Enhancement of Cutting Tool Life by Wear Study

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Abstract: **In any manufacturing industry the presence of precision in the cutting tool life is justified, hence it is essential to study the amount of wear on the cutting tool. The number of times it can be reused for machining the components and the number of tools to be present at any given time to avoid the stoppage of automated line in the manufacturing industry. The objective of the thesis is to study the wear data on the various scrapped tools and increase the tool life which results in one of the major form of cost savings in a manufacturing industry. After analyzing the data collected during the study period the process of standardization of all the important parameters pertaining to a tool can be initiated. The consequence of increased tool life would be direct reduction in the tool purchase costs, effective utilization of tool room resources and further reduced quality related problems in the components.**

Keywords: **Tool life, automated flow line, insert, wear, GENBA, Rapid I machine.**

I. INTRODUCTION

The manufacturing industry is constantly striving to decrease its manufacturing cost and increase the quality of the products as the demand for high tolerance manufactured goods. To increase product need to boost productivity to machine more difficult materials and to improve quality in high volume by the manufacturing industry has been the driving force behind the development of cutting tool materials. Numerous cutting tools have been developed continuously since the first cutting tool material suitable for use in metal cutting, carbon steel, was developed a century ago. Cemented carbides are the most popular and most common high production tool materials available today. The productivity enhancement of manufacturing processes is the acceleration of improved cutting tools with respect to the achievement of a superior tribological attainment and wear-resistance. This resulted in developing hard coating for cutting tools, these hard coatings are thin films of one layer to hundreds of layers. The hard coatings have been proven to increase the tool life by as much as 10 folds through slowing down the wear phenomenon of the cutting tools. This increase in tool life allows for less frequent tool changes, therefore increasing the batch sizes that could be manufactured and in turn not only reducing manufacturing cost but also reducing the setup time as well as the setup cost.

In addition to increasing the tool life, hard coating deposited on cutting tools allows for improved and more consistent surface roughness of the machined work piece. The surface roughness of the machined work piece changes as the geometry of the cutting tool due to wear and slowing down the wear which leads more consistency and better surface finish. The cutting tool is an important basic tool required in the machining process of a part in the production. It not only performs the cutting action but helps in getting required surface finish and accuracy of the part. In order to perform these tasks the tool has to be strong enough to withstand wear resistance and serve for long period of time to produce more number of components with the same accuracy. Machining is important in the manufacturing process to achieve good dimensional accuracy and for aesthetic requirements. In modern machining process by using the CNC machine tools the cutting tool will play a vital role in machining process and in improving the surface finish. Many reputed cutting tool manufacturing organizations globally with their rich experience of research and development, invented different ways of enhancing the life of cutting tool in order to optimize the rate of the production and to reduce the cost of production, which is highly acceptable to the manufacturing Industry.

The concept of material removal process in metal cutting operation is essential in selecting the tool material and also in assuring consistent dimensional accuracy and its surface integrity of the finished product. The Friction of metal cutting influences the cutting power, machining quality, tool life and machining cost. When tool wear reaches a certain value which results increasing cutting force, vibration and temperature cause deteriorated surface integrity and dimension error greater than tolerance. Due to this cutting tool must be replaced and the cutting process may be interrupted. The cost and time for tool replacement and adjusting machine tool which increases the cost and decrease the productivity. Hence friction in metal cutting relates to the economics of machining and prediction of friction is of great significance for the optimization of cutting process.

II. LITERATURE SURVEY

Tool wear is of foremost importance in metal cutting operation. Owing to its direct impact on the surface quality and machining economics, tool wear is commonly used to evaluate the performance of a cutting tool. Many research studies to understand and predict tool wear have been carried out. However, most of these studies are considered to be an empirical approach to tool wear. Consequently, many fundamental issues have not been resolved mainly due to the complex physics behind tool wear. The complexity surrounding tool wear from many factors including work material, machine tool, cutting tool, coolants and cutting conditions. Because of the coupled effects of these factors, the tool-chip and tool-work interfaces have almost unidentifiable contact conditions with highly localized interfacial temperatures and tractions. In multiple wear mechanisms the metal cutting operation is most cases simultaneously which makes a systematic study of tool wear very hard. The responsible wear mechanisms changes depending on cutting conditions and tool-work materials combination. Tool wear mechanisms that have been identified and are commonly accepted include adhesion, abrasion, diffusion and dissolution, chemical reaction and oxidation.

A. Abrasive wear:

Abrasive wear occurs whenever a hard rough surface or a surface containing hard particles slides on top of a softer surface as shown in Fig 1.

