A COMPREHENSIVE REVIEW ON INFLUENCE OF PROCESS PARAMETERS BY A NOVEL METHOD FORM DRILLING TECHNIQUE

[1]Bhaumik Gajjarkar, [2]Mr. Nitin Kamble, [3]Mr. Yogesh Kamble
[1]M. E. Student, [2]Assistant Professor, [3]Assistant Professor
[1, 2, 3]Department of Production Engineering,
[1, 2, 3]D.Y. Patil College of Engineering-Akurdi, Maharashtra

Abstract—Drilling plays a very influential role in machining since more than 40% of material removal operations are associated with this type of action. Traditionally, it generates high temperature during drilling operation. Therefore, the drilling tool becomes dull and leads to a limited service life. Moreover, the workpiece materials have been hardened during drilling operation which makes the post operation troublesome. Also, the chips adhered to the exit of a drilled hole destruction the surface quality and deteriorates the drilling precision. To eliminate this difficulty form drilling established. Form drilling, also known as "thermal drilling", "flow drilling", "friction drilling", or "friction stir drilling", is the best result to the aforementioned difficulty. Form drilling is a non-traditional hole making operation. A rotating conical tool is appeal to penetrate a hole and create a bushing in a single step without initiating chip. The form drilling process relies on the heat initiated from the frictional force between the tool and sheet metal workpiece to soften, penetrate, and deform the work-material into a bushing.
The present review focus on a complete explanation of the influence of various drilling process parameters of form drill tool on different work material in form drilling process.

Key words- Form Drilling, Temperature, Bushing

I. INTRODUCTION

In the automotive assembly plant, one of the major problems in manufacturing engineering is joining of sheet metal, tubing or thin walled profiles in a simple, efficient and cost-effective way. Among of the process currently being employed are J nuts, Weld nuts and other threaded inserts. These processes suffer with drawbacks like material wastage, more cycle time, addition of external elements and therefore more weight and costs with compromising quality. Form drilling is the best solution to all these problems of joining thin wall materials in simple, efficient and most economical way, **Scott F. Miller et al. (2006) [14]**.

Form drilling, also known as thermal drilling, flow drilling, friction drilling, or friction stir drilling and it is a non-traditional hole making method. Form drilling is suitable to apply ductile materials only. The Form drill comes into contact with the material using relatively high axial force and rotational speed. The heat generated from friction between a rotating conical tool and the work-piece makes the material soft and malleable enough to form a plastic state near the heat generated zone, thus it causing the tool to penetrate and deform the work material into a bush shapes, **formdrill, (2009) [16]**.

A. Basics of Form Drilling

The concept of form drilling first given by Jan Claude de Valliere, told that if enough heat is generated between two rubbing material it could melt and form a hole through the material. Along with that thought in mind, he developed a special drill designed to increase friction. After many trials, he found a shape that worked. Exemplar based form drill method expressed by **Scott F. Miller et al. (2006) [14]** as the form drill indents into the material, some the soften material flowed in tool movement direction and forming bushing under of hole and some of the soften material flowed in counter tool movement direction and forming a collar at the top of the hole. As a result this formed bushing is remarkably strong and can be used for bearing sleeves.

B. Technical Features of Form Drilling

These bushings are ideal for threaded applications; it is an excellent alternative to threaded inserts. This chip less machining process has the advantage of reducing the time required for drilling and incurring less tool wear, thus lengthening the service life of the drill so, that it is a dry drilling process, also form drilling process can be used in any application where the material thickness does not provide support for a threaded surface or a sleeve bearing application have shown by **formdrill (2009) [16]**.

C. Form Drill of Cast Metals

Han-Ming Chow[a], Shin-Min Lee[b], Lieh-Dai Yang[c], (2007) [15] had successfully applied friction drilling to Al-380 cast and examined different quality characteristics after machining including hole roundness as well as surface roughness and hardness of hole wall Cast metals exhibit the brittle property unappealing to friction drilling. For example, Fig. 1 shows the petaling problem of a hole in brittle cast aluminum material. The hole in Fig. 1 exhibits an undesirable bushing shaped like a flower, it is due to brittle fracture and radial peeling of work-material. Additional processes incorporated with friction drilling, such as workpiece preheating, have been developed to improve process effectiveness and flexibility.

