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INFLUENCE OF CUTTING FLUIDS ON RESIDUAL STRESSES IN CNC TURNING OF AUSTENITIC STAINLESS STEEL RODS

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Abstract - *Cutting fluid is an essential item to be used in marching operation. The effective utilization of cutting fluid not only perform the machining well in addition to this it also saves the environment from the pollution. Hence in this regard the familiarization to the cutting fluids as well as the emphasis on cutting fluids is required. Here in the experiment two bio oils of various viscosity and different properties have considered and their optimal and or stoichiometric mixture of this cutting fluid has yielded the reduced residual stresses. The experiment is carried out with austenitic stainless steel rods of 30mm diameter to be turned to 25mm diameter have used. In each run 5 rods are considered as one unit and as a total of 20 rods are considered to find the residual stresses. Hence at the four times the results are obtained for the work pieces. Out of this the minimum residual stresses obtained against the cutting fluid combination is selected. While analyzing the results the surface roughness is also considered for the best possible cutting fluid. This research is useful in further machining processes and application of machining because of optimal benefits. Hence the experiment to find the influence of cutting fluids over turning operation to find the residual stresses magnitude makes an arena towards the optimal machining process.*

Key Words: **Cutting fluids, Residual stresses, CNC turning, Austenitic stainless steel**

1. INTRODUCTION

Cutting fluids are the common fluids used in the machining operation to carry out the heat generated in the material and also they are used to reduce the friction in between the contact surfaces that is the point of contact between the cutting tool and the work piece [1,2,3,4]. The importance of the cutting fluid is understood if the machining operation is imagined without any cutting fluids. On the other hand the cutting fluids are also useful because they reduce the reaction tendency of the material and also they act as catalyst in the machining process. Besides to these advantages there are few limitations the cutting fluids have. There are some of the cutting fluids which have adverse effect to the environment particularly they used to promote the water pollution, sand pollution. Machining process is a common application of engineering hence in many industries of mass production utilizes the cutting fluids [5,6,7]. Hence a detailed and elaborated study is helpful in the formulation of the new eco friendly cutting fluids. In this experiment the same thing is going to be reflected.

There is always a way for the work to perform. Here in this area of cutting fluids much research is made towards the establishment of eco friendly and machine friendly cutting fluid formation. In recent days nano-fluids have can into picture which can make the machining process hazzle free. However there is a know-how methodology is required for the optimal operation of machining process. In this arena there are synthetic, non synthetic fluids are used to some extent. But it is good to add some green solid particles in the existing cutting fluids to improve their thermo mechanical properties. Some of them are molybdenum disulfide (MoS_2), hexagonal boron nitride (hBN), carbon nanotube (CNT), aluminum oxide (Al_2O_3) and nano-diamond [8,9,10]. The main advantage with the usage of these particles is, these will make a protective layer over the surface of the cutting tool and work piece. This protective film is essential to isolate the machining elements from the reactions with the atmosphere. And another advantage with these particles is they usually have the low coefficient of friction that will help the cutting fluids to perform their intended tasks effectively and efficiently. It further makes a platform in between the inner layers of the cutting fluids to exhibit the property of low viscosity. On the other hand the vaporization temperature of the cutting fluid, generally it should not get dropped but if the viscosity of the cutting fluid reduces then its vaporization temperature may get dropped down. Hence the optimal composition of various elements to the cutting fluid needs to be added. This is evaluated by using the practical measurement method. A few cases have been selected in different ratios then their viscosity and vaporization temperature are to be found. After the number of experiments at the end the optimal quality cutting fluid (OQ_lCF) is determined. All this is one side of the coin and the second side is to have the optimal quantity of cutting fluid (OQ_nCF) is also to be determined [11,12,13]. Here the quantity and quality of the cutting fluid are very important considerations to reduce the residual stresses.