Fig.1. Abrasive wear in the metal cutting tool

In tool wear, abrasive wear is the removal of tool material by hard abrasive phases in work material. The abrasive phase with complex morphologies results in 2-body abrasion while the abrasive with simple morphologies results in 3-body abrasion.

B. Adhesion wear:

Adhesive wear occurs when one surface is sliding against another and fragments of one surface adhere to the other and then are pulled out of the original surface as shown in Fig 2. The origin of adhesive wear is the strong adhesive forces that arise whenever atoms come into intimate contact.

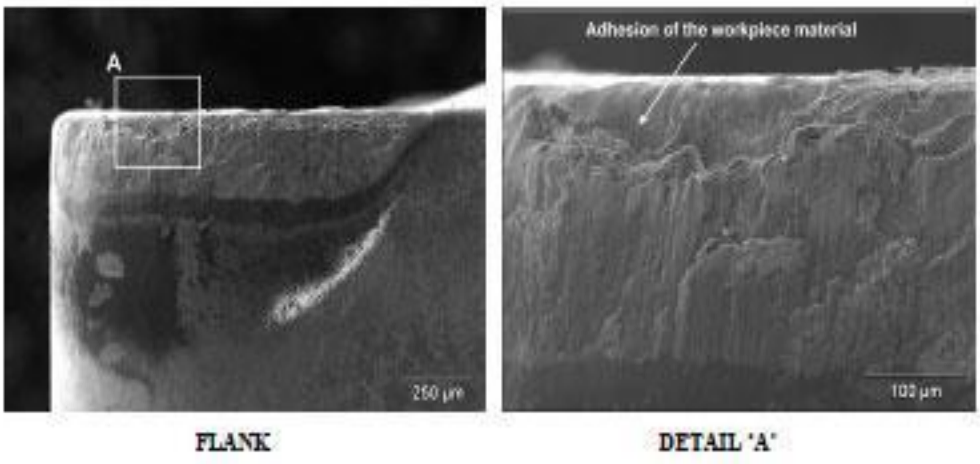

Fig.2. Adhesion wear in the metal cutting tool

In metal cutting, the adhesion may occur because the work material or the wear debris from the work material forms strong bonds (junction) with the tool under the high interfacial pressure and temperature. If the failure strength of the junction formed is larger than the local failure strength of one of the sliding surfaces and the junction will be detached from the surface with the lower failure strength. Tool wear will occur if the lowest failure strength happens to be on the tool.

C. *Diffusion wear:*

Solid-state diffusion takes place from regions of high atomic concentration to regions of low atomic concentration. The diffusion rate increases exponentially with temperature. Diffusion wear can occur in metal cutting due to the intimate contact at high temperatures in a very narrow reaction zone between the tool and the chip as shown in Fig 3. Diffusion wear mainly causes weakening of the surface structure of the tool.

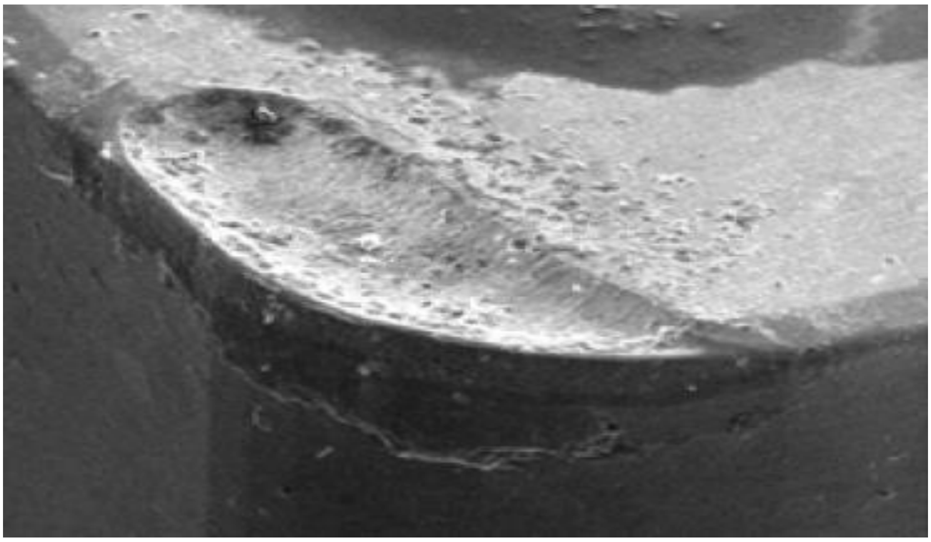

Fig.3. Diffusion wear in the metal cutting tool

Diffusion wear becomes a possibility when interface temperatures of sliding surfaces are relatively high and velocities in the close neighborhood are low. This condition can be found exclusively in heavily loaded sliders along with subsurface flow. For this case, the high speeds above the layer can account for the high temperatures while the relative low speeds near the bottom of the layer can account for longer contact times needed for diffusion.

