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Numerical Simulation and Analysis of Friction Drilling Process for Alumina Alloy using Ansys

[1]Dr. A. Gopichand,
Professor & HOD, Department of Mechanical Engineering, Swarnandhra college of Engineering and Technology, NARASAPUR.

[2]M. Veera Brahmam,
P.G.Student, Department of Mechanical Engineering, Swarnandhracollege of Engineering and Technology, NARASAPUR.

[3]D. Bhanuprakash
Associate Professor, Department of Mechanical Engineering, Swarnandhra college of Engineering and Technology, NARASAPUR.

***Abstract*— Friction drilling process is a circular hole making in a sheet materials. It is a novel method using the principle of hot forming. The process involves penetrate a rotating conical tool through a sheet metal work piece. The heat generated from the frictional force due to axial and rotational forces between the interface of tool and work piece. Is to soften the work piece material, causing that tool to penetrate and deform the work material in to bushing shape in a single step without generating chips.**

In this paper investigates large Elastic strain, stress and work material deformation in friction drilling. The friction drilling process will develop high temperatures and deformation of the work material is very high. Which are difficult to measure experimentally. So, modeling and simulation is a necessary tool to understand the material flow. In which explicit dynamic analysis of a friction drilling with HSS, Tungsten (WC) tools and A7075-T6 as work piece is done using Ansys work bench. The modeling of the friction drilling tools and work piece will develop in PRO/E. The simulation of the friction drilling is used to analyze the stress, strain and deformation of the work piece.

Keywords*— *Friction drilling, Ansys, cutting speed, feed rate.

1. INTRODUCTION:

The Friction drilling is also known as thermal drilling, flow drilling, form drilling or friction stir drilling. Friction drilling is nontraditional metal treatment method, used to produce holes in the thin-walled sheet metal for assembly of various structural elements. The explicit dynamic method was well suited to simulate and analyze the large deformation of work-material and contact conditions in friction drilling [1].The finite element modeling of metal cutting is done by L. Soo, D. K.Aspinwall in 2004.The sufficient frictional heat is produced at high spindle speeds and low feed rates [2].CebeliOzek in 2013 they are investigated in friction drilling grater bush forming heights are obtained at low spindle speeds and high feed rates.P.D.Pantawanein 2011. They study the effect of friction drilling with different rotational speed, feed rate and tool diameter on the dimensional error and surface roughness of the bush [3]. The friction drilling finite element modeling is to understand the material flow, temperature, stresses and strains which are difficult to measure experimentally has been done by[4],[5]. The theoretically semi empirical analytical model will developed based on the contact pressure and measured temperature will predict the torque and thrust forces has been done by S.F.Miller in 2007.The friction angle, feed rate and contact area ratio are increased gradually the torque and thrust forces will also increase. The drilling speed is increased torque and thrust forces are decreases,[6] it is observed by Mehmet Tuncay Kaya in 2014.The mechanical aspects of form drilling are investigated by Diwakar Reddy.V, Gopi Chand. A in 2011,[7].The Scott F. Miller,Rui Li are investigated thermal and mechanical aspects of friction drilling. Under the constant tool feed rate, contact area and pressure to predict the thrust force and torque [8].T.Prabhu, are research the experimental and analysis of friction drilling on the aluminum and copper alloy by HSS and Tungsten carbide tool. It is show that materials with different compositions and thermal properties affect the friction drilling process parameters [9].P. Krasauskas is deals with the experimental investigation and analysis of the thermo-mechanical friction drilling process of hot rolled S235 steel, AISI 4301 stainless steel and Al 5652 aluminum alloy are presented and discussed [10]. Statistical five variable linear regression analysis was per-formed in order to evaluate the influence of mechanical properties of the materials.

2. FRICTION DRILLING:

The FEM solution of the friction drilling modeling is required adaptive explicit meshing of elements. The fine meshing will give the aquarate deformation of the work piece. The FEM was chosen because the work material deformation is very large and tool, work piece temperatures are high in friction drilling. Modeling is a necessary tool to understand the material flow, stress and strains. The adaptive meshing will maintains high quality mesh throughout the process. The large work material deformation and complex contact conditions in friction drilling are studied by explicit method. In this modeling the meshing elements are 3425, 1345 nodes are created.

