COMPARATIVE QUALITY INVESTIGATION OF ROLLED AND FLAT CARBON STEEL PLATES IN DRILLING

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Comparative Quality Investigation of Rolled and Flat Carbon Steel Plates in Drilling

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Abstract – Comparative investigation of machining quality of rolled steel plate and flat plate are studied, where, the effects of cutting speed, feed rate and numbers of holes drilled are taken into account. For this purpose, AISI 1045 carbon steel was drilled in dry machining conditions using CNC HAAS milling machine. Drilling process was carried out with 10mm diameter twist drill tool with 118° point angle. Ranges of the feed rate and cutting speed recommended by the tool manufacturer were tested to investigate the surface quality drilled holes. The Surf-Test SJ-301 has been used to measure the micro defects on drilled holes. In the experiments, surface roughness found to be increased in pattern with the holes drilled. The results also discusses about the influences of cutting speed and feed in determining the surface finish of holes produced.

Keyword: Rolled steel plate; surface roughness, drilling, cutting speed, feed rate.

I. INTRODUCTION

Drilling is the most common machining process and almost 75% of preliminary processes in all metal-cutting operations. By using the selected parameters, this paper describes the quality of drilled holes in terms of surface roughness for flat and rolled steel plates. Drilling process is the most commonly associated with producing machined holes. Although many other processes contribute to the production of holes including; boring, reaming, broaching, internal grinding, etc. drilling still accounts for the majority of holes produced in the machine shop due to its quick and economical method of hole producing. The other approaches are also used principally for more accurate, smoother and larger hole making. Drilling is one of the most complex machining processes. The chief characteristic that distinguishes it from other machining operations is the combined cutting and extrusion of metal at the chisel edge in the centre of the drill. The high thrust force caused by the feeding motion first extrudes metal under the chisel edge, and then it tends to shear under the action of a negative rake angle tool.

The purpose of this comparative study is to investigate the quality results of drilled holes on flat steel plate and rolled steel plate. The surface finish for the holes was investigated to define the reasons for different gain in surface roughness of both conditions. The selection of machining parameters are used to minimize the surface roughness of drilled holes on flat and rolled steel plate to reduce the rework cost in repairing the defected drilled holes. This paper also describes the effect of parameters in both drilling conditions of flat and rolled steel plates to further reduce the manufacturing cost and increase the production rate. This paper also emphasizes on the surface roughness quality of drilled holes because the quality of the surface is significantly important in evaluating the productivity and quality aspect of mating parts.

II. LITERATURE REVIEW

Study on the various coated twist drills for stainless steel drilling investigated experimentally by Wen-Chou Chen and Xiao-Dong Liu [1]. The experimental results show that the TiN-surface multilayer coated drills result in the smallest average thrust forces and torque, whilst the TiN-surface monolayer coated drills result in the largest amongst three coated twist drills in the drilling of JIS SUS 304 stainless steel. Erik Persson, Ingvar Eriksson and Leif Zackrisson [2] investigated effects of hole machining defects on strength and fatigue life of composite laminates. Effect of machining parameters and coating on wear mechanisms in dry drilling of aluminum alloys has

been investigated by M.Nouri, G.List, F.Girot, and D.Gehin [4]. The temperature generated by friction and plastic deformation in the secondary shear zone strongly controls tool wear was discussed in this paper. Thrust force, torque and tool wear in drilling the bulk metallic glass has been studied by Mustafa Bakkal, et al [5].
Two drill tool materials, M7 high speed steel (HSS) and WC in cobalt matrix (WC-co) were used in this experiment. The chip light emission, associated with high chip and tool temperatures, showed a detrimental effect on the drill life. Drilling of X2CrNi 19 11 stainless steel with NiTi coating was presented by J.A.Paro, T.E.Gustafsson, and J.Kosinen [6]. This study investigated the suitability of TiN and TiCN coated cemented carbide tools in the machining of conventionally produced stainless steel with HIPed (Hot Isostatic Pressed) NiTi coating. The researchers found that the drilling of NiTi-coated stainless steel with sufficient cutting parameters is possible without severe tool wear and a cutting speed of 50 m/min and feed rate between 0.1 and 0.2 mm/rev with solid carbide drills with pressurised spindle through coolant system. John Hewson [7] has studied the surface roughness (Ra) in dry drilling of Ti-6Al-4V. In this study, hole quality studies for as surface roughness, linearity, hole diameter, and roundness which traditionally been used to confirm formation modes and additional parameters in drill performance ratings.