D. *Dissolution wear:*

The high temperature required for dissolution wear to occur, not only the machining condition must be severe but also it occurs on rake face. In dissolution wear, the species from the tool material forms a solid solution within the chip. As the chip passes, tool material is constantly removed from the rake face. Dissolution wear depends on the chemical inertness of the tool material as well as on the chemical affinity of the tool components with the work material. At relatively high cutting speeds, dissolution wear dominates the wear process.

E. chemical reactions:

The dissolution theory breaks down when machining highly reactive materials such as titanium, where a chemical reaction followed by diffusion is more plausible. Strictly speaking, chemical reaction is not a wear mechanism. However, if chemical reaction occurs, it can affect tool wear tremendously when the tool material reacts with the work material or other chemicals to form compounds that are carried away in the chip stream or in the new generated surface of the work piece.

F. *Oxidation:*

Oxidation represents one of the chemical reaction wear mechanisms which occur when the species in the tool material or the work material reacts with atmospheric oxygen. It is often observed at the regions where the tool-chip contact is exposed to the atmosphere and is easily recognizable by the tool material discoloration of the zone affected. Oxidation can be observed as a severe depth-of cut notch (notch wear). The notch growth can lead to catastrophic failure by tool breakage. Sometimes wear debris are produced by oxidation leading to increased abrasive wear.

III. OBJECTIVES

The objectives are as follows:-

A. To improve life of the cutting tool

B. To reduce machining cycle time and increase production rate

C. Efficient cost utilization

A. To improve life of the cutting tool:

Generally, when a vendor supplies tools, He would mention its tool life with respect to the number of operations that it can be used for which they do not consider wear data and other cutting parameters. Hence by carrying out wear analysis, we check for possible ways to improve the tool life.

B. To reduce machining cycle time and increase production rate:

Machining cycle time is the minimum time required to finish machining operation. If the tool life is increased the tool change time would be reduced. Normally in any manufacturing industry there is a set of tools or calculated number of tools provided periodically for a month to the production department. As a result of our project we check if the increased tool life can reduce the number of tools that can be utilized for the given period of time and the additional components that can be manufactured using same tool.

C. Efficient cost utilization:

The cost of insert would range from Rs 1000 – Rs 4000 on an average. It would take on an average Rs 10 to manufacture one unit transmission system taking only inserts into consideration. The increase in the tool life would definitely save the cost spend for the inserts (Tools).

IV. WEAR MEASUREMENT DEVICE

Recent advances in optical scanning devices enable us to collect millions of sample points of reasonable individual accuracy on a part to be inspected. There are obvious advantages of non-contact inspection methods: speed, coverage, ease of operation, price, etc. One may ask why non-contact methods are not even more widespread in dimensional measurement. In fact the automatic extraction of actual dimensional and GD&T values from non-contact measurement data is not an easily repeatable and reproducible procedure. Non-contact measurement software had to take a different route. Instead of single points the basic information is a set of range images (possibly unregistered) or more directly unordered point clouds or polygon meshes. Consequently scanner software has built on Computer Vision software, Discrete Computational Geometry, and CAD. These are not just algorithmic differences but in many ways that of different culture. Rapid-I Vision Measuring Systems are top-of-the-line instruments that are designed for dimensional metrology as shown in fig. 4. It's a multi-functional product that spans all capabilities of a profile projector, tool maker's microscope and a video measuring system and many capabilities of a CMM.

Fig.4. RAPID I Machine

The machine consists of a precision X-Y work-stage on which the component to be measured is placed. A high-precision zoom optical system combined with a digital camera is fitted on a movable Z-axis. This allows for adjustable focusing of various components and even extends to non-destructive measurements of depth and height. All axes are motorized and operated with joystick or manually. Magnifications in the range of 5X to 650X (depending on optical configurations) allows for varied requirements to be easily accommodated. Rapid-I employs advanced digital camera technology that gives amazing image quality and best-in-class video resolution (800×600 pixels at 20 frames/sec). Intuitive and powerful geometric measurement software comes standard with the machine. The Rapid-I software comes with many pioneering features that have revolutionized the approach to metrological software development. One of the most widely used tools is the scaled graphical representation of geometric shapes on the video itself. This allows for intricate visual and logical analysis of errors in design and manufacturing. Seamless CAD integration powerful tools such as import, overlay, alignment and editing of CAD drawings has enabled many users to trouble-shoot errors more accurately, reduce development times and significantly reduce R&D/production costs.