Fig. 1 Friction drilling cast Al part with flower shape bushing

II. WORKING PRINCIPLE

a) The tip of the conical tool approaches and contacts the work-piece. The tool tip, like the web center in twist drill, indents into the work-piece and supports the drill in both the radial and axial directions. Friction on the contact surface, created from axial force and relative angular velocity between tool and Work-piece, produces heat and softens the work-piece material.

b) As the tool is extruded into the work-piece, it initially pushes the softened work-material sideward and upward.

c) With the work-piece material heated and softened the tool is able to pierce through the work-piece.

d) Once the tool penetrates the work-piece, the tool moves further forward to push aside more work-piece material and form the bushing using the cylindrical part of the tool. As the process is completed, the shoulder of the tool may contact the work-piece to collar the back extruded burr on the bushing.

e) Finally, the tool retracts and leaves a hole with a bushing on the work-piece. Friction drilling is a technique to create a bushing on sheet metal, tubing, or thin walled profiles for joining devices in a simple, efficient way.

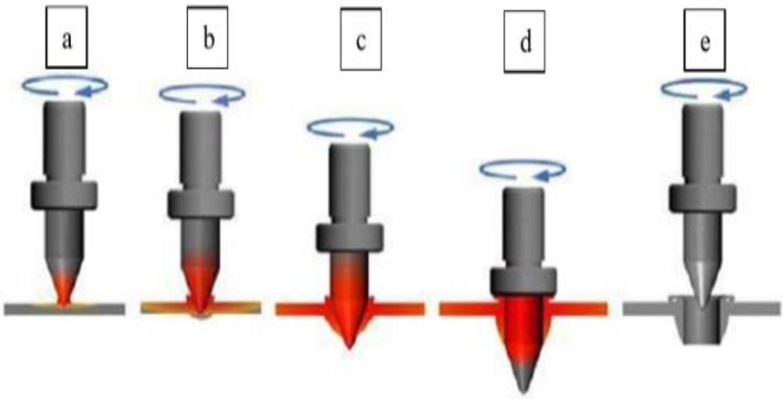

Fig. 2 A schematic illustration of the five steps in form drilling

For form drilling operation no special equipment is required. A standard drill press, milling machine or CNC machining center is suitable. Form drilling is also ideal for automation because it is a chip less process, produces accurate holes, and has a long tool life. Form drilling is also well suited for short run or prototype work because of its ease of use. There is absolutely no cutting involved during the creation of the hole **Prabhu et al. (2014) [1]**.

III. LITERATURE SURVEY

Different methodologies have been adopted by investigators to understand the sustainability of a drilling process. **Investigator T. Prabhu[1], Mr. A. Arulmurugu[2] , (2014) [1]** explained the basic principle of form drilling and investigated the behavior of form drilling temperature on the aluminum and copper alloy work material by using high speed steel and tungsten carbide conical drill tool. The result and discussion covers that during drilling workpiece temperature can increase up to 600ºC and the heat generated from friction between a rotating conical tool-workpiece, rapidly climbs to around 650-750 degrees C. They notice the effect of output parameters on aluminum and copper material and compared with conventional drilling method. The conclusion from result so got clarified that materials with different compositions and thermal properties affect the selection of friction drilling process parameters such that thrust force torque and surface roughness and tool wear.

Mehmet Tuncay Kaya[1], Alaattin Aktas[2], Bertan Beylergil[3] and Hamza K. Akyildiz[1], (2014) [2] objective of their study to analyze the effects of drilling independent parameters such as friction angle, friction contact area ratio (FCAR), feed rate and spindle speed on workpiece surface temperature, thrust force and torque as dependent parameters in form drilling of disc shaped ST12 material by tungsten carbide coated with TiN treatment. The experimental result indicated that friction angle, feed rate and contact area ratio are increased gradually as the torque and thrust forces increases, whereas the drilling speed is increased torque and thrust forces are decreases. Here the conclusion made by them, when the drilling speed increases, the temperature of workpiece surface increases so that drilling speed has an important effect on the workpiece surface temperature. Increasing or decreasing the friction angle and FCAR has no significant effect on the workpiece surface temperature.