III. EXPERIMENTAL SETUP AND PROCEDURE

A CNC HAAS Milling machine has been used for the drilling 10 mm thickness of AISI 1045 carbon steel rolled and flat plates with hardness of 170BHN at 25°C. The rolled plates are formed into the external diameter of 180mm from the same 10mm thickness flat plates used in this experiment. This research is meant to investigate the variation of surface roughness produced on flat and rolled steel plates using identical geometry drill tool. The cause and deviations are also discussed. Eight experiments were conducted with three replications by different combinations of machining parameters for the selected drill tool. The first set tools marked and used in this experimental work is shown in figure 1. Table I summarizes the DOE matrix of a single complete cycle which were randomized to prevent bias in data collection. Surf-Test SJ 301 was used to measure the surface roughness of drilled holes. The center-line-average method has been used to measure the surface roughness of drilled holes at three location of 120° each over the hole circumference and average values were used in this analysis. Standard sampling length (λc) and standard evaluation length, (EVA-L) have been used to evaluate the hole wall surface roughness.

(λc)= 0.8mm x5, ; (EVA-L)=4.0mm

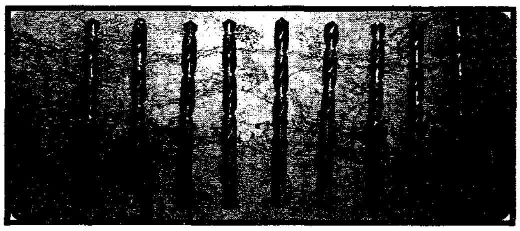

Figure 1: Samples of first set drill tools

Table 1: DOE matrix

Randomized Run	Speed (RPM)	Feed (mm/min)	Work type
1	1	1	1
2	1	1	-1
3	1	-1	1
4	1	-1	-1
5	-1	-1	1
6	-1	-1	-1
7	-1	1	1
8	-1	1	-1

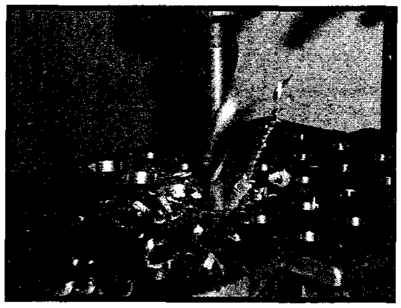

Figure 2: Drilling of a flat plate

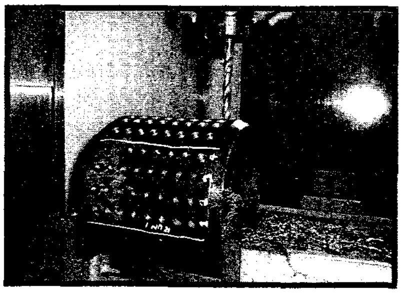

Figure 3: Drilling of a rolled steel plate

The experimental setup and procedures of drilling flat and rolled carbon steel plates are shown in Figure 2 and figure 3 respectively.

IV. RESULT AND DISCUSSION

Four experimental results were presented in this paper, namely experiment number 1, 4, 6 and 8. Three main comparisons of the experiments were made here;

- Between the surface roughnesses observed on rolled and flat plates for the same machining conditions.
- Between the variation of feed rate.
- Between the variation of cutting speed

In summary, experiment 1, 4, 6 & 8 presents the differences in result for flat and rolled steel plates. Where as, experiment 1 & 4 compares the result of surface roughness for different level of feed rates with constant speed for both the rolled and flat work pieces. The same with experiments 6 & 8, where, the low level of speed is used to investigate the surface roughness with two different feed rates for both the rolled and flat steel plates.

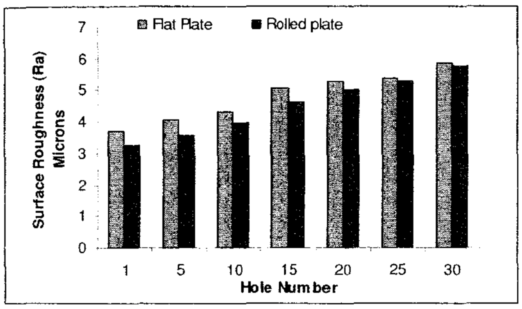

Figure 4:Comparative surface roughness for experiment 1

Figure 4 shows the observed results for experiment 1 with the cutting speed of 478 rpm and 15 mm/min feed rate for 10 mm drill tool. The experimental results show that, for most of the drilled holes, the flat plate produces higher surface roughness values as compared to the rolled steel plate. The minimum and maximum deviation were observed on hole number 28 and 9 where, roughness of flat palate is greater than rolled steel plate by 0.17μm and 0.82μm respectively.

