Eco Friendly Drilling Process in AISI SS317 Material

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ABSTRACT

Stainless steel family material making a drilling hole has mainly focusing on higher material removal rate, better surface quality and analysis of tool surface wear. However, in order to researcher focuses not only material drill hole quality, but also on the eco-friendly machining process. Now days the safety aspects take place most priority to the manufacturing industries and working people. In this reasons, this paper endeavor is applied in vortex generated coolant for numerical control (NC) drilling process used an eco-friendly machining systems. In this study, vortex generated cold air coolant for computer numerical control (CNC) drilling process compared with dry condition machining process. In this connection to investigate various optimization machining process applied in AISI SS317 (10X10X20)mm size material used in vortex generated green coolant tube to shows higher surface roughness for different machining conditions with respect to dry air conditions.

KEY WORDS: Drilling, Vortex tube, Surface roughness, Drill dia.

1. INTODUCTION

Machining process is called high speed machining process, medium speed machining process, lower speed machining process. AISI SS317 material cutting need high speed machining process, it produces higher cutting temperature at the tool and work piece. In this case different types of cutting fluids because of machining temperature increase. The vortex generated green coolant is created better surface quality of hole in mild steel material. Anayet (2015), analyzed various machining parameter conditions using taguchi techniques in Inconel 718 material, but the process maximum material Removal Rate (MRR), best surface roughness they have been identified. Dudzinski (2004), Inspected the development of dry machining of high speed material cutting in inconel 718 alloy. They are focused some solutions to reduction of coolant usages and different tool coating techniques to enable a dry machining process. Maximum material removal of drilling process the output of chip is analysed, Zhirong Liao (2016), have been monitored in chip formation, and also they have studied in depth penetration of drilling tool and cutting malfunctions in micro-drilling through acoustic emission. Dhar (2007), analyzed the performance of material turning process used in minimum quality lubrication (MQL) in AISI-1040 steel. They are compared between metal cutting temperature, output coefficient of chip reduction, various cutting forces, Edge tool wears, surface roughness, and drill hole dimensional deviations. During machining process used to software analysis manufacturing is another method Moseley (2015), investigated finite element simulation used optimization of hard metal rotary percussive drill bits and cold forming tools, the author have been performed in two different cases are executed, one from the development phase for a new product and the other one continuous enhancement process during mass production in manufacturing industry, in this simulation developed in finite element module software. Kelly (202), was studied the effect of minimal lubrication machining of (Al) aluminium alloy material. They also investigated in different methods of cutting fluid into various applications with the objective of deriving the optimum cutting condition for the drilling of aluminum alloys. Braga (2002), used in low quantity of lubricant (LQL) and a diamond coated tool in drilling of aluminum-silicon alloys materials. They have compared the performance of the uncoated tool and diamond coated carbide drilling tool, using rich soluble oil as a lubricant in the drilling of aluminum- silicon alloys (A356) material. Ranganatha (2016), studied in Mechanical Behaviour of Al2014 Reinforced with Boron Carbide and Short Basalt Fiber Based Hybrid Composites, They were investigated various optical microstructure revealed the homogeneous dispersion of B4C particles and Short Basalt fiber in the matrix in hybrid composite materials. The high hardness materials like Zeilmann (2006), was studied the effect of thermal effect during drilling of Ti6A14V with applied least quantity of lubricant. The lubricant was applied with an external nozzle or internally through the drill holes. The results showed major benefits with MQL applied internally through the drill tool. For drilling with MQL applied with an external nozzle of the surface quality hole. Davim (2006), made experimental investigations on drilling of aluminium material under dry condition, least amount of lubricant and flood lubricated conditions. The experimental investigations were planned based on L_{27} Orthogonal arrays. An analysis of variance (ANOVA) was carried out to check the authority of the multi number of experimental parameters and also their percentage contributions. Results showed that cutting power and specific cutting force were higher for dry drilling compared to other two techniques. Results also showed that with a proper selection of the range of cutting parameters, it is possible to obtain performances similar to flood lubricated conditions by using Minimum quantity lubricant. This paper investigates a novel technique of using vortex tube generated as cooled and hot air and coolant in drilling process as a substitute of dry condition. A unique portable vortex tube has been developed for this process. This vortex generated green coolant shows that good surface finish and maximum material removal rate for different assortment of cutting conditions. This process is called as eco-friendly drilling process in AISI SS317 material.

