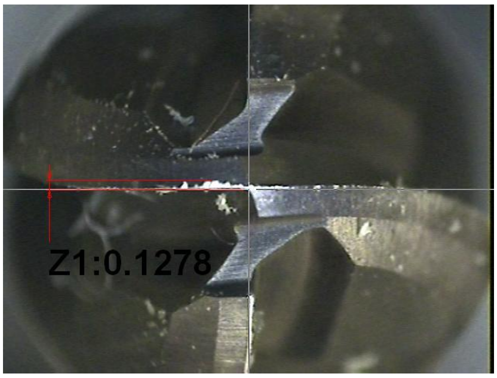

Fig. 3: Flank wears for Stavax.

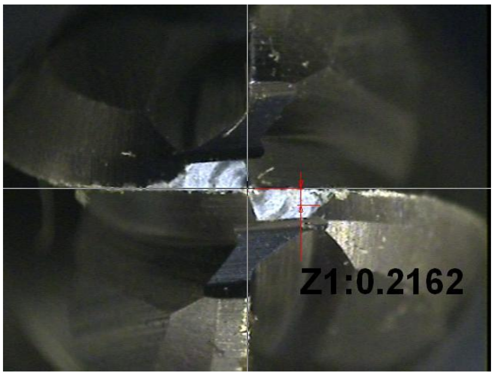

Fig. 4: Flank wears for XW-5.

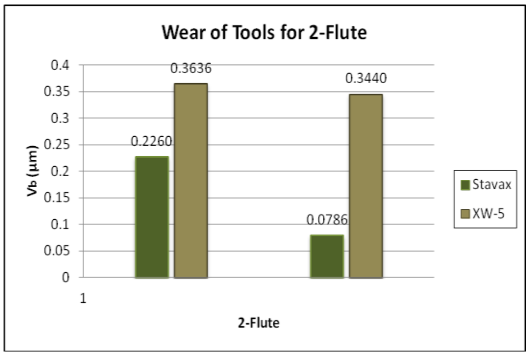

Fig. 5: Tools wear value of 2-flute ball nose.

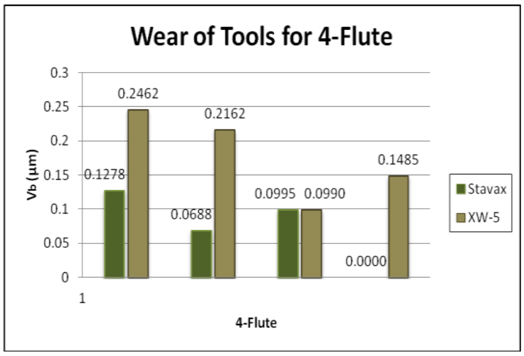

Fig. 6: Tools wear value of 4-flute ball nose.

The flank wear exists on all cutting tools used to machine all of the materials, Stavax and XW-5. The maximum value of wear on each flute of 2 and 4-flutes of Ball Nose end mill will be taken as the real value of tool wear on each cutting tools, after the new value that has been measured minus the old value of tools wear.

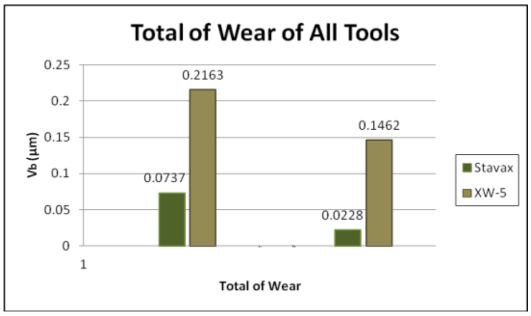

Fig. 7: Total tools wear value of all tools.

Based on the result obtained as shown in Figure 7, the 4-flute cutting tools have better resistance towards wear compared to the 2-flute cutting tools. Through the data, it shows that each material has a small value of wear on 4-flute cutting tools and bigger value of wear on 2-flute cutting tools.

Figure 7 also shows the change of the maximum wear width, V_b with cutting distance in machining 52 HRC-SV (Stavax with hardness of 52 HRC) and 62 HRC-XW-5 (XW-5 with hardness of 62 HRC) under wet condition. It proves that the usage of different type of materials will affect the tool wear. It is found that the flank wear increased with the hardness of the workpiece (W.Y.H Liew, 2010). The flank wear increased together with the hardness of the materials used. This is led by Stavax (52 HRC) which is low in hardness than XW-5 (62 HRC).

