# Cutting Edge Nose Radius and Cutting Parameters Effect on Productivity in Turning of Cylinder Liners with Interrupted Area

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*Abstract*—Productivity in the machining of grey cast iron with interrupted area is adversely affected to tool failure which is significantly affect on the cycle time or processing time which increases the cost of the production. It can be overcome by proper selection of inserts, tool geometry, and cutting conditions to obtain economical benefits. Tool nose radius has significant influence on tool life which reduces the tool changing time with least cycle time. In this research work, an attempt has been made to investigate the effect of tool nose radius under different cutting conditions and their effect on cycle time and productivity. The measurement has been carried out from rough boring operation at three cutting speed (vc) and feed rate (f). Depth of cut (doc) is kept constant at 2.5mm.cutting tool used in this work is multilayer coated tool of nose radius 0.8mm and 1.2mm nose radius. Tool coated with titanium nitride (tin) + titanium carbo nitride (ticn) + aluminium oxide (al2o3) coating. The insert is designated with snmg 120408. Cutting conditions used is speed (vc) 100m/min, 125m/min and 150m/min. Feed rate (f) 0.20mm/rev, 0.25mm/rev, 0.27mm/rev.results of the present work determine the appropriate parameter for increasing the productivity by decreasing the cycle time using two different nose radius tools.

***Key words:*** Materials, Machining, Tool Nose Radius, Coating

## I. Introduction

The cutting tool is an important basic tool required in the machining process of a part in 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. 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.

In metal cutting industries they expect to have more and more productivity in their machining processes (high removal rate of work-material) and low wear of their cutting tools (long tool life). These demands require major improvements in the design of cutting tools: new substrates, new coatings, cutting tool geometry and materials etc. According to tool manufacturers [1], the manufacturing procedures of their cutting tools, especially the micro-geometry preparation (Cutting edge etc.), have a major influence on their performance and on their reliability.

Now a day in modern machining industries major challenge is mainly focused on achieving high quality in terms of workpiece dimensional accuracy, surface finish and less tool wear. The harder the material, the more difficult it is to machine. Cast iron has been used in large quantities for years because of desirable properties as good cast ability and low cost. This is brittle, weak and is not malleable. In industries for various applications wide variety Cast Iron is used. Machinability of Cast Iron is affected by the amount of carbon in it.

In order to attain sufficiently high production rates at minimum cost, optimization of cutting tool geometry is necessary [2, 3]. The design of cutting edge geometry and its influence on machining performance have been a research topic in metal cutting for a long time. Edge preparation has a critical effect on the tool life. A tool with poor edge preparation may chip and fail quickly [4].It was reported that, in the manufacturing industry is constantly striving to decrease its cutting costs and increase the quality of the machined parts as the demand for high tolerance manufactured goods is rapidly increasing. The increasing 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 [wall bank 9].

Literature of the coated tools with variation in cutting parameters and tool geometry has been discussed in the following paragraphs. According to Thamizhamanii (2006) reported that major challenge of modern machining industries is focused mainly on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear, on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact [5]. During turning one of the most important factors is tool wear whether it is soft or hard work pieces. The primary tools wear are classified as flank wear, crater wear and nose wear, are important wear which will affect the smoothness of the product, cost of operation and performance. Authors proved that tool wear is caused by the normal load generated by interaction between tool work piece and tip of the tool. Tool wears which results in tool substitution, is one of the most important economical penalties, so it is very important to minimize tool wear, and optimizing all the cutting parameters like depth of cut, cutting velocity, feed rate and cutting fluids (7).But at a high cutting speed tool wear occurs more intensively and causes the requirement of frequent tool changing. Again, tool changing time increases machine downtime and reduce the productivity of machining (Khan, 2006). [6] The authors reported that there exists an optimum cutting edge radius that minimizes tool stresses, especially within the coating layer, and prolongs the tool life .The authors claimed that the cutting edge radius increasing can lead to a longer tool life. Rech et al. investigated the effects of edge radius of

 

PVD coated tools upon chip formation and tool stresses in orthogonal cutting of steel. [8].