Working Principle Of Vortex Generated Green Coolant Tube:

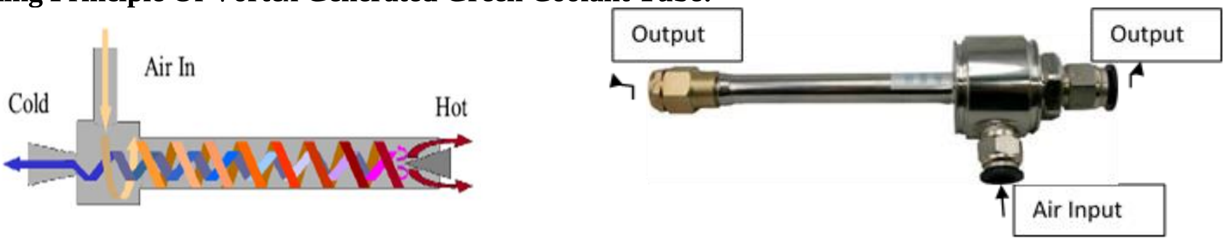

Figure.1. Vortex tube

A vortex tube used in compressed air as a main power source, the hot air is outlet from one end and cold air form the other a shown in fig.1. The temperature and volume of these two air are regulating with a valve built into the hot air are exhaust. The warm compressed air is supplied to the vortex tube and passes through nozzles an internal counter bore. This revolving stream of air turns in 90^0 and passes down the hot tube in the form of a revolving shell. The principle of conservation of angular momentum and the rotational speed of the vortex might be predictable to increase the air outlet. But the comparison of vortex tube, the speed of the inner vortex and remains is the same. Angular momentum has lost from the inner vortex tube. The energy that is lost heat in the outer vortex. Thus the outer vortex becomes warm, and the inner vortex air is cooled air.

2. EXPERIMENTAL SETUP AND METHODOLOGY

Experimental Setup:

Figure.2. CNC Drilling Machine

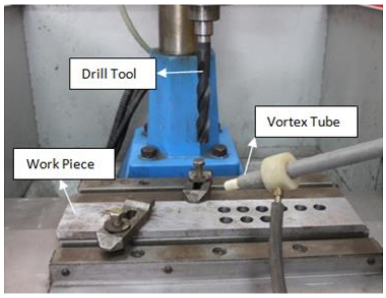

Figure.3. Experimental setup

In this experimental setup drilling process was conducted in Z K 2512-3 CNC drilling machine shown in (fig.2). In this machine the axis travelled in X, Y and Z directions. The material plate size is (10X6X20) mm respectively. The main advantages of this machine input and output value are entered in computer numerical control setup. However to apply the cold air into the drilling process a novel portable vortex tube (Fig.3.) was developed. The vortex tube pipe was made up of PVC. The compressed air inlet lets in the compressed air into the swivel chamber which sets the air into vortex motion. Hot and cold air was then obtained at the hot and cold air and respectively. The temperature of the cold air was able to reach as low as 10 ^{0}C.

Experimental Methodology: In this Experimental investigation to study different combination of cutting conditions have measured for functioning the experiments under two coolant settings. One is Dry cutting condition, and another one is, Vortex tube generated cold air condition. Here Table 1 shows the experimental input parameters, there are two level and three parameters and the experiments conducted in AISI SS317 steel bars of thickness 20mm. For each one dry and vortex cooled air condition, 15 experiments were conducted with different combination of material cutting parameters. All experiments Surface roughness of was measured, the surface roughness values measured in mitutoyo surf test SJ-210 contact profilometer.

