Improvement in Productivity of Circular Blade Saw Machine by Modifying the Tool Parameters

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Abstract

Advances in the technologies create competition between organizations and any organization needs to survive in this competition. There are several factors which should be improve for surviving in the competitive market for example productivity, quality and lead time etc. In this paper we are going to discuss the improvement in the productivity through improvement in the tool parameters. The circular blade saw machine, of which we are going to improve the productivity, is use for cutting the end portions of the ingot which is made of aluminium and its alloys. For finding out effective tool parameters, we are going to apply trial and error method considering all the factors affecting the productivity of the machine. After finding out the effective parameters, implementation in the tool will be done and output of the machine will be observed in terms of number of jobs done per shift. The study finally concludes with implementation of optimum tool parameters for improving the productivity of the saw machine.

Keywords: Productivity, Tooth Geometry, Tipping Material, Tooth Forms, Feed Speed, Profit

I. INTRODUCTION

To survive in today’s competitive market, every organization come up with more and more advances in the machining technology and the process. Improvement in the productivity, quality, and lead time are some of the ways to improve profit of the organization. The traditional approach to increasing profits is to invest in new machinery and computer systems. While this option does work, major upgrades are risky in terms of system integration, training issues and reliability. Furthermore, the competition is also buying the same equipment. This leads to the conclusion that the competitive advantage comes from how the equipment is used and optimized more than what type of equipment you have. The changes needed for equipment to be used to its full potential are neither expensive, nor risky. The process of optimizing a machine is usually done in incremental steps, none of which cost much and can easily be reversed if a problem shows up. Frequently, the change is just a change in how things are done and cost nothing. In the manufacturing industries, this process is call “continuous improvement” and is one of the cornerstones of the manufacturing philosophy originally developed by the Japanese. One of the other time-tested cornerstones is that consistent and quality production result in significant profits and happy customers.

In this paper the improvement in the productivity of the circular blade saw machine which is used to cut end portions of the ingots which are made of aluminium and its alloys, is discussed. The tool used for cutting purpose, is segmented HSS circular saw blade. This blade has 36 segments and each segment has two teeth made HSS. So it has total 72 teeth. These segments are assembled on the base plate which has outer diameter of 62.375” and has 144 holes on its pitch circle of diameter 61.6875”, with the help of welding process. The outer diameter of the blade measured from tip to tip is 66.125”. Teeth of the blade has triple chip grind tooth form having one beveled tooth and one flat top tooth in each segment. The difference between the heights of these two teeth is 0.025” to 0.030”.

There are some parameters on which productivity depends and should be consider for improving productivity of the saw machine. Such as tip material, tooth geometry, tooth forms, feed speed, blade speed etc. All these parameters are then compared with best suitable parameters which are experimented by various authors. Then the trial and error method is used and examined the results for improving the productivity of the machine.

II. METHODOLOGY

Design of Experiment is an essential piece of the reliability program pie. It plays an important role in Design for Reliability (DFR) programs, allowing the simultaneous investigation of the effects of various factors and thereby facilitating design
optimization. Most of our knowledge about products and processes in the engineering and scientific disciplines is derived from experimentation. An experiment is a series of tests conducted in a systematic manner to increase the understanding of an existing process or to explore a new product or process. Design of Experiments, or DOE, is a tool to develop an experimentation strategy that maximizes learning using a minimum of resources.

In this paper, most of the productivity affecting factors of the saw machine tool are considered and on the basis of trial and error method, the optimum values of various parameters have been found out. Various authors have performed the experiments and found out the effect of tooth geometry, tipping material etc. on the cutting parameters such as cutting forces, temperature. Considering those effects and selecting most suitable parameters, implementation is done over the old cutting tool and results are observed in the form of number of ingots cut per shift. Parameters, by which the productivity is improved are selected and finally implemented on the cutting blade.

III. STAGES OF DOE

Designed experiments are usually carried out in five stages planning, screening, optimization, robustness testing and verification.