2. METHODOLOGY

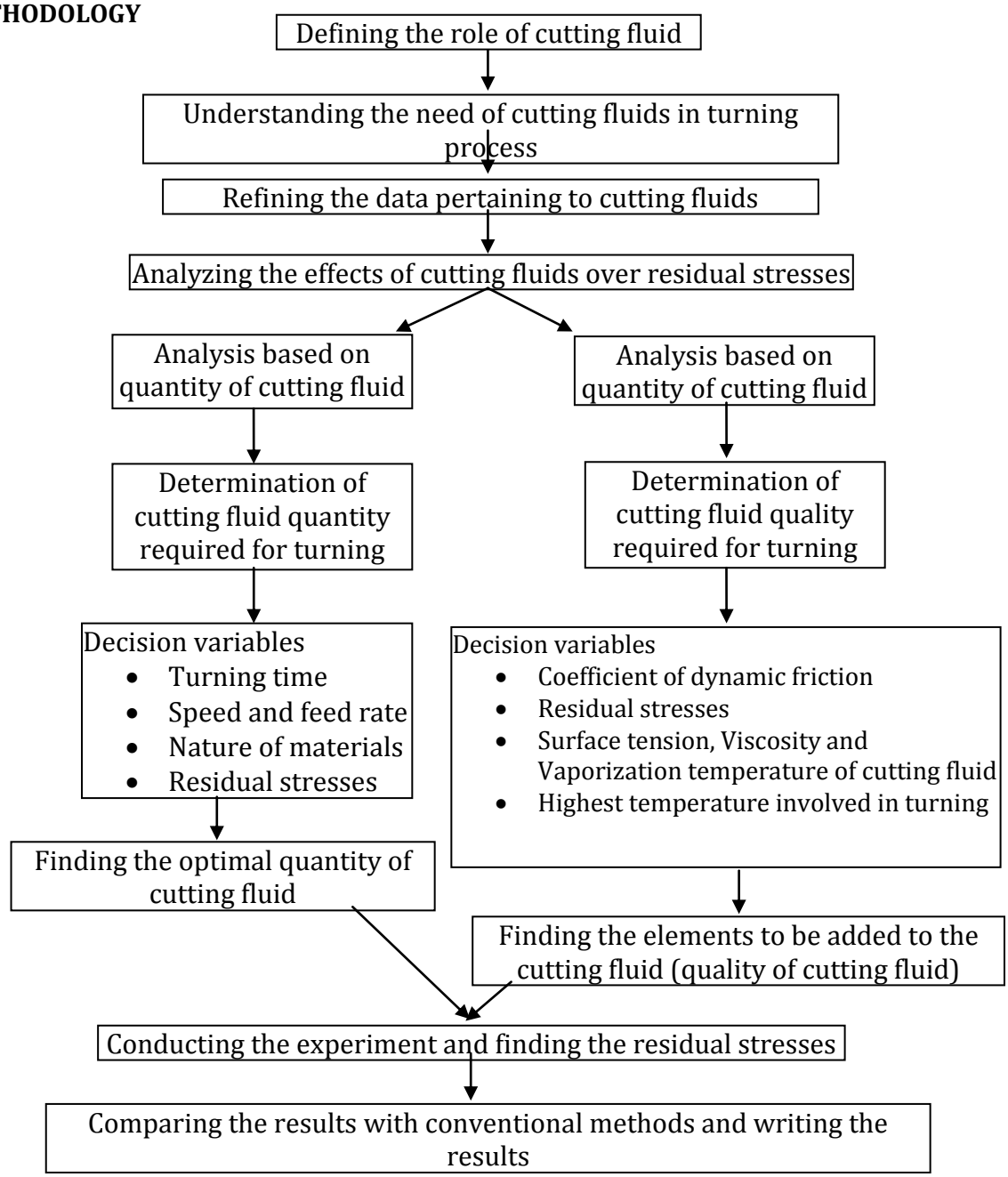

Figure 1: Method of reducing the residual stresses by optimal use of cutting fluid

The above flowchart describes the method of reducing the residual stresses in turning operation of austenitic stainless steel material using CNC machines. Out of all the other parameters here in this research the quality and quantity of the cutting fluids are emphasized. And at the end of the experiment it is found that there is a great reduction of residual stresses. There is no doubt that the cutting fluid reduces the friction between the cutting tool and work piece, and it will carry away the heat generated during the operation. Besides to that there is much more mechanism is found, if it is observed microscopically. They are detailed below.

Surface tension of the cutting fluid is an important consideration for the turning operation. And a fluid by virtue it has one value of surface tension but if it got mixed with some other fluid then the surface tension varies. In this experiment a combination cutting fluid is used Palmolein oil and tamarind seed oil mixed with hexagonal boron nitride, carbon nano tube and aluminum oxide.

3. EXPERIMENT

This cutting fluid is prepared in the following quantity and quality as shown in table 1.

Table 1: Different compositions of cutting fluids used for turning

Sl No	Composition of cutting fluid	Percentage (w/w)			
		Case 1	Case 2	Case 3	Case 4
1	Palmolein oil	53	51	49	48
2	Tamarind seed oil	35	33	35	36
3	Hexagonal Boron Nitride	5	5	7	6
4	Carbon nano tubes	3	5	4	6
5	Aluminum oxide	4	6	5	4
Total		100	100	100	100

The experiment is carried out with above mentioned four cases of cutting fluids with the austenitic stainless steel work pieces. The process parameters used in turning operation for the experiment are shown in below table 2.