Process Input Parameters:

Table.1. Process Input Parameters

Process Input Parameters			
Coolant	Speed (RPM)	Feed (mm/min)	Drill Dia (mm)
Dry Condition	500,1000,1500	5,10,15	6,8,10
Cold Air applied from vortex tube			

Experimental Level:

Table.2. Experimental Input Parameters

Input	**level 1**	**level 2**	**level 3**
Speed (RPM)	500	1000	1500
Feed (mm/min)	5	10	15
Drill dia (mm)	6	8	10

Experimental design and results of aisiss317 material drilling process dry and vortex cooled set up:

Table.3. Different coolant for surface roughness

S. No	Cutting Coolant	Speed (RPM)	Feed (mm/min)	drill dia	SR
1	Dry Condition	1000	10	8	3.36
2		500	5	8	3.53
3		1500	15	8	1.5
4		1000	15	10	3.82
5		1000	5	6	3.98
6		1500	10	10	1.28
7		1000	15	6	2.8
8		500	15	8	3.01
9		1500	5	8	1.02
10		500	10	6	3.52
11		500	10	10	3.37
12		1000	5	10	3.77
13		1500	10	6	1.02
14		1000	10	8	3.17
15		1000	10	8	3.54
16	Cold Air applied from vortex tube	1000	15	10	1.75
17		1000	10	8	2.23
18		500	15	8	2.98
19		500	10	6	2.86
20		1000	15	6	2.01
21		1500	10	10	1.02
22		1000	5	6	1.98
23		500	5	8	2.78
24		1500	15	8	1.12
25		1000	5	10	2.15
26		1000	10	8	2.08
27		1000	10	8	1.98
28		500	10	10	2.3
29		1500	10	6	1.32
30		1500	5	8	1.98
S.No	Cutting Coolant	Speed (RPM)	Feed (mm/min)	drill dia	SR
1	Dry Condition	1000	10	8	3.36
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8		500	15	8	3.01
9		1500	5	8	1.02
10		500	10	6	3.52
11		500	10	10	3.37
12		1000	5	10	3.77
13		1500	10	6	1.02
14		1000	10	8	3.17
15		1000	10	8	3.54
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18		500	15	8	2.98
19		500	10	6	2.86
20		1000	15	6	2.01
21		1500	10	10	1.02
22		1000	5	6	1.98
23		500	5	8	2.78

24		1500	15	8	1.12
25		1000	5	10	2.15
26		1000	10	8	2.08
27		1000	10	8	1.98
28		500	10	10	2.3
29		1500	10	6	1.32
30		1500	5	8	1.98

3. RESULTS AND DISCUSSIONS

Table.3, shows that experimental results of surface roughness and using different coolant. The effect of different rotational speed and feed rate and using various drill diameters on surface roughness for different coolant is discussed given below.

Effect of Rotational Speed on Surface Roughness: The results of drilling hole performed as input of modeling and optimization technique, were used in Response Surface Methodology (RSM) in minitab 17 software. The process is has been carried on surface roughness in various optimized hole size. The results of the various multiple regression equation analysis and significance of the different factors are given in the table.4.

Table.4. Dry Conditions for Response Sequence

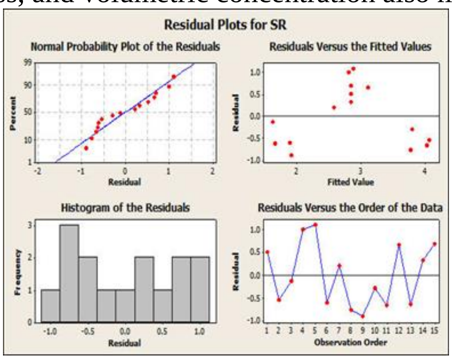
Term	Coef	SE Coef	T	P
Constant	7.40167	2.71194	2.729	0.041
Speed (RPM)	0.00557	0.00155	3.589	0.016
Feed (mm/min)	-0.45658	0.15532	-2.940	0.032
Drill dia	-0.88917	0.55696	-1.596	0.171
Speed (RPM) *Speed (RPM)	-0.00000	0.0000	-9.080	0.000
Feed (mm/min) *Feed (mm/min)	0.00407	0.00526	0.774	0.474
Drill dia *drill dai	0.03354	0.03285	1.021	0.474
Speed (RPM) *Feed (mm/min)	0.00010	0.00005	1.980	0.105
Speed (RPM) *drill dia	0.00010	0.00013	0.812	0.454
Feed (mm/min) *drill dia	0.03075	0.01263	2.435	0.059