The earlier work reported that tool nose radius and cutting conditions provides substantial improvement in the machinability characteristics machining through a reduction in cycle time to enhance more number of components (Productivity). Currently machining work carried out using coated tools of nose radius 0.8mm and 1.2mm. Considerable experimental work carried out during machining grey cast iron cylinders used in automotive industry. In order to improve the productivity, Cycle time is considered as the major aspect to be minimized to enhance the productivity. The current requirement can be achieved by changing the depth of cut from 1.25mm to 2.5mm which changes double cut pass to single cut pass. At different speed and feed rate investigated cycle time or processing time and productivity in terms of components produced per cutting edge and also per shift. Finally it has been investigated the optimized cutting conditions for minimizing the cycle time to enhance the productivity.

## II. EXPERIMENTAL DETAILS

(a) (b) (c)

Fig. 1: a) Carbide inserts b) Cylinder liner c) Machining process

| Alloying Elements | C | Si | Mn | Cr | Ph | Su | Cu |
|---|---|---|---|---|---|---|---|
| % wt | 3.00 – 3.50 | 1.90 – 2.20 | 0.45 – 0.65 | 0.30 – 0.50 | 0.10 | 0.05 | 0.30 – 0.60 |

Table 1: Chemical Composition of Grey Cast Iron (Greaves Cylinder)

| Sl. No. | Description | Experimental details | |
|---|---|---|---|
| 1 | Work material | Grey cast iron (Greaves cylinder) | |
| 2 | Cylinder size | Ø81x137mm | Hardness : 220 BHN |
| 3 | Cutting tool | Coated carbide tool : SNMG120408 | |
| 4 | Coating type | CVD Coating, TiN coating & TiN+ TiCN +$Al_2O_3$ | |
| 5 | Cutting condition | Wet machining | |
| 6 | Machine type | Midas 8i CNC turning, Galaxy made | |
| 7 | Tool holder type | Special type boring bar | |
| 8 | Tool geometry | Nose radius = 0.8mm and 1.2mm<br>Negative rake angle = -6° | |
| 9 | Cutting parameters | Speed (Vc) m/min : 100, 125, 150<br>Feed(f)mm/rev: 0.22,0.25,0.27<br>Depth of cut(doc):2.5 | |
| 10 | Parameters to measure | Cycle time, Productivity (Number of components per corner and per shift) | |

Table 2: Experimental Details

## III. RESULTS AND DISCUSSIONS

Table 1 and 2 shows that the experimental results of number of components produced per corner and production rate per shift while machining with 0.8mm nose radius tool and 1.2mm nose radius tool. The experimental results are summarized below.

Fig 2 and Fig 3 shows that the effect of feed rate and cutting speed on numbers of components produced in one cutting edge while using multi-layer coated tool of 0.8mm nose radius and 1.2mm nose radius tool. According to figure 1 and 2 while machining grey cast iron feed rate has a significant influence on machining. It was observed that, as the feed rate increased, this results to decreases in the number of components per corner for all the trials in 0.8 mm and 1.2 mm nose radius tool.

| Sl. No | Speed ($V_c$), m/min | Feed (f ), mm/rev | Depth of cut (doc), mm | Cycle time, sec | No. of components/corner | Productivity/shift (7hr) |
|---|---|---|---|---|---|---|
| 1 | 100 | 0.27 | 2.5 | 95 | 38 | 245 |
| 2 | 100 | 0.23 | 2.5 | 108 | 42 | 224 |
| 3 | 100 | 0.2 | 2.5 | 115 | 45 | 200 |
| 4 | 125 | 0.27 | 2.5 | 78 | 40 | 280 |
| 5 | 125 | 0.23 | 2.5 | 85 | 38 | 256 |
| 6 | 125 | 0.2 | 2.5 | 94 | 58 | 225 |
| 7 | 150 | 0.27 | 2.5 | 65 | 38 | 331 |
| 8 | 150 | 0.23 | 2.5 | 74 | 49 | 300 |
| 9 | 150 | 0.2 | 2.5 | 80 | 10 | 280 |