Table 2: Input process parameter values used in turning operation

Sl No	Composition of cutting fluid	Percentage (w/w)			
		Case 1	Case 2	Case 3	Case 4
1	Speed in rpm	450	470	455	460
2	Feed in mm/min	0.35	0.35	0.3	0.3
3	Depth of cut mm/min	0.25	0.25	0.2	0.25
4	Power consumption in Watt / cycle	2	2.05	2.2	2.1
5	Quantity of cutting fluid in ml/min	300	320	290	305

The above table 2 depict the input parameters fixed for the turning operation on the austenitic stainless steel rods. There are five parameters given emphasis for the operation. And these parameters are assumed to be the most affective parameters on the outcomes of the operation. And in addition to that one more note worthy parameter is the quantity of the cutting fluid as the quality of the cutting fluid id altering from case to case; certainly there is a significant effect on the performance of the outcomes. Hence the quantity of the cutting fluid is considered carefully to maintain the minimum residual stresses.

The below table no 3 shows the outcomes of the experiment. The outcomes are categorized in terms of their importance and briefed below.

Table 3: Output process parameter values obtained in turning operation

Sl No	Parameter	Outcomes			
		Case 1	Case 2	Case 3	Case 4
1	Material removal rate in mm^3/min	7.56	7.56	7.21	7.38
2	Time required for turning in seconds	315	302	311	307
3	Residual stresses in N/mm^2	253	247	258	249
4	Material hardness (Rockwell)	76	70	74	72
5	Surface roughness µm	53.7	42.6	48.7	51.8

The above results are obtained in that particular environment in which the input parameters are controlled as per objective. It is quite possible for the machining operation to uphold the outcomes by altering the inputs. It is also to be noted that in the outcomes some of the parameters are to be minimum and some of the parameters are to be maximum and some of the process parameters are to be maintained to a particular value. Hence in this mixed combination of circumstances the objective function formulation becomes meticulous and cumbersome. But on the other hand it is also possible to make decision over the outputs instead of inputs. By analyzing the outcomes of the experiment listed in table number 3, it is found that the combination and composition of case 2 is more adoptable and suitable for the requirement after through consideration of the all parameters.

4. RESULTS

After the completion of the experiment the expected outcomes are obtained. And the main observations at the experiment are the mini mum residual stresses and minimum surface roughness along with the minimum material removal rate. By default the addition of the carbon nano tubes and nano diamond have produced a significant effect on the material surface. In addition to that the optimal usage of the cutting fluid is found. This is very useful for the machining operation because in the conventional machining operation it is proved there is a lot of pollution to the environment. And on the other hand the conventional cutting fluids have not produced the outcomes as compared with the present experiment. The results obtained of the

experiment are shown below in the form of graph in the below figure no 2.

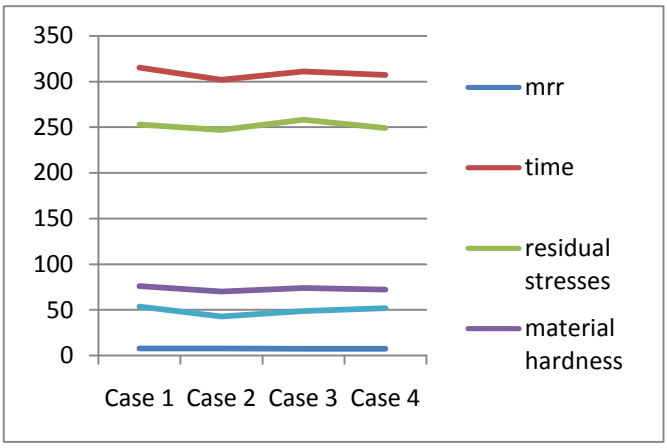

Figure 2: Comparison of results with various cases of machining operation

Out of the all cases in the above figure it is best and optimal to choose the case 3 for the optimal results of possible outcomes. This combination and composition implies the minimum material removal rate and minimum time for operation and also the maximum material hardness with minimum residual stresses and minimum surface roughness. It is one of the best outcomes in the turning compared with the conventional way of operation. By adopting the case 2 category of the cutting fluid by quality and quantity the optimal outcomes to the output parameters are obtained.

5. CONCLUSION

This experiment of emphasizing cutting fluids for the reduction of the material removal rate, reduction of surface roughness, time required for the operation and residual stresses. And on the other hand the maximization of the surface hardness is obtained. This research is very useful for the further development of the optimization policy to promote the productivity as well as reduction of environmental pollution.

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BIOGRAPHIES

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