Analysis of Variance for SR

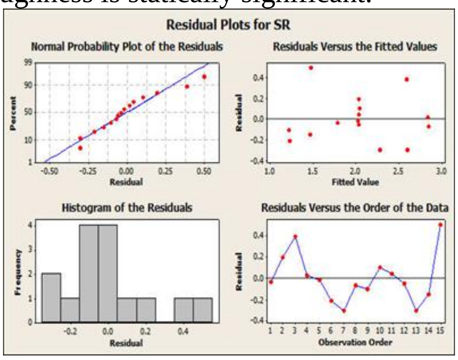
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	15.7787	15.77872	1.75319	27.49	0.001
Linear	3	9.5434	1.79323	0.59774	9.37	0.017
Square	3	5.5650	5.56504	1.85501	29.09	0.001
Interaction	3	0.6703	0.67025	0.22342	3.50	0.105
Residual Error	5	0.3188	0.31884	0.06377		
Lack-of-Fit	3	0.2504	0.25038	0.08346	2.44	0.304
Pure Error	2	0.0685	0.06847	0.03423		
Total	14	16.0976				

S = 0.2525 R-Sq = 94.0% R-Sq (adj) = 88.5%

In order to validated the obtained regression functions, the Analysis of Variance) ANOVA table has been carried out, and the results are given in table 3. For these Regression coefficient of table is measured in dry condition of drilling in SS317 material the coefficient of regression sequence is 94%, and adjacent sum of sequence is 88.5%.When closely investigated p-values in given table 4 with the consideration of the significance level is 0.1 in drill diameter (d),feed rate (f),speed (s) was found to be statistically significant for influencing in drill surface roughness, and volumetric concentration also measured surface roughness is statically significant.



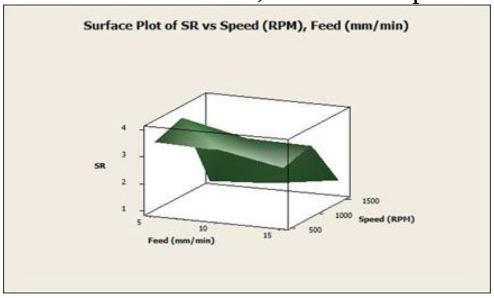
a



b

Figure.4. Dry condition of Normal probability plot for residuals for surface roughness

Fig 4(a), (b), shows that one factor plot for spindle speed, feed rate and drill diameter towards surface roughness. However, the plot shows the interactions among each of parameters. However the Speed is increasing roughness value is decreased, in case the speed is decreased feed rate is increasing the roughness value is increasing.



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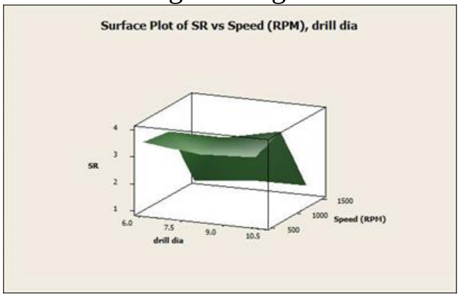


b

Figure.5. 3D Plot for Dry condition surface roughness analysis

From the graphs 5. (a), (b) shows that better surface roughness developed among speed and feed value is significantly analyed, the speed is 1000 RPM and feed is 10(mm/min), and 9.0 (mm) drill diameter interaction is obtained for better surface roughness .