2.1Work piece:

The work piece was 50mm length, 25mm width and 2mm thickness aluminum A7075-T6 plate is taken as work piece material. The four faces of the plate are fixed. The work piece is sheet metal material have a thin wall thickness.

2.2Tool:

The geometrical features of the tool is shown in figure .1.In this two different material tools are taken. There are HSS, Tungsten carbide (WC) conical tools is used to penetrate in to the work piece. The dimensions of the tool used in this study has d=7.3 mm, α=90°, β=36°, hc=0.970 mm, hn=8.490 mm, hl=8.896 mm.

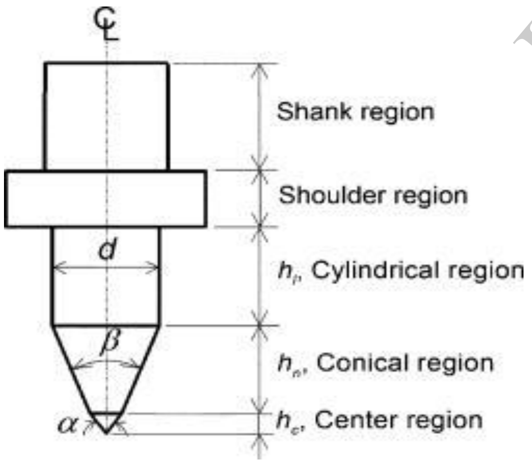


Figure.1 Geometry of the friction drilling tool

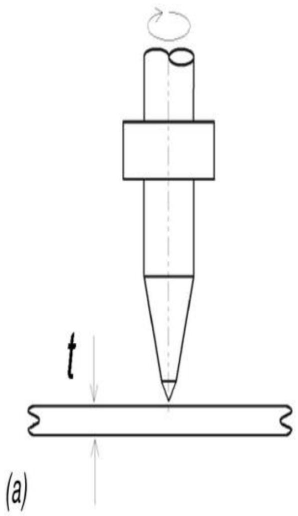
The friction drilling tool consists of center region, conical region, cylindrical region, shoulder region, shank region. The center region will have conical angle 'α' and length 'hc'. The conical region cone angle is sharper then the center region it is 'β' and the length is 'hn'. The conical region will produce the friction heat to the work piece and form the bushing. The cylindrical region length is 'h*l*' and diameter is 'd' .In this region hole and shape of bushing is generated. Shoulder region is form the collar on the upside of the sheet metal work piece. Shank region will hold on to the tool holder of the machine. The material properties of the work piece and tools are given below table 1.

3. MATERIAL PROPERTIES

Properties	A7075-T651
Melting Temperature (^oC)	635
Density (g/cm^3)	2.8
Thermal conductivity (W/m-K)	130
Tensile strength (MPa)	572
Yield strength (MPa)	503
Elongation (%)	11
Shear strength (MPa)	152

Table 1, properties of the A7075-T6

The main five stages of the friction drilling is illustrated below it is shown in figures 2(a),2(b),2(c),2(d),2(e). The conical tool tip of the center region is contact with the work piece as shown in figure 2(a). The tool tip will generate the frictional forces as well as rotational and axial directions in the second stage. The tool will penetrate through the work piece due to the softened material in the third stage. The cylindrical region will form the bush shape and hole. Then finally shoulder of the tool will form the collar on the top surface of the work piece.



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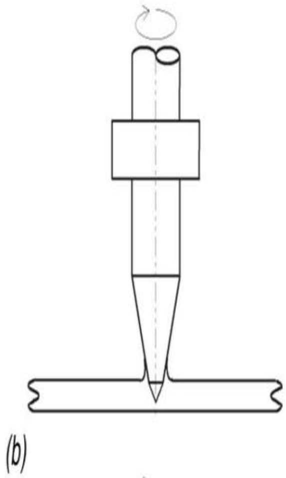
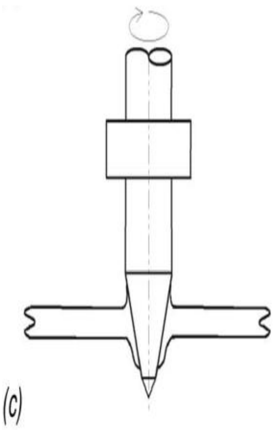
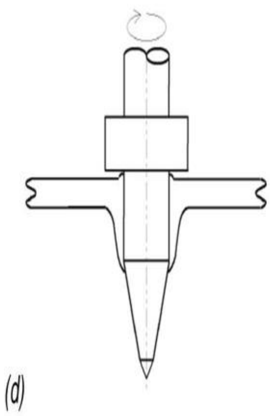