Table 4: Experimental Results for 0.8mm Nose Radius Tool

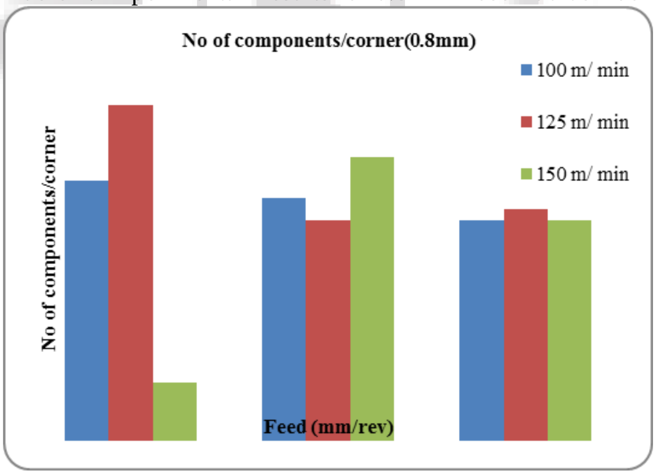


Fig. 2: Feed vs Number of components/corner

38 to 40 Numbers of components per cutting edge is machined at cutting speed 100m/min and feed rate 0.27mm/rev for 0.8mm nose radius tool. On other hand it was noticed that up to 50 to 55 components produced per cutting edge (corner) for 1.2mm nose radius tool. This is due to the rapid movement of tool produces vibration and friction, causes cutting edge failure. At interrupted portion in cylinder liner, cutting edge get chip off or broken due to the impact load (sudden load) on the cutting edge. At high feed rate tool travels rapidly, resulting corner burnt or broken due to

| Sl. | Speed | Feed (f ), | Depth | Cycle | No. of component | Productivity/shift |
|---|---|---|---|---|---|---|

 

| No | ($V_c$), m/min | mm/rev | of cut (doc), mm | time, sec | s/corner | (7hr) |
|---|---|---|---|---|---|---|
| 1 | 100 | 0.27 | 2.5 | 95 | 52 | 265 |
| 2 | 100 | 0.23 | 2.5 | 106 | 53 | 237 |
| 3 | 100 | 0.2 | 2.5 | 115 | 48 | 213 |
| 4 | 125 | 0.27 | 2.5 | 75 | 46 | 323 |
| 5 | 125 | 0.23 | 2.5 | 83 | 44 | 293 |
| 6 | 125 | 0.2 | 2.5 | 92 | 64 | 259 |
| 7 | 150 | 0.27 | 2.5 | 61 | 40 | 387 |
| 8 | 150 | 0.23 | 2.5 | 72 | 51 | 340 |
| 9 | 150 | 0.2 | 2.5 | 80 | 19 | 315 |

Table 5: Experimental Results for 1.2 Mm Nose Radius Tool

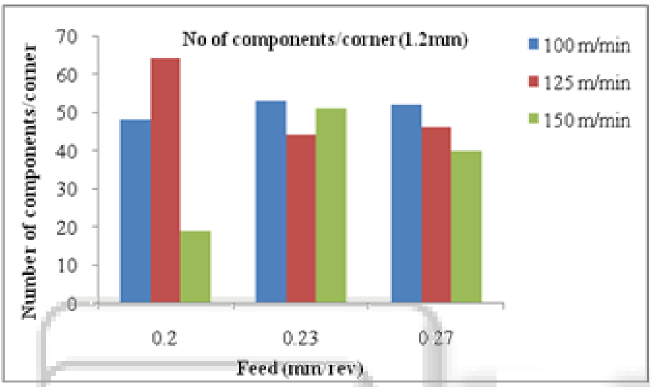


Fig. 3: Feed vs Number of components/corner

rubbing action between tool and work, this leads to vibration and chattering. Vibration tendency is a result of cutting force. Cutting edge with smaller radius chipped off or broken at interrupted portion due to excess cutting force/ feed force. Larger nose radius (1.2mm) tools easily absorb the excess cutting force/ feed force in high cutting velocity and feed rate which leads to increases the components per cutting edge shown in figure. The effect of feed rate on the number of components produced is as follows: The increase in the high feed rate at 0.27mm/rev, resulting less number components/corner. Whereas it is in increasing trend in case of 0.2 mm/rev and 0.23mm/rev for all respective speeds.