Flank wear occurred from abrasive wear of the cutting edge against the machined surface on the material machined. Flank wear pattern produced wear lands on the side and end flanks of the account of the abrasive action of the machined surface (Z.Q. Liu et al,. 2002). Abrasive wear occurs because there is contaminant on the surface material that has been machined such as carbon, nitrate and oxide compound. It is a mechanical wear and one of the main causes of the tool wear at low speed. Abrasive wear is likely to take place at low cutting speeds if the work material is hard enough (due to heat generated) to plough into the tool (Gu J et al,. 1999).

Surface Roughness:

The relationship between the surface roughness and tool wear contributes a major part to this study. At each 1mm of depth, the value will be measured at 3 places on the surface. Then the average of the value will be calculated at the end of each 1mm of depth.

Figure 8 below shows the means of each 1mm of depth for all of the materials. Based on the results that have been obtained, the average value of the lowest surface roughness are the results of the best surface finish.

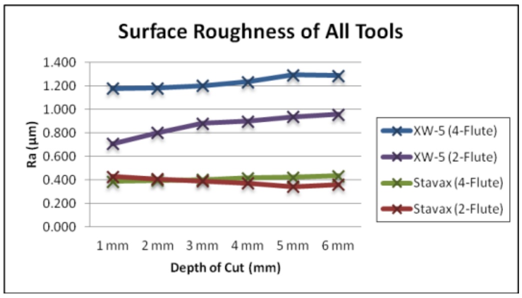

Fig. 8: Surface roughness mean of all tools.

Based on the result shown on Figure 8 above, the roughness values for 4-flute cutting tool materials increase proportionally to the depth of cut applied during the machining process. The increase of the depth of cut deteriorates the surface finish of the machined left by the carbide tool (B. Rao, Y. C. Shin, 2001).

Figure 9 and 10 below show the comparison of surface roughness between 4 and 2-flute for each material. The differences can be seen on the graphs that have been plotted.

Referring to Figure 9 and 10, it shows that the small Stavax values represent higher surface finish than XW-5 with large values that represent low surface finish. Although the Chromium (Cr) composition in Stavax which is 13.6% (Assab., 2012) is higher than in XW-5 which is only 12.5% (Assab., 2012) because high chromium composition may cause the machining process become harder (J. Kopac, 2004), the wear of the cutting tools affected the result of surface roughness, the increase of tools wear deteriorates the surface finish of the machined left by the tool (B. Rao, Y. C. Shin, 2001). Based on the tool wear result values which the wear of the 4-flute cutting tool for XW-5 is 0.1462µm meanwhile Stavax is 0.0228µm, and the wear of the 2-flute cutting tool for XW-5 is 0.2163µm, meanwhile Stavax 0.0737µm, it proves that although the Chromium (Cr) composition in Stavax is higher than in XW-5, the wear of tools used in machining XW-5 have caused the machining process to become harder when machining XW-5 than Stavax.

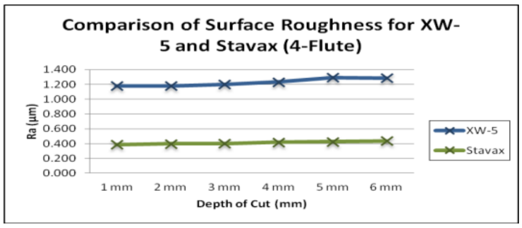

Fig. 9: Comparison of surface roughness cutting with 4-flute ball nose.

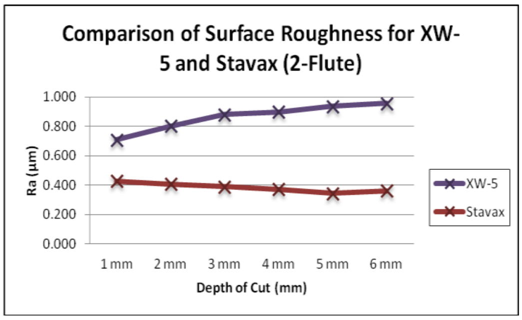

Fig. 10: Comparison of surface roughness cutting with 2-flute ball nose.