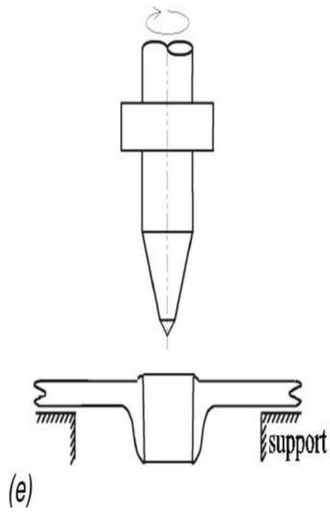


Figure 2, shows the different stages of the friction drilling process

4. FEM ANALYSIS OF FRICTION DRILLING:

The friction drilling process will analyze and simulated using Ansys. In which Hss, tungsten tools are machined the A7075-T6 Alumina work piece. The deformation and Equivalent (von-mises) stress, Maximum elastic strain of friction drilling with different speeds and feeds are simulated on explicit dynamics. It is shown in figure below. In which two different material tools are used to analyze the drilling process. The three different speeds and feed rates are 2000rpm, 3000rp m, 4000rpm and 20m/s, 30m/s, 40m/s is taken respectively. The finite element modeling analysis of friction drilling is done at different speeds, feed rates and tools at that point we analyze the stress, strain and work piece deformation.

5. FEM SIMULATIONS OF WORK-MATERIAL DEFORMATION AND STRESS, STRAINS:

The stress induced in the friction drilling at 4000rpm speed and different feed rates of 20m/s,30m/s,40m/s is shown in below figures 3 (a), 3(b), 3(c) .

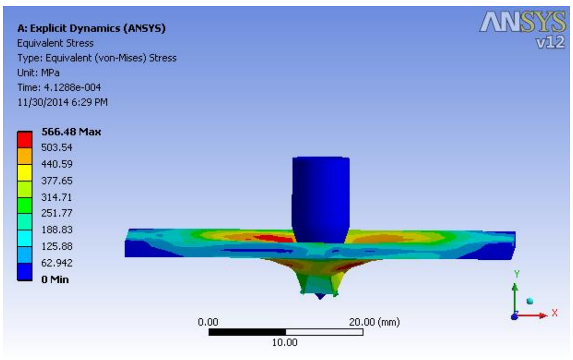


Figure 3(a), 4000rpm-20m/s

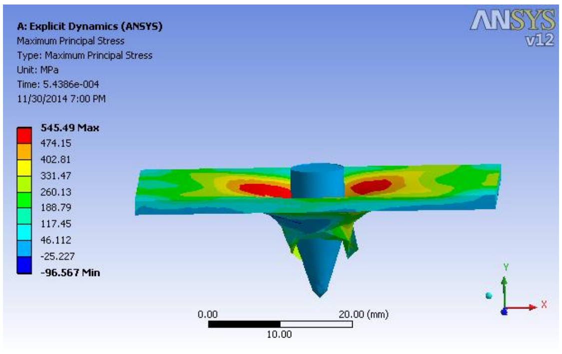


Figure 3(b), 4000rpm-30m/s

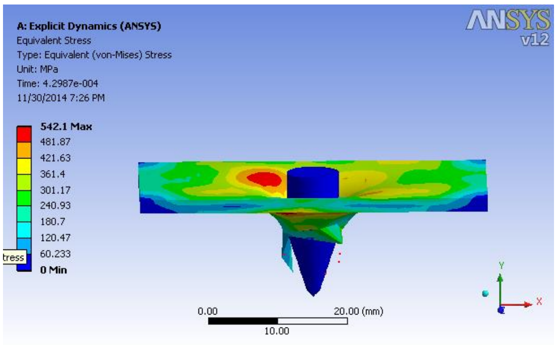


Figure3(c), 4000rpm-40m/s

The strain induced in the friction drilling process at 4000rpm speed and feed rates of 20m/s, 30m/s, 40m/s is shown below figures 4(a), 4(b), 4(c).