M.Boopathi[a], S.Shankar[a], S.Manikandakumar[a], R.Ramesh[b], (2013) [3] worked on micro structure of drilled hole on Brass, Aluminum, stainless steel and reported hardness variation in the heat affected areas of the work piece as the temperature distribution during the friction drilling for various spindle speeds. They depict the form drilling of aluminum, brass and stainless steel attained a maximum temperature of 164^0, 252^0 and 468ºC respectively by using an infrared thermometer. They examined microscopic observations of the drilled holes by Scanning Electron Microscope (SEM) and reported peak hardness value of drilled hole are 122, 208 and 477 in form drilling of aluminum, brass and stainless steel respectively. They reached on conclusion that thrust forces is gradual increment for increase in feed rates for constant speed and in the case of aluminum high adhesion of work piece and material transfer showed by the microstructure images.

Cebeli Ozek[1], Zulkuf Demir[2], (2013) [4] studied output process parameters which are the generated frictional heat, surface roughness and bushing height according to input parameters spindle speeds, feed rates and thermal conductivity coefficient of the different aluminum alloys such that A1050, A6061, A5083, A7075-T651. The authors nullify that with increasing thermal conductivity coefficients, the sufficient frictional heat was gained at the high spindle speeds and low feed rates. Also a conclusion made by author, in form drilling greater bush forming heights were obtained at lower spindle speeds and high feed rates which are 8.56mm bushing height at 1800rpm and 50mm/min feed rate in friction drilled A1050 aluminium alloy. In friction drilled A6061 alloy the larger bushing height was measured as 6.71mm. In friction drilling A7075-T651 aluminium alloy the bushing height was measured as 6.27mm at 3000rpm spindle speed and 50mm/min feed rate, at 3600rpm spindle speed and 100mm/min feed rate it was measured as 6.06mm for A5083 aluminium alloy. The optimum surface roughness values were measured at 4200rpm and 25mm/min as 2.6µm for A1050, at 2400rpm and 75mm/min as 2.8µm for A6061, 3µm for A5083 and at 2400rpm, 50mm/min and 100mm/min feed rates as 2.4µm for A7075-T651 aluminium alloy.

Cebeli Özek [1], Zülküf Demir [2], (2013) [5] focuses on workpieces (St 37 steel & heat treated A7075-T651 aluminium alloy) and tool material (HSS & WC) type's parameters which are surface roughness, bushing sheet thickness, height and spindle speed, feed rate, tool conical angle, workpiece material thickness respectively. Consequently they discovered that in friction drilling of 2, 4 and 6mm thickness of heat treated A7075-T651 aluminium alloy, the bushing was formed as petal shape, which limited providing connection length and clamping strength owing to the brittleness of the material. Experimental data suggested that surface roughness values of A7075-T651 aluminium alloys were higher than St 37 steel materials. They gave conclusion that the optimum surface roughness values were obtained as 0.6 μm in form drilling conditions that selected at 50 mm/min feed rate, 4800 rpm spindle speed, 6 mm workpiece thickness, 48^0 tool conical angles for heat treated A7075-T651 and 0.2 μm at 3600 rpm spindle speed, 75 mm/min feed rate and 36^0 tool conical angle conditions, in friction drilling of St 37 steel material with WC tool.

Cebeli Özek [1], Zülküf Demir [2], (2013) [6] analyzed the effect of tool conical angle on the bushing height, bushing wall thickness and bushing shape of heat treated A7075-T651 with thickness of 4 and 6 mm. Experimental result revealed that according to 4 mm and 6 mm materials thicknesses for bushing height, the most optimum tool conical angle was 24° for all diameters. They discussed that with decreasing tool conical angle the bushing height was increased and bushing wall thickness was decreased-vice versa. Authors concluded that with increasing both tool conical angle and spindle speed the cracks in obtained bushing were advanced and the shape of bushing formed as petal, but with increasing feed rate the bushings shapes were not changed. The highest bushing wall thicknesses were obtained at optimum tool angle 48°, spindle speed 4800 rpm, and 100 mm/min feed rate in friction drilling 4 and 6mm thick sheet of A7075-T651 aluminium alloy and the bigger bushing sheet height were obtained at 2400 rpm spindle speed, 50 mm/min feed rate, and 24^0 tool conical angle. Finally they stated that drill with 8 mm diameter have the most optimum tool conical angle was 36° and 24° for 10 mm and 12 mm diameters.

