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Research Article

Effect of machining parameters on surface roughness and material removal rate during hot machining of 17-7PH martensitic stainless steel

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Abstract

The materials used in aerospace industry require high strength, good corrosion resistance and formability.17-7 precipitation hardened stainless steel is well suited for aerospace and other applications which have the above properties. Conventional Machining of 17-7PH stainless steel is difficult due to high tool wear, poor surface finish. In the present work an attempt is made to study the feasibility of machining the above material using hot machining process by different cutting speed, feed and depth of cut. The effect of these parameters on surface roughness and material removal rate and the optimal process parameters to minimize the surface roughness and to maximize the metal removal rate are identified.

Keywords: *Hot machining, cutting speed, feed, depth of cut, surface roughness, Material Removal Rate.*

1. Introduction

17-7 Precipitation-Hardened (PH) stainless steel is chromium and nickel alloy that have the properties like high strength and hardness, excellent fatigue properties, good formability, good corrosion resistance and minimal distortion upon heat treatment that are well suited for aerospace applications. Conventional machining of the above material results in high tool wear, poor surface finish and low material removal rate. Machinability of 17-7 PH steel is 75% and while machining long gummy chips are observed and it requires chip breakers. The basic principle behind the hot machining process is that the surface of the work piece that is to be machined is preheated or heating is done during machining. Softening of the work piece will happen because of the heat that is applied, this will Provide high material removal rate, good surface finish and increased tool life.

2. Material Properties and Applications.

The chemical composition and Mechanical properties of 17-7PH stainless steel is show in the Table 1 and Table 2.

Table 1 17-7 PH Stainless steel Chemical composition in %

	Cr	Ni	Al	S	p	C	Fe
Min	16	6.50	0.75	-	-	-	Remaining
Max	18	7.75	1.50	0.030	0.040	0.09	

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Table 2 Mechanical Properties of 17-7PH stainless steel

Tensile strength (Mpa)	Yield strength (Mpa)	Poisson's ratio	Hardness Rockwell
1170	965	0.30	B85

The following are the applications of 17-7PH precipitation hardened stainless steel.

a. Aerospace.
b. Chemical processing Equipment.
c. Oil and petroleum refining Equipment.
d. Food processing Equipment.
e. Heat Exchangers.
f. Power Boilers.

3. Hot Machining

To softening the work piece by heating various sources are available. By introducing current into the entire work piece, due to the resistance offered by the work piece to the flow of current heat is generated. This heat is used to increase the temperature. The work piece is heated in a furnace and it is taken out after the required temperature is reached and it is machined. In another method, a fuel gas is send through the torch and the torch is placed ahead of the work piece. The torch releases the fuel gas when ignited generates the flame, which is the source of heating the work piece. The above flame heating method is having advantages like inexpensive when compared to other methods and equipment used is simple. Butane is used as the fuel gas in the present work and when ignited generates a flame temperature of approximately 1430^0 C. Tungsten Carbide is the cutting tool material used with 0^0 clearance angle and 12mm cutting length and 0.4mm radius. The tool insert is placed in tool holder which is shown in Figure 1 are used for turning operation on an all geared lathe machine.

Figure 1 Cemented carbide tool and tool holder.

4. Experimental procedure.

17-7PH stainless steel cylindrical work piece of 25mm diameter is mounted on the chuck and turning operation is performed on the work piece with the following cutting speed, feed and depth of cut. Surface roughness and material removal rate is calculated and is shown in Table 3

Table 3 Surface Roughness and Material Removal rate

S.no	Speed RPM	Feed mm/rev	Depth of cut mm	Surface roughness µm	M.R.R gm/sec
1	1145	0.15	0.1	0.3323	0.00793
2	1145	0.145	0.2	0.298	0.01523
3	1145	0.14	0.3	0.3303	0.02280
4	750	0.15	0.2	0.2993	0.01054
5	750	0.145	0.3	0.353	0.01497
6	750	0.14	0.1	0.3153	0.00496
7	480	0.15	0.3	0.3413	0.00950
8	480	0.145	0.1	0.762	0.00313
9	480	0.14	0.2	0.3217	0.00632

Hot machining set up is prepared by mounting nozzle on the tool carriage, opposite to the cutting tool to provide moving flow of heat. 17-7PH stainless steel cylindrical work piece of 25mm diameter is mounted on lathe chuck. Cutting speed, feed and depth of cut are set on the lathe machine and the flow of butane from the torch is adjusted and it is ignited to heat the work piece as shown in the Figure 2.

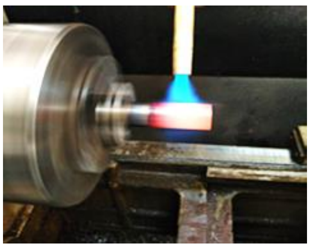

Figure 2 Hot machining using butane

5. Results

Table 4 shows the surface roughness at same input parameters (i.e. speed, feed, depth of cut) except temperature which gave minimum surface roughness, The two runs are performed at two different temperatures i.e. 32°C and 400°C. Both the runs are performed at parameters so that surface roughness can be compared at two temperatures.

Table 4 Surface Roughness at 32^0C and 400^0C

S.no	Speed (RPM)	Feed (mm/rev)	Depth of cut (mm)	Surface roughness (µm)	Temperature (°C)
1	1145	0.145	0.2	0.298	32
2	1145	0.145	0.2	0.286	400

Metal removal rate is maximum at 1145 RPM, 0.14mm feed and 0.3 mm depth of cut, with the above parameters machining is performed at 400^0C and the material removal rate at both the temperatures is shown in Table 5.

Table 5 Material Removal rate at 32^0C and 400^0C

S.no	Speed (RPM)	Feed (mm/rev)	Depth of cut (mm)	M.R.R (gm/sec)	Temperature (°C)
1	1145	0.14	0.3	0.02280	32
2	1145	0.14	0.3	0.02443	400

Conclusions

Machining is performed on the 17-7PH stainless steel and the surface roughness and Material removal rate are calculated. From the values obtained, the parameters which will give the minimum surface roughness and maximum material removal rate are identified. Again hot machining is performed by using butane as fuel gas and the values are tabulated. The maximum material removal rate is obtained at 1145 RPM, 0.14 mm/rev and 0.3mm depth of cut. At these parameters when hot machining is performed at 400^0C the material removal rate has increased.

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