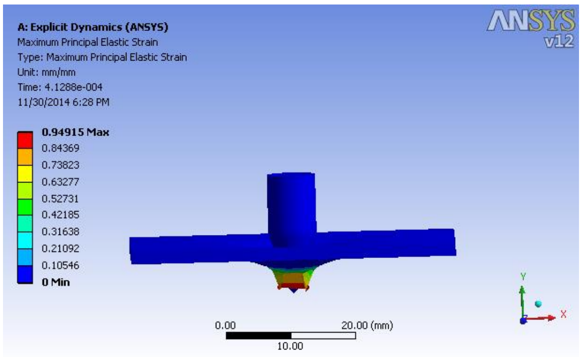


Figure 4(a), 4000rpm-20m/s

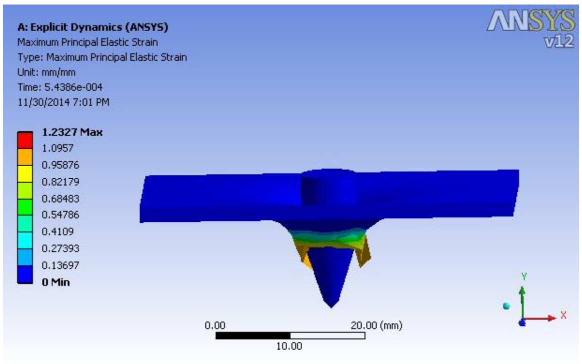


Figure 4(b), 4000rpm-30m/s

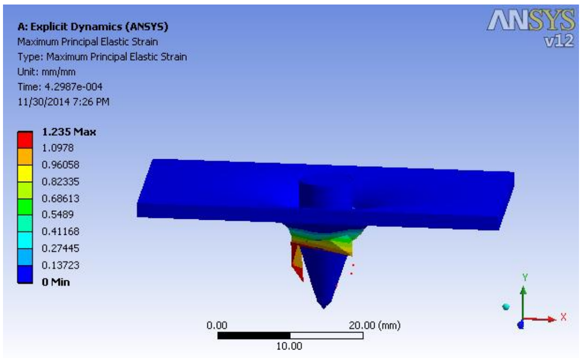


Figure 4(c), 4000rpm-40m/s

The bush formation of the work piece at different speeds of 2000rpm, 3000rpm, 4000 rpm and feed rates of 40m/s is shown in figure 5(a), 5(b), 5(c).