Pantawane. P. D, Ahuja. B.B, (2011) [7] applied form drilling on hollow workpiece of AISI 1015 by using two M8 & M10 standard geometry of tungsten carbide with cobalt matrix form drilling tools and investigated the effect of dimensional error and surface roughness of the bush on changing the independent parameters which are rotational speed, feed rate and tool diameter. They presented Response Surface Method (RSM) as statistical analysis tool to develop an empirical model for the responses in terms of drilling parameters. They completed optimization of machining condition with multiple response method which makes use of an objective function called as 'Desirability Function'. By the experimental measurement they conclude that with the increase of speed from 2500-4500 RPM, feed from 71.36-198.64mm/min the surface roughness decreases from 0.536 μm to 0.341 μm and Dimensional error found to be proportionally increasing from 452 μm to 497 μm. Tool diameter affects surface roughness negatively indicating proper selection of tool diameter.

Wei Liang Ku, Ching Lien Hung, Shin Min Lee, Han Ming Chow, (2011) [8] have introduced the new procedure for form drilling in which form drill tool made of sintered carbide and investigated the effects of friction angle, friction contact area ratio, feed rate, and spindle speed on the two quality characteristics surface roughness and bushing length. The experimental result showed the optimal combination levels of machining parameters for bushing length obtained when frictional contact area ratio =50%, feed rate=75 mm/min, and spindle speed=1200 RPM thus, friction contact area ratio was the only significant parameter for bushing length. Moreover, the optimal machining parameter levels for surface roughness Ra=0.96 μm obtained when frictional angle=30°, frictional contact area ratio=50%, feed=100 mm/min, and spindle speed=3,600 rpm. They concluded that form drilling provided the better machining performance and longer tool life.

G. Somasundaram[1], S. Rajendra Boopathy[1] and K. Palanikumar[2] , (2011) [9] utilized conical drill tool with d=5.3 mm, α=90°, β=36°, hc=0.970 mm, hn=7 mm, hl=15 mm, shoulder region length 7mm, shank region length 30mm of high speed steel (HSS) and done comprehensive analysis on friction drilling of Al/SiC_p metal matrix composites and discussed the roundness (hole diameter accuracy) errors on dry form drilled holes. They prepared design of experiments by using response surface methodology. They analyzed roundness errors of workpiece with experimental design matrix and gave empirical relation between the process parameters which are spindle speed and feed rate. They used Analysis of variance for analyzing the results and the influences of individual input process parameters on roundness error also studied. They gave conclusion that this technique is convenient to predict the main effects and interaction effects of different influential combinations of machining parameters.

Diwakar Reddy.V, Krishnaiah.G, Gopi Chand and Indumathi, (2011) [10] Showed the relationship between thrust forces and torque with speed, feed and frictional contact area ratio of aluminum AA1100 with thickness 6mm by using high speed steel conical drill tool. They designed experiment layout by full factorial method and analysis done by analysis of variance (ANOVA). They discussed when frictional contact area ratio increased from 0.11 to 0.44 mm there is increase in value of thrust force 192-250N and torque 2 to 2.6Nmm. The experimental measurements conclude that when the spindle speed increased from 700-760 rpm the thrust force decreased to 235-205N, so that for base tool requires less torque and thrust force compared to pointed tool. From the contributed values it is concluded that the R2/R1 ratio is a critical parameter and is influencing both torque and thrust force.

[1]G.Somasundaram, [2]S.Rajendra Boopathy, (2010) [11] adopted a low volume low cost fabrication technique to fabricate the AlSiC MMC plates by liquid metallurgy method manufactured conical drill tool of high speed steel (HSS), which is an economical and efficient one. They proposed the effectiveness and advantages of this novel technique on dry friction drilled holes and analyzed the interaction effect of these parameters which are composition of work piece, temperature of work piece, work piece thickness with spindle speed, and feed rate by using design of experiments applied with response surface methodology. They concluded that roundness error increase with increase in spindle speed, feed rate and thickness of plate. Also it decreases with increase in weight percentage of SiC. Hole quality is smoother as thermal energy makes its strong contribution in the process of plastic deformation during the friction drilling.

P. V. Gopal Krishna[1], K. Kishore[1] and V. V. Satyanarayana[2], (2010) [12] investigated mechanical aspects of friction drilling by taking Aluminum (AA6351) as work material and form drilling is carried out by high speed steel conical tool. The researcher developed Mathematical analysis for axial thrust and torque. They designed experimental layout by Taguchi method to evaluate the performance of high speed steel form drill on AA6351 workpiece of thickness 1mm. They reached on conclusion that when frictional angle increased from 30^0 to 60^0 the value of thrust force increase to 299-549N and value of torque decrease to 1.766-0.796Nmm. Also, with increasing spindle of speed from 2000-3000rpm value of thrust force and torque both are decreasing by 454-394N and 1.295-1.248Nmm. At last the highly burnished surface is obtained for AA6351 in friction drilling at low and medium speed and discolorations is observed at high speed.

