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Experimental Analysis on Turning of Super Duplex UNS 32750 Steel Using Minimum Quantity Lubrication Process

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Abstract. Current production trends necessitate extensive use of cutting fluids, resulting in adverse climatic changes and increasing industry expenses. Modern manufacturing businesses are looking for new ways to meet the demands for faster machining rates, less waste, and improved product quality while also lowering manufacturing costs. Material removal rate (MRR) and surface roughness (SR) of the work piece machined with coated tools are all evaluated. Cutting speed (CS), pressure flow (PF), and depth of cut(DOC), are the input parameters. An aerosol mixture of air and oil was used to give the least amount of lubrication. To assess the relative performance tuning with the MQL setup, an investigation was conducted. When compared to dry turning, the MQL system for turning super duplex stainless steel UNS 32750 has shown to be more effective. The MQL technique significantly improves cutting performance in terms of increasing tool life and improving machined component quality.

1 Introduction

There is a significant motivation to utilize the cutting fluid. The main inspiration to use the minimum liquid is to reduce the temperature, longer existence of cutting instrument and gets great machining process. Utilizing cutting fluid might ideal for machine. However, utilizing high measure of cutting fluid become costly besides it makes unfavorable side impacts. It is absolutely financial and amicable interaction. MQL give generally best execution than Dry and Wet as far as having the option to increment cutting apparatus life, lower temperature which is thoroughly benefit for workers and nature. MQL addresses the oil innovation safe. It was utilized in machining different materials', including prepares, aluminium combinations, and Inconel, utilizing carbide apparatuses. Utilizing MQL cutting

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fluid can infiltrate profound into the tool chip and material interface, subsequently the positive outcomes. In this strategy, a minimm quantity of cutting fluid, normally in the size of 50-400 ml/h is showered on to the cutting region through a spray made utilizing packed air [1-2].

Cutting fluid is a few times bigger than reducing tools expense, a general expense of creation. Likewise dealing with limit of oil, removal of it additionally serious issue. Likewise, flood cutting expands reasons for medical issue to bosses and may establish issue to nature. MQL machining is some benefits like to guarantee eco-friendly machining but also provide substantial technological benefits by using minimum amount of fluid. Investigated the role of various MQL flow rates besides the CS and FR on the machining performance characteristics in end milling of hardened steel and claimed that the flow rate influences the SR mostly[3]. Studied the effects of MQL by vegetable oil on cutting forces (CFs), chip formation mode temperature during the industrial speed-feed combinations of AISI 1060 steel machining using an uncoated carbide insert. Significant temperature reductions, shorter chip-tool contact lengths, and positive chip-tool interactions all contribute to the encouraging results, which also show a significant reduction in cutting forces. Machining of AISI 1060 steel with coated carbide inserts different machining conditions on measuring the MRR and SR. Design of experiments (DOE) was chosen to determine the number and combination sets of cutting parameters. It reveals that the most significant impact on SR was followed by feed rate and tool configuration respectively [4]. Sadeghi et al. used the MQL approach to study the surface grinding of AISI 4140 hardened steel. They developed a multifunctional fluid with MQL results, such as cooling, lubrication, and high ecological and environmental safety performances, by comparing a number of grinding fluids, including mineral, vegetable, and synthetic esters oil, based on their surface quality properties and grinding forces. Additionally, the efficacy of fluids in dry and traditional fluid grinding processes was assessed [5]. By adjusting various machining settings, the direct MQL turning probes attach to AISI 4340 compound steel for the purpose to measure cutting performance, feed rate, and cutting rate. The investigation's response parameters were determined by SR and CP. The lowest feed rate of 0.04 m/min, cutting velocity of 75 m/min, and cutting profundity of 1 mm suggest that MQL produced better results in terms of surface unpleasantness and CP within less perfect cutting boundaries. When MQL was used on a superficial level nature of Inconel 718 combination utilizing PVD TiAlN covered fine grained high cobalt carbide as the cutting instrument. The best surface finish was obtained at 0.91 µm with medium cutting velocity and feed rate. A slight improvement of 12% to 17% smoother surface completion has been accomplished with the usage of MQL [6-7].

Y.Kumbhar and C.A.Waghmar utilized Taguchi strategy to optimize process conditions of turning for EN31 compound steel having high hardness under dry Turning. Tool life effect of ANOVA shows the most impacting factor is feed which contributes the 9%. With 3.86% the second most significant element is cutting rate and DOC is having less commitment 2.39%. ANOVA for surface unpleasantness gives the main component that is feed which contributes 87 % DOC and cutting pace are less critical boundaries [8]. Varadarajan et al. compared with MQL, flooded and dry machining of hardenable steel having hardness up to 46 HRC [9]. In this paper super duplex steel UNS32750 with coated carbide cutting tools in MQL setup was used to measure the material removal rate and surface roughness. CS, feed rates and DOC was chose machining process parameters.