A. Planning:

It is the process of testing and data collection. The factors or the parameters of the cutting tool, which affects the overall productivity of the machine, are found out. Those parameters will be then replaced with the new parameters. These new parameters are collected from the experiments done by various authors. New parameters will be then implemented on the new blade. That new blade will be installed and the results are observed. In case there is problem found in the result then by examining the problem the changes will be done again. And same procedure will be repeated until we get best result. Following are the data collected from the older cutting blade.

1) Tool: HSS Segmented circular saw blade.
2) No. of teeth: 72.
3) Outer dia: 66.125"
4) Feed speed: 2"/min
5) Return: 4 "/min.
6) Saw blade speed: 6000 to 3000 fpm.
7) Tooth form: Triple chip grind.
8) Jobs done per shift: 8 to 10.

B. Screening:

Screening experiments are used to identify the important factors that affect the process under investigation out of the large pool of potential factors. These experiments are carried out in conjunction with prior knowledge of the process to eliminate unimportant factors and focus attention on the key factors that require further detailed analyses. Screening experiments are usually efficient designs requiring few executions, where the focus is not on interactions but on identifying the vital few factors. Following are the factors/parameters of the blade on which the productivity depends.

1) Tooth geometry
2) Tooth forms
3) Tip material
4) Feed speed
5) Blade speed

From all the above factors, number of jobs to be done per shift can be increased by increasing the feed speed. But if we only increase the feed speed there can be any damage to the tool or machine or the tool life may be decreased. So for increasing the feed speed other factors should also be taken into consideration.

IV. OPTIMIZATION

Once attention has been narrowed down to the important factors affecting the process, the next step is to determine the best setting of these factors to achieve the desired objective. Depending on the product or process under investigation, this objective may be to either increase yield or decrease variability or to find settings that achieve both at the same time.

A. Tooth Form & Blade Speed:

Before selecting best settings for the affecting factors, it should be noted that there is no arrangement for changing the rotational speed of the blade, so blade speed kept constant. The tooth form used in the old blade is triple chip grind form. Several studies show that this kind of tooth form is used for the material which is subjected to chipping. These tooth forms have good wear resistance, balanced cutting force, low tooth drag, and free chip flow. Therefore in newer blade also this kind of tooth form will be best suitable.
B. Tipping material:

Tip material also plays an important role in cutting operation. There are several materials used for the tipping material such as diamond, cubic boron nitride, cermets, tungsten carbide, high speed steel, tool steel etc. Several studies observe that if any material requires 50 minutes for a whole cut by cutting alloys, tungsten carbide will need 15 minutes, cermets will need 5 minutes and diamond will need 1 minute for a whole cut. So there are three options which can replace HSS tooth of the old blade i.e. tungsten carbide, cermets and diamond. From these three material types the tungsten carbide is cheapest amongst three and diamond is expensive. Tungsten carbide has high performance than the HSS. The cost of the single tip of tungsten carbide will be around 200 to 300 INR. And for the segmental HSS blade the cost of the single segment is more as compared to TCT (Tungsten Carbide Tool).

You could machine more metal if you made tungsten carbide than if you used it for high-speed steel. You can typically cut three to 10 times faster with tungsten carbide than you can with high-speed steel. You get very hard grains for wear resistance and the cobalt stays relatively soft for impact resistance. You can take tungsten carbide, heat it and bend it into spirals and curves for cutters, which you cannot do with ceramics.

C. Tooth Geometry:

In tooth geometry of the circular saw blade, the important factors to be considered are hook/rake angle, top clearance angle and its effect on the cutting force and temperature generated. The Hook angle for the previous blade is 0° to -5°. Lungu N., Chroitoru S. M., Borzan M. experimented the influence of hook angle and clearance angle on cutting forces and the temperature generated in the tool. They performed the experiment with taking 6°, 7°, 8° as hook angles and 8°, 10°, 12° as clearance angles. Influence of hook angle: The lower force values were obtained for an angle of 8°. Regarding to the temperature variation and thermal deformation with the rake angle, the results show that the highest values were recorded for an angle of 7° [1]. Influence of clearance angle: Forces were approximately same for all the clearance angles. There is a reduction with 170°-200° for a clearance angle value of 10° compared with 8° and 12°. All these results are shown in the following figures.