Figure 30 and 31 below show the comparison of surface roughness between cutting tools for XW-5 and Stavax. The difference can be seen on the graphs that have been plotted.

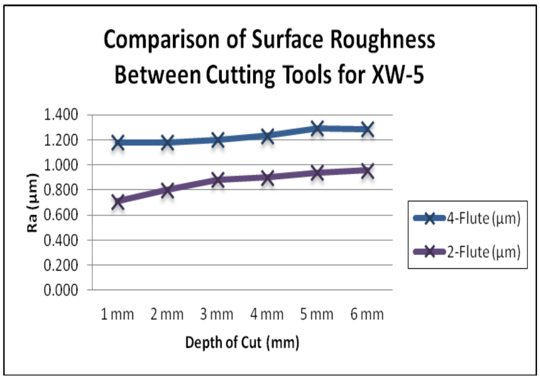

Fig. 11: Comparison of surface roughness between cutting tools for XW-5.

In comparing the surface finish between 4 and 2-flute of cutting tools for XW-5 and Stavax, the graphs that have been plotted show that 4-flute ball nose result is higher than the 2-flute ball nose and the surface roughness value is increased except for Stavax that has been cut by 2-flute ball nose. As for the 2-flute used for Stavax, the value decreases as the tool starts to wear and produces a better surface finish. A worn tool produces a better surface finish than the new tool (the fresh tool cuts well defined scallops resulting in a higher surface roughness) (M. A. Elbestawi et al., 1997). Besides that, the slot-like flutes design at the end of the ball shape on 4-flute ball nose, refer to the Figure 32 below, is not suitable when used in machining a flat profile like what has been done in this research. This is unlike a round profile such as in making a drain for the runner of a mould which causes the result of the surface roughness for each materials that have been cut using the 4-flute ball nose is higher than the 2-flute ball nose (refer to low surface finish). Ball Nose Endmill is used for profiling and finishing operation of corner radius. This endmill is especially effective when milling curved surfaces and the lesser of the Ball Run out tolerance, the better the surface finishing of the work materials (C. W. Chong., 2005).

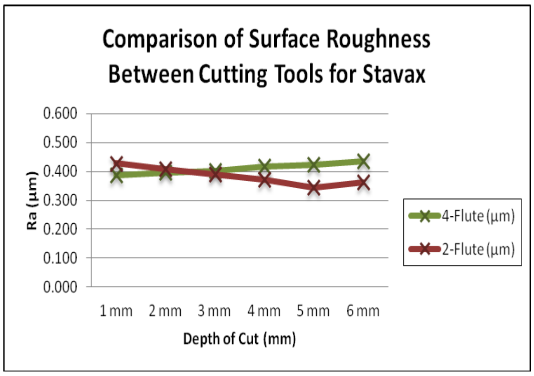

Fig. 12: Comparison of surface roughness between cutting tools for Stavax.

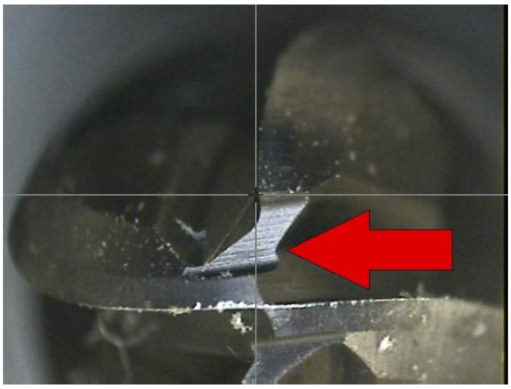

Fig. 13: Flutes design at the end of ball shape on 4-flute ball nose endmill.

Conclusion:

From the result obtained, it is found that:

1. The hardness of the workpiece has a significant impact to the tool wear mechanism. It is found that the flank wear will increase with the hardness of the workpiece.
2. The wear of the cutting tools affects the result of surface roughness which causes the machining process to become harder when the wear of tool increases.
3. The roughness value of materials increases proportionally to the depth of cut applied during the machining process but at some values of tool wear it produces a better surface finish before it increases back at such cutting depth.
4. Tools selection which refers to the profile that need to be machined also can affect the surface finish. Right selection of cutting tool will ensure the best result of surface finish.

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