2 Experimental procedure

A self made MQL system was developed to attach to the all geared lathe machine. Developed an Arduino based controller and equipped with automatic air compressor whose function was to compress the air and store it for later use. An Arduino based controller and connected to 4 channel relay which further connected to 3 switches with each relay channel is designed for specific minimum lubricant to flow. The equipment was turned on with all the necessary connections according to the need we select the fluid flow regulation button and Arduino nano passes certain instructions to the booster pump how much quantity of lubricant to pump from the reservoir and this lubricant was stored on the head of nozzle with storage capacity of 250ml and on the head of the nozzle the air is mixed with lubricant and create aerosol mixture and sprayed through nozzle in fine atomization by varying the pressure using the pressure regulator valve attached to the compressor. MRR was calculated to consider the equation 1. The volume of material removal rate can be variety as the portrayed as the volume of material emptied isolated by the machining time. One more way to deal with describe MRR is to imagine a flashing material clearing rate as the rate at which the cross-fragment an area of material being ousted goes through the workpiece. Cutting powers are mostly dependent on the characteristics of the work material and how it shifts throughout the chip enhancement process. For instance, the shape of a tool for cutting can be modified within reason so long as the device's quality remained acceptable.

$$MRR=V_c*F*t\ (cm^3/min)---------------------(1)$$

Where, Vc is Cutting speed (m/min), ‘F’ is Feed rate mm, ‘t’ is Depth of cut mm

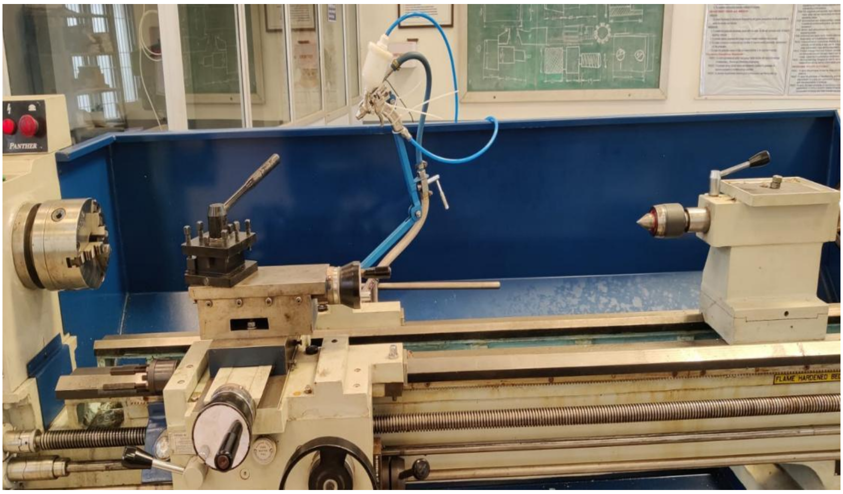

Fig.1. All geared lathe machine with MQL setup.

SR shows the state of a turned machined surface of duplex SS material. The shape and size of irregularities on a machined surface significantly influence the quality and execution of that surface, and on the execution of the completed outcome. Surface roughness, subsequently depends upon surface geometry, oxidation, disintegration, remaining weights and surface and subsurface miniature breaks. A surface irregularity was estimated during the MQL condition. The surface offensiveness achieves during turning of Super Duplex Steel UNS32750 at different Cs, FD and DOC is estimated utilizing Talysurf instrument.

3 Results and Discussion

Here the turning operation is done on Super Duplex Steel UNS32750 using All geared lathe machine under MQL condition using coconut oil as lubricant by taking experimental conditions as shown in below Table1.

Table 1. Experimental condition for wet machining

S.No	Cutting speed (m/min)	Depth of Cut (t mm)	Pressure (bar)
Level 1	400	0.15	0.050
Level 2	600	0.20	0.075
Level 3	800	0.25	0.100

Table 2. Experimental layout with their results

S.No	Cutting speed (m/min)	Depth of Cut (t) mm	Pressure (bar)	*MRR (mm3/min)	*Ra (μ)
1	400	0.15	2	0.3278	2.41
2	400	0.20	4	0.4698	2.65
3	400	0.25	6	0.8098	2.36
4	600	0.15	4	0.5624	1.22
5	600	0.20	6	0.7272	2.26
6	600	0.25	2	0.8313	3.27
7	800	0.15	6	0.7372	1.97
8	800	0.20	2	0.9696	2.41
9	800	0.25	4	1.1305	2.24

3.1 Material removal rate (mm^3/min)

Table 2 shows the Taguchi L9 OA experimental outcomes of MRR. Fig. 2 was observing the S/N response plot of cutting speed, pressure and depth of cut values was increasing with increasing the MRR. The optimum conditions in wet condition are speed: 800, pressure:6, DoC:0.45.