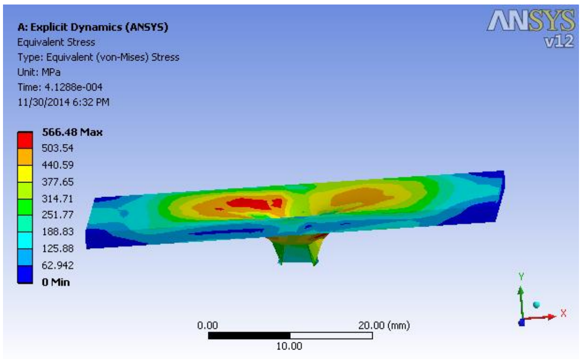


Figure 5(a), 2000rpm-40m/s

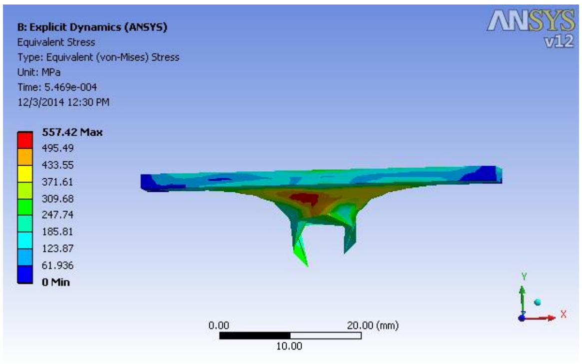


Figure 5(b), 3000rpm-40m/s

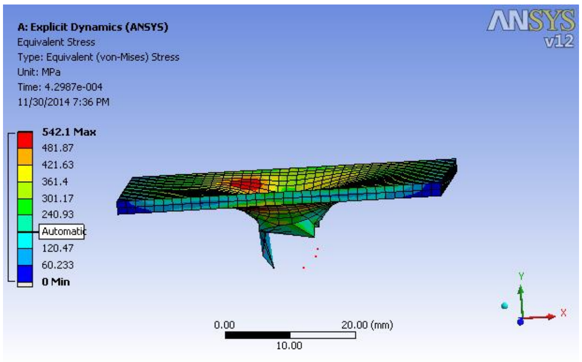
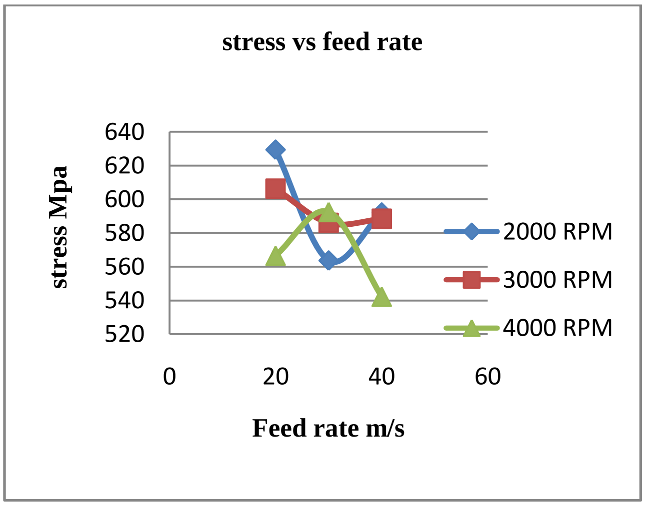


Figure 5(c) 4000rpm-40m/s

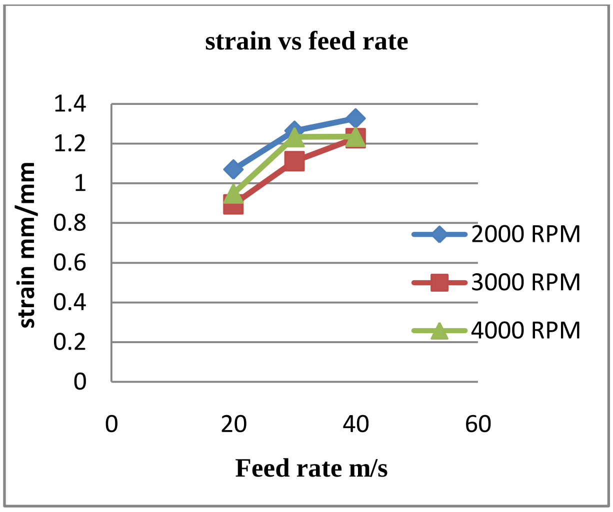
6. RESULTS :

The stress variation of the friction drilling at different feed rates and speeds are shown in graph .1. We observed the maximum stress at 2000rpm and 20m/s feed rates.



Graph.1

The strain variation of the friction drilling at different feed rates and speeds are shown in graph .2 .The maximum strain is observed at 2000 rpm speed and 40 m/s feed rate.