Han-Ming Chow[a], Shin-Min Lee[b], Lieh-Dai Yang[c], (2008) [13] performed experiment of form drilling to make holes on austenitic AISI304 stainless steel as a work piece material using tungsten carbide drills. The experimental results indicated that the drilled surrounding area obtained fine grain size and compact structure with a higher micro hardness than that of the area away from the drilled area. They explore the optimal geometrical shape of drill and optimal parameters of drilling were found in order to obtain a quality hole surface after exploring the surface roughness using Taguchi Method. They gave a conclusion that friction drill had a better performance such as avoiding serious tool wears, enhancing hole quality, and prolonging the tool life significantly.

Scott F. Miller, Hsin Wang, Rui Li, and Albert J. Shih, (2006) [14] presented thermal and mechanical aspects of form drilling. They developed form drilling finite element modeling to understand the material flow, temperature, stresses and strains which are difficult to measure experimentally and another is semi empirical analytical model on the base of contact pressure to predict thrust force and torque for AISI1020 steel using tungsten carbide friction drill. The conclusion indicated that materials with different compositions and thermal properties affect the selection of friction drilling process parameters, the surface morphology of the bore, and the development of a highly deformed layer adjacent to the bore surface.

1Dr. A. Gopichand, 2M. Veera Brahmam, 3D. Bhanuprakash, (2014) [17] used FEM for analyze the stress, strain and deformation of the work material in friction drilling because modeling and simulation is necessary tool to understand the material flow. They used the Ansys software to simulate the behavior of friction drilling Process which is difficult to measure experimentally. The modeling of the friction drilling tool HSS, WC and work material A7075-T6 developed in PRO/E software. They conclude that from finite element analysis 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 tungsten tools strain is increasing with speed and feed rates.

Shin Min Lee[a], Han Min Chow[b], Fuang Yuan Huang[a], Biing Hwa Yan[a], (2009) [18] utilized friction drilling on austenitic AISI 304 stainless steel to make holes by uncoated and PVD AlCrN- and TiAlN- coated using tungsten carbide drills. The authors showed that coated tungsten carbide tool experiences less tool wear than uncoated drills at the same spindle speed and for the same number of drilled holes. Drill coating suffered greater tool wear and the difference in surface temperature between coated and uncoated tools diminished at higher spindle speeds.

P. Krasauskas, (2011) [19] presented and discussed the experimental investigation and statistical analysis of the thermo-mechanical friction drilling process of hot rolled S235 steel, AISI 4301 stainless steel and Al 5652 aluminum alloy by using Tungsten Carbide tool. The experiment data showed that drilling force considerably depends on sheet thickness & ANOVA showed that sheet thickness t , feed ratio FR and yield limit σ y are significant parameters that most intensively affect F max and T max , however spindle rotational speed S has less valuable influence.

IV. SUMMARY

Form drilling process for different tool regions is reviewed. The heating, mainly from friction, produced high temperature of 760°C, about ½ of the melting temperature for ferrous and nonferrous materials. Thrust force and temperature initially increased rapidly as the center region contacted the workpiece. Torque increases gradually as the area of tool-workpiece contact grew. The conical and cylindrical regions of the tool contributed to form the bushing. Because of increasing both material thickness and hole diameter, the material volume, bushing height and bushing wall thickness were increased and therefore the bushing shape become cylindrically due to high *t*/*d* ratio.

From the review R2/R1 (FCAR) ratio of the tool is a critical parameter and is influencing both torque and thrust force & fictional angle (FA) is a critical parameter for bushing height. Thrust force and torque increases gradually with increasing friction angle, feed rate and FCAR. Thrust force and torque decreases with increasing spindle speed. Discolorations are observed at high speed in ferrous materials. There is an increase in surface roughness as the feed rate increases. Higher feed rate and shorter cycle time for hole drilling was feasible with the reduced thrust force and torque. At higher spindle speeds, the bushing height was decreased and bushing sheet thickness was increased- vice versa, owing to the ascending momentum impression.