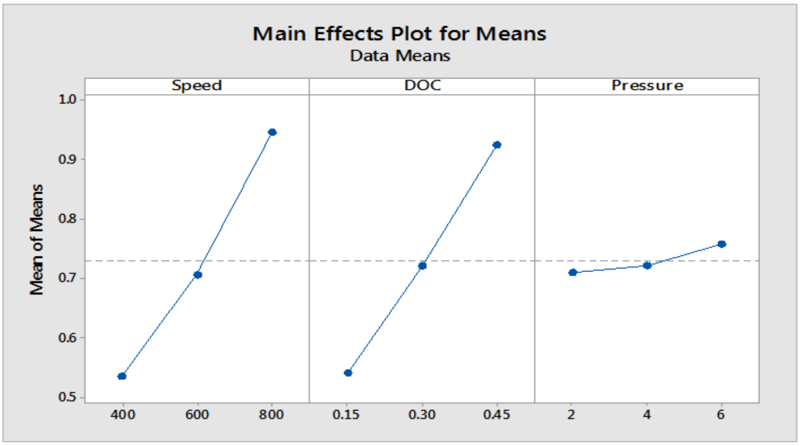

Fig. 2. Material removal rate main effect plots for means

3.2 Surface roughness (Ra)

SR displays a machined surface's condition. The size and form of imperfections on a machined surface have a big impact on the surface's quality and execution as well as the finished product's execution. The Talysurf tester was used to measure the surface roughness.

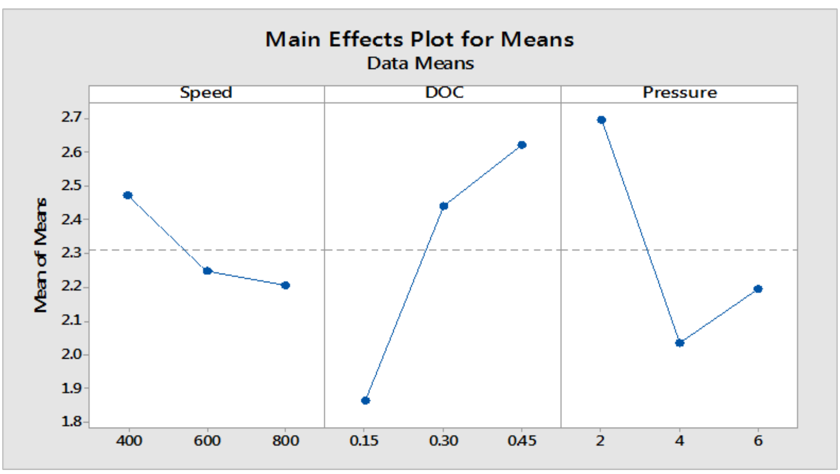

Fig. 3. Surface roughness main effect plots for means

Table 2 presents the Taguchi L9 OA the S/N ratios derived from the surface roughness findings. Fig. 3 depicts the main influence graph for the surface roughness (S/N) ratio. Fig. 3 illustrates how flat tools' surface roughness ratings decreases and then increase in response to cutting speed and depth of cut. Observe yet another pattern: Surface roughness first gets lower with an increase in the pressure trend from 4 to 6 bars then gets better with succeeding increases. From the graph shows that the surface roughness was very low when we apply the condition of increasing the speed, pressure and by decreasing the DoC. The optimum conditions for better surface roughness are cutting speed 800, DoC 0.15, pressure 4 bar.

4 Conclusions

The current investigation looked into the MQL affect on the MRR and SR for Super Duplex Stainless Steel UNS 32750 material. The experimental results depend on varying the process parameters i.e cutting speed, depth of cut, and fluid pressure.

A self made MQL setup was fabricated successfully with automatic module.

Experiments were conducted through Taguchi experimental layout three factors and three levels.

Higher MRR was obtained at cutting speed of 800 rpm, fluid pressure of 6 bars and depth of cut of 0.45 mm.

Lower surface roughness was found at cutting speed of 800 rpm, fluid pressure of 2 bars and depth of cut of 0.15mm.

- A self made MQL setup was fabricated successfully with automatic module.
- Experiments were conducted through Taguchi experimental layout three factors and three levels.
- Higher MRR was obtained at cutting speed of 800 rpm, fluid pressure of 6 bars and depth of cut of 0.45 mm.
- Lower surface roughness was found at cutting speed of 800 rpm, fluid pressure of 2 bars and depth of cut of 0.15mm.

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