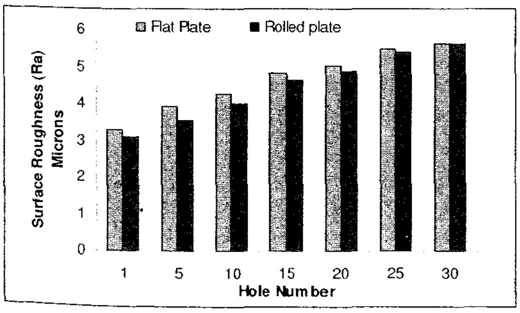

Figure 5:Comparative surface roughness for experiment 4

Experiment 4 as shown in figure 5 is the plot of observed results for the same cutting speed of experiment 1, but the feed rate was set at 13mm/min - lower side for the same diameter drill tool. The results show almost the same trend with experiment 1. The lowest and highest deviation between the flat and rolled steel plate occurs for the hole number 29 and 4 where they are 0.35μm and 1.78μm respectively. The reduction in feed from 15 mm/min to 13 mm/min also witnesses the improvement of surface roughness in experiment 4 as compared to experiment 1.

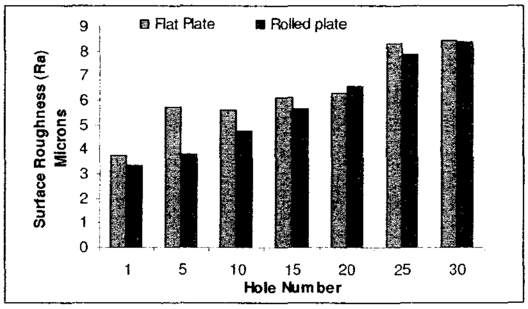

Figure 6:Comparative surface roughness for experiment 6

Experiment number 6 is represented by figure 6 which witnessed producing higher surface roughness as compared to experiment 1 and 4. This is due to the reduction in the cutting speed where it is set to 382rpm with the combination of high level setting of the feed rate. The deviation of 0.09μm and 2.15μm was observed on hole number 29 and 5 with the positive values residing to the flat plate as compared to rolled steel plate.

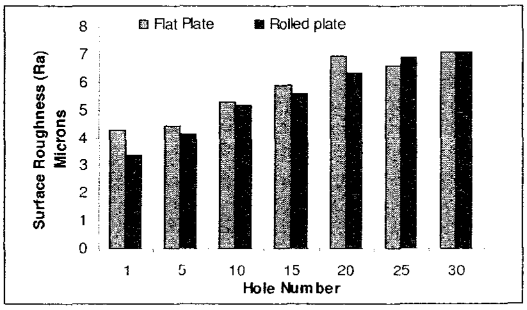

Figure 7:Comparative surface roughness for experiment 8

Experiment 8 shown by figure 7 is the result of feed rate reduction from 15mm/min to 13mm/min compared to experiment 6. This experimental results present better surface roughness for both the flat and rolled steel plate as compared to experiment 6. It shows that the control of feed rate gives significant effect on the surface roughness regardless of rolled or flat plate. The minimum and maximum deviations are observed for hole number 30 and 2, where they were 0.03μm and 0.83μm respectively with more roughness on the flat plate.

V. CONCLUSION AND RECOMMENDATION

From the whole experimental results observed for the combination of machining parameters, it is found to be that the rolled steel plate experiences better surface roughness as compared to flat plate. These results are validated for the rolled external diameter of 180 mm with 10 mm wall thickness. From the investigation, the authors found that the residual stress and tension state of the rolled steel plate reduces the friction and abrasion effect between the tool and work wall which result in better surface roughness as compared to flat plate drilling within the range of experimental values. The authors also found that the reduction in feed rate produces better surface roughness for both the flat and rolled steel plate drilling. For the experiments with higher level cutting speed, the surface roughness found to be better than the lower ones within the range of experimental parameters. Therefore, it is recommended that the cutting parameters to be taken at the lower side for the feed rate and higher side for the cutting speed in this phenomenon.

From the plots and numerically analyzed data, found that the comparative result is more obvious between rolled and flat plate surface roughness on the first 2/3 holes drilled on each workpiece. Therefore, it is recommended to carry out an extensive investigation which consist of more that 50 holes in a workpiece to recognize the trend of drilling effect on rolled and flat plates.

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BIOGRAPHIES

Mr. Sivarao is a research academia in manufacturing engineering faculty, Universiti Teknikal Malaysia Melaka (UTeM). He is currently active in his research area namely precision machining, cutting tools and artificial intelligence in the area of manufacturing. He also presented his research findings at many international events including University of California (USA), University of Calgary (Canada), Feng Chia University (Taiwan), etc. He has also published several numbers of research papers in national and international conference proceedings and journals.

Besides his research work, Mr. Sivarao is also a reviewer for;

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His research work on invention & innovation has also won him several medals in the national and international invention competitions including international exhibitions of inventions, Geneva year 2007.

Mr. Taufik is an expatriate from Indonesia serving the manufacturing engineering faculty, University Teknikal Malaysia, Melaka. He has published a number of scientific research papers at international and national level. He specializes in the area of manufacturing design and development mainly involving concurrent and robust engineering; His invention capability has also made him to win a medal in the invention competition of Malaysia Technology Expo (MTE) year 2007.