Graph.2

The friction drilling effects Hss and Tungstun tools in stress, strain and deformation of the work piece.Due to the different speeds of 2000rpm, 3000rpm, 4000rpm and feed rates of 20m/s, 30m/s, 40m/s is given in below tables 2 and 3.

s.no	tool	Speed (rpm)	Feed rate (m/s)	Total Deformation (mm)	Maximum Elastic strain (mm/mm)	Equivalent (von-mises) Stress(Mpa)	Maximum principal Stress(Mpa)
1	Hss	2000	20	8.8372	1.0701	629.43	706.89
2	Hss	2000	30	16.589	1.2651	563.69	591.37
3	Hss	2000	40	16.609	1.3275	592.16	656.68
4	Hss	3000	20	8.4629	0.89441	606.28	593.46
5	Hss	3000	30	9.3531	1.1119	585.99	683.45
6	Hss	3000	40	17.395	1.2276	588.33	646.03
7	Hss	4000	20	8.4788	0.94915	566.48	559.75
8	Hss	4000	30	16.656	1.2327	592.45	545.49
9	Hss	4000	40	17.536	1.235	542.1	578.21

Table 2,The FEM simulation values for HSS tool

s.no	Tool	Speed (rpm)	Feed rate (m/s)	Total Deformation (mm)	Maximum Elastic strain (mm/mm)	Equivalent (von- mises) Stress(Mpa)	Maximum principal Stress(Mpa)
1	Wc	2000	20	8.452	0.889	583.19	577.14
2	Wc	2000	30	16.954	1.2723	562.87	537.77
3	Wc	2000	40	15.689	1.2072	620.06	748.7
4	Wc	3000	20	8.4674	0.86374	590.61	599.62
5	Wc	3000	30	8.4005	1.0832	589.73	550.74
6	Wc	3000	40	18.161	1.2559	580.03	608.65
7	Wc	4000	20	8.4563	0.85022	584.17	579.62
8	Wc	4000	30	16.89	1.2476	557.42	561.15
9	Wc	4000	40	46.937	1.2444	462.34	450.37

Table 3,The FEM simulation values for Tungstun tool

CONCLUSIONS:

From finite element analysis it is observed that the minimum Equivalent von-mises stress is obtained at maximum speed and feed rate for HSS tool. Proper Bush formation is occurred at 2000 rpm and 40 m/s feed rate .for both HSS and tungusten tools strain is increasing with speed and feed rates.

REFERENCES

[1]Soo, S. L., Aspinwall, D. K., and Dewes, R. C., 2004, "3D FE Modeling of the Cutting of Inconel 718," J. Mater.Process. Technol., **150**, pp. 116–123.

[2]CebeliOzek, ZulkufDemir, Investigate the Friction Drilling of Aluminum Alloys According to the Thermal Conductivity, TEM Journal – Volume 2 /Number 1/ 2013.

[3] Pantawane. P.D, Ahuja.B.B, Experimental investigations and multi-objective optimization of friction drilling process on AISI 1015, Volume 2, No 2, 2011

[4]B. Padma Raju, KumaraSwamy,Finite Element Simulation of a Friction Drilling process using Deform-3D,IJERA Journal Vol. 2, Issue 6, November- December 2012, pp.716-721

[5] Scott F. Miller, Albert J. Shih (2007), thermo-Mechanical Finite Element Modeling of the Friction Drilling Process, Journal of Manufacturing Science and Engineering, 129, pp 532 -538.

[6] Mehmet Tuncay Kaya, AlaattinAktas, BertanBeylergil and Hamza K. Akyildiz, An experimental study on friction drilling of ST12 steeel,Transactions of the Canadian Society for Mechanical Engineering, Vol. 38, No. 3, 2014

[7] DiwakarReddy.V, Krishnaiah.G, Gopi Chand and Indumathi,Analysis in Form Drilling AA1100 Using HSS Tools,International Conference on Trends in Mechanical and Industrial Engineering (ICTMIE'2011) Bangkok Dec., 2011

[8] Miller S.F., Wang H., Li R., Shih A.J (2006), experimental and numerical analysis of the friction drilling process, ASME Journal of Manufacturing Science and Engineering, 128, pp 803-81

[9]T.Prabhu,A.Arulmurugu,Experimental and analysis of friction drilling on Aluminium and copper, International Journal of Mechanical Engineering and Technology (IJMET), ISSN 0976 – 6340(Print),ISSN 0976 – 6359(Online), Volume 5, Issue 5, May (2014), pp. 123-132 © IAEME

[10] P. Krasauskas, Experimental and statistical investigation of thermo-mechanical friction drilling process, ISSN 1392 - 1207. MECHANIKA. 2011. 17(6): 681-686