## IV. Effect of Feed Rates on Productivity

It can be seen from the figure 4 and figure 5, effect of feed rates on productivity with three different velocities. Increasing in the productivity rate with increasing the feed rate and velocities. As the feed increases, this leads to increases the components per unit time. At high speed and feed rate material removal rate is high with minimum cycle time.

Experimental results shown in table 4 and 5 it was clear that, the productivity rate is in increasing trend at higher feed rate and speed. Results can be explained due to the decreasing in cycle time or processing time leads to increases in the productivity rate. In order to attaining this goal is to gain a more productivity with less cycle time and better tool life.

According to Fig. 4 and 5 it can be observed that, compare to 0.8mm nose radius tool productivity rate is in increasing trend where using 1.2 nose radius tool. At high feed rate and speed, components per shift is in the range of 180 to 220 no. This can be explained that, the properties like high wear resistance and toughness of multi-layer coated tool. Sometime tool life is also factor which effect on productivity. Tool changing time which leads to the less productivity. According to results, tool changing time is less in case of 1.2mm nose radius tool compares to single layer coated tool, due to the failure of tool is after long period of time.

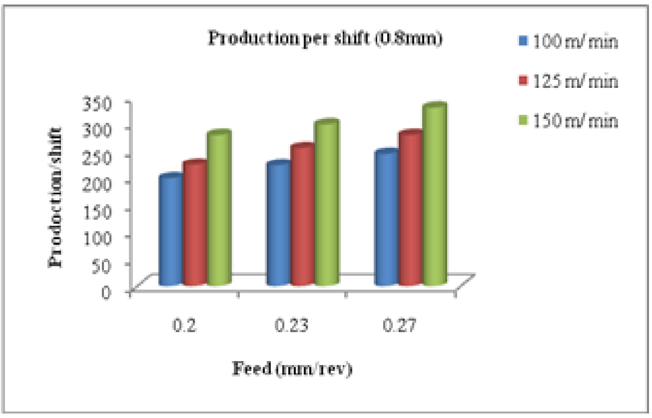


Fig. 4: Feed vs Production/shift

Thus the purpose of development of cutting tool material with different nose radius has different advantages such as reducing the manufacturing cost and lead time, machining more difficult materials, moving to unmanned machining operations, improving surface integrity and achieving high metal removal rates.

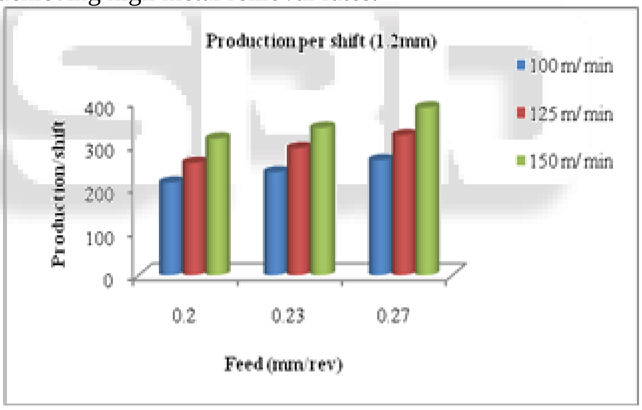


Fig. 5: Feed vs Production/shift

## V. Conclusions

1) At high cutting speed and feed rate productivity is maximum for 1.2mm nose radius tool compare to 0.8mm nose radius tool.
2) As the feed rate is increases to 0.27mm/rev for all speeds which results insert broken or less tool life with less productivity.
3) Productivity rate is increased with increasing speed and feed rate with less tool wear for 1.2mm nose radius tool.
4) The Optimized parameter for high productivity with less tool wear is at speed 125m/min, 150 m/min and feed 0.2mm/rev, 0.27mm/rev is obtained.
5) Insert type (geometry) was found to have a majority effect on the productivity.
6) Cost of production of components using larger radius (1.2mm) tool is less than smaller radius (0.8) tool.

 

7) To obtain the maximum profit the optimized parameters which are recommended are to be performed than using the current parameters.

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