From above results found in the experiment done by Lungu N., Chroitoru S. M., Borzan M., it’s clear that the force required and the temperature generated in the process is less for the rake angle of 8°. The force required for cutting is approximately same for 8°, 10°, 12° clearance angles but temperature generated is less for the angle of 10°.

V. Verification

This final stage involves validation of the best settings by conducting a few follow-up experimental runs to confirm that the process functions as desired and all objectives are met.

Considering the above optimizing factors, these parameters are applied to the older blade and the newer blade is made by applying these parameters. The tooth form implemented was triple chip grind, the tipping material selected was tungsten carbide and the rake and clearance angles implemented were 8° and 10°. The older blade is replaced with the new one for conducting
trial. For this blade the feed speed kept 2 inch/min initially and the cuts made in one shift were increased from 8 to 12 by utilising all the time in the shift with no delay in loading and unloading the ingots to the machine.

After one week the feed speed was increased from 2 inch/min to 3 inch/min. Due to this change in the machining speed the cuts made per shift increased from 12 to 18 but after some days 2 to 3 teeth were worn out. It was because of the increased feed speed. But for increasing productivity the increment in the feed speed is necessary. For more value of rake/hook angle, the cutting operation will be more aggressive. And due to this aggressiveness, the teeth of the blade can get worn out quickly. Therefore we made a decision to choose another rake/hook angle for the tooth of the blade less than 8°. After 8° rake angle option, another option which requires less cutting force and generate less temperature is 6°. Then the rake angle of the blade teeth changes to 6° and that blade was installed on the machine for conducting another experiment.

With this new blade, with new rake angle as 6° and feed speed as 3 inch/min the cuts made per shift were 18 and the tool life got better in comparison with the blade with 8° rake angle.

VI. RESULT AND DISCUSSION

With this new blade, with new rake angle as 6°, 10° clearance angle, feed speed as 3 inch/min, tungsten carbide tip and triple chip grind tooth form, the cuts made per shift were increased from 8 to 18. We performed experiments with two rake angles as 8° and 6°. In case of the 8° rake angle the productivity was increased but the teeth of the blade were worn out quickly due to aggressive cutting. So the rake angle changed to 6° and due to this the tool life was increased as compared to blade with 8° rake angle. One of the operators reached up to 24 cuts per shift by increasing the feed speed from 3 to 3.5 inch/min and by minimising the delay in loading and unloading the ingots.

The cost of the older HSS blade was around 3 lac. and the cost of the TCT blade is less than 1 lac. So comparatively the price of the TCT blade is less. The cost per tooth is 200 rs to 300rs. So in case there is damage to any tooth, it can be replaced with low cost. Therefore the re-tipping cost is also decreased.

VII. CONCLUSION

In this paper the various factors on which the productivity depends are discussed and the most suitable parameters are implemented on the new blade. For increasing productivity of the circular blade saw machine the important factors are tooth form, tooth geometry, feed speed and tipping material. Out of these factors the most important factor is feed speed. As feed speed increases the productivity can be increased. But to increase the feed speed changes should be done in the tooth geometry, tooth form, tipping material. Only increase in the feed speed can reduce the tool life. So along with feed speed, other parameters also have to be considered. The teeth with more rake angle value will cut more aggressively and can reduce tool life. So tool life of blade with 6° rake angle is more as compare to the blade with 8° rake angle. As there is more productivity, less cost of blade and less re-tipping cost, there is increased in the profit as compared to older blade.

REFERENCES