Workpiece preheating can be beneficial to improve bushing formation, decrease the thrust force, torque, energy and power for form drilling in brittle cast aluminum. The external source of heat increased ductility and softened the work-material.

REFERENCES

[1] T. Prabhu, Mr. A. Arulmurugu,” Experimental And Analysis of Friction Drilling on Aluminium and Copper”, International Journal of Mecahnical Engineering And Technology (IJMET), vol.-5, no 4, pp. 130-139, May 2014.

[2] Mehmet Tuncay Kaya, Alaattin Aktas, Bertan Beylergil[3] and Hamza K. Akyildiz, “ An Experimental Study on Friction Drilling of ST12 Steel” Transactions of the Canadian Society for Mechanical Engineering”, vol.38, No. 3, May 2014.

[3] M. Boopathi, S. Shankar, S. Manikandakumar, R. Ramesh, ”Experimental Investigation of Friction Drilling on Brass, Aluminium and Stainless Steel”, International Conference on Design And Manufacturing (IConDM), Procedia Engineering64 1219-1226, 2013.

[4] Cebeli Ozek, Zulkuf Demir, “Investigate the friction drilling of Aluminium Alloys According to the Thermal Conductivity”, TEM Journal, vol-2/number 1/2013.

[5] Cebeli Ozek, Zulkuf Demir, “Investigate the Surface Roughness and Bushing Shape in Friction Drilling of A7075-T651 and St 37 Steel ”, TEM Journal, vol-2/number 2/2013.

[6] Cebeli Ozek[1], Zulkuf Demir[2], “ Experimental Investigate the effect of tool conical angle on bushing height, wall thickness and forming in friction drilling of A7075-T651 aluminum alloy”, Usak University Journal of Material Sciences1, Pgs:61-74, 2013.

[7] Pantawane. P. D, Ahuja. B.B, ”Experimental investigation and multi objective optimization of friction drilling process on AISI 1050”, International Journal of Applied Engineering Research,Dindigul, vol-2, No-2, 2011.

[8] Wei Liang Ku, Ching Lien Hung, Shin Min Lee, Han Ming Chow, “ Optimization in thermal friction drilling for SUS 304 Stainless Steel”, International Journal of Advance Manufacturing Technology (IJAMT), Pgs: 953-944, 2011.

[9] G. Somasundaram, S. Rajendra Boopathy and K. Palanikumar[2], “Modeling and analysis of roundness error in friction drilling of aluminum silicon carbide metal matrix composite”, Journal of Composite Materials, Pgs:169-181, 2011.

[10] Diwakar Reddy.V, Krishnaiah.G, Gopi Chand and Indumathi, “Analysis in Form Deilling AA1100 Using HSS Tools:, International Conference on Trends in Mechanical and Industrial Engineering (ICTMIE), 2011.

[11] G. Somasundaram, S. Rajendra Boopathy, “Fabrication and Friction drilling of Aluminium Silicon Carbide Metal Matrix Composites” IEEE Journal, 2010.

[12] P. V. Gopal Krishna[1], K. Kishore[1] and V. V. Satyanarayana[2], “Some Investigation in Friction Drilling AA6351 Using High Speed Steel Tools”, ARPN Journal of Engineering and Applied Sciences, vol-5, No-3, March 2010.

[13] Han-Ming Chow[a], Shin-Min Lee[b], Lieh-Dai Yang[c], “Machining Characteristic Study of Friction Drilling on AISI 304 Stainless Steel”, Journal of Materials Processing Technology, Pgs”180-186, 2008.

[14] Scott F. Miller, Rui Li, Hsin Wang, Albert J. Shih, “Experimental and Numerical Analysis of Friction Drilling Process”, Transactions of the ASME, vol-128, August 2006.

[15] Lee, S.M, Chow, H.M. and B.H., “Friction drilling of Al380 cast alloy”, Materials and Manufacturing Process, Vol. 22, Nos. 7-8, pp. 893-897, 2007.

[16] Formdrill, http://formdrill.eu, 2009.

[17] $_1$Dr. A. Gopichand, $_2$M. Veera Brahmam, $_3$D. Bhanuprakash, "Numerical Simulation and Analysis of Friction Srilling Process for Alumina Alloy using Ansys", International Journal of Engineering Research & Technology (IJERT), Vol