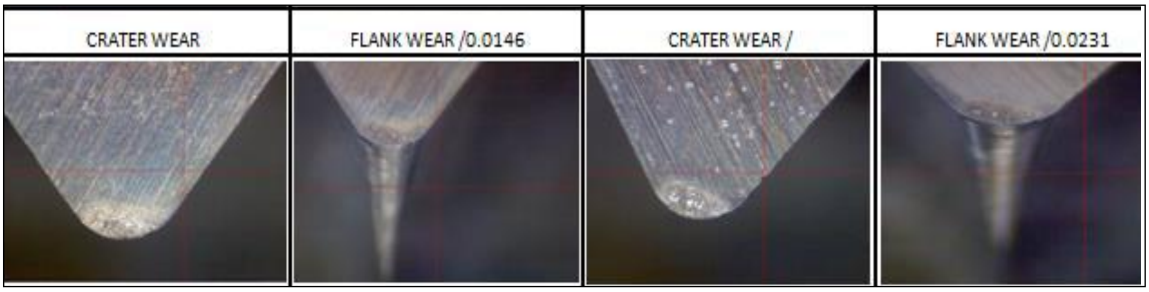

Fig.5.Cutting tool images obtained from RAPID I Machine

Automated program runs with one of the world's smallest CNC controllers have led to the use of Rapid-I in the high-volume repetitive measurement segment. Once measurements are complete, software generates reports in MS Excel automatically as shown in fig.5.These reports can be customized to meet your formats, colours and statistical processes.Image reports with graphical overlay on component image itself, along with comments and formula calculations are possible.

V. RESULTS AND CONCLUSION

Yellow bar represents the number of parts produced in the usual cycle for the respective machines and the green bar represents the number of parts produced after improvement for respective machines. As the result of life improvement 11350 components were produced more than before. For example, as observed in SSP0018, 400 parts extra were produced from usual in the normal cycle time. Similarly, the same was observed in other machines as indicated in fig.6.

This paper reviews the essential to increase production rate and minimize the production cost by increasing cutting tool life.

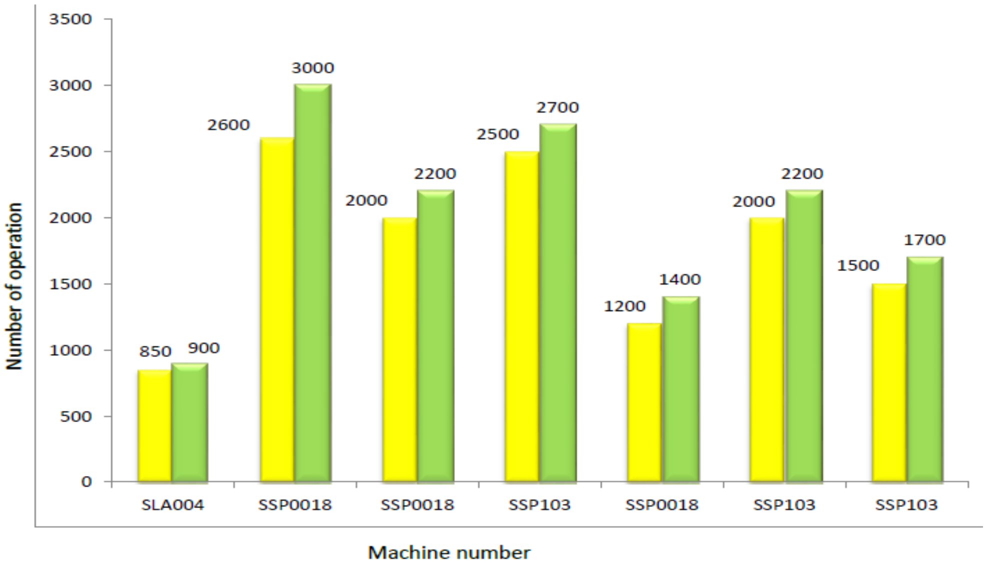

Fig.6. Effect of cutting tool life improvement

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