Table. 5. Vortex Cooled Conditions for Response Sequence

Estimated Regression Coefficients for SR

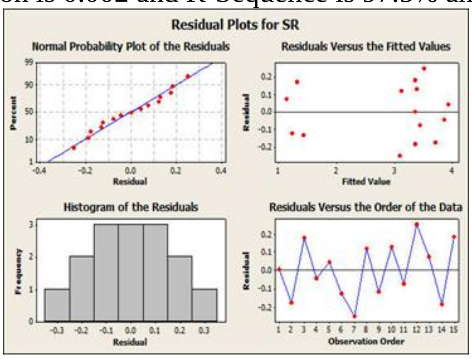
Term	Coef	SE Coef	T	P
Constant	-0.440833	1.66020	-0.266	0.801
Speed (RPM)	-0.000913	0.00095	-0.961	0.381
Feed (mm/min)	0.079917	0.09509	0.840	0.431
Drill dia	0.911458	0.34096	2.673	0.044
Speed (RPM) *Speed (RPM)	0.000000	0.00000	0.129	0.902
Feed (mm/min) *Feed (mm/min)	-0.058021	0.02011	-2.885	0.034
Drill dia *drill dai	0.004317	0.00322	1.341	0.237
Speed (RPM) *Feed (mm/min)	-0.058021	0.02011	-2.885	0.034
Speed (RPM) *drill dia	-0.000106	0.00003	0.841	0.019
Feed (mm/min) *drill dia	0.000065	0.00008	-1.391	0.439

Analysis of Variance for SR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	4.60227	4.60227	0.51136	21.40	0.002
Linear	3	3.99922	0.23130	0.07710	3.23	0.120
Square	3	0.25902	0.25902	0.08634	3.61	0.100
Interaction	3	0.34403	0.34403	0.11467	4.80	0.062
Residual Error	5	0.11949	0.11467	0.02390		
Lack-of-Fit	3	0.08783	0.08783	0.02928	1.85	0.370
Pure Error	2	0.03167	0.03167	0.01583		
Total	14	4.72176				

S = 0.1546 R-Sq = 97.5% R-Sq(adj) = 92.9%

table 5 (a), b) ,shows that Vortex cooled surface roughness is measured as speed, feed, and drill dia, for these regression is better than then dry condition drilling process, because the speed of the coefficient sum of sequence regression is 0.002 and R-Sequence is 97.5% and R-sequence adjacent is 92.9%.



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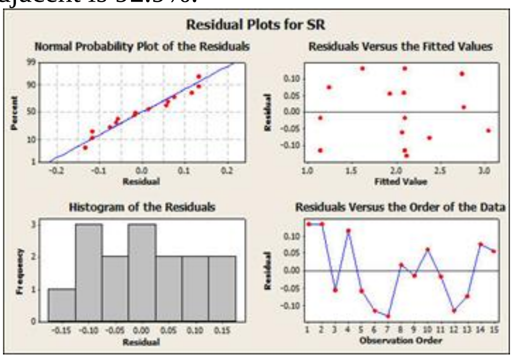

b

Figure.6. Vortex cooled air condition of Normal probability plot for residuals for surface roughness

Above fig 6(a),(b), shows that residual plot in surfece roughness, however the graphs found that Normal probability plot for residuals is better than that dry condition of drilling process measured values are 0.02.µm.

Figure.7. (a), (b) 3D Plot for Vortex cooled drilling process

Figure.7 (a), (b) shows that better surface roughness is founded, in this graphs is compared dry condition drilling hole, The most apparent occurrence is executed in vortex cooled air condition in drilling process, because of temperature analysis. The average temperature of the vertex generated cooled air is less than other coolants. For this cause, the thermal gradient of vertex generated cold air is higher. This causes the effective cooling for the machining zone is applied. In conclusion, it gives better surface roughness for this current experimental arrangement.

4. CONCLUSION

Vertex generated air coolant is a innovative method for producing eco- friendly coolant. In this study of investigation, a vertex tube is designed and fabricated in a simple way and then a set of experiment is conducted in order to examine the better performance of vertex generated cold air as a coolant.

The following points were performed from the above experimental investigation studies.

- The better surface roughness have been achieved by using vortex generated cold air is better than dry coolant and machining process.
- In order to development of surface roughness, from optimum values of speed, feed and diameter of drill tool is selected from the given graphs. Vertex generated cold air is called as green environment and easy to handle.
- In vortex generated cold air experiments is easy and economical manufacturing process. the surface roughness will be better than the achieved once because of the input air pressure and the structure of the vortex tube.
- In these green coolant methodology increasing better quality drill of hole and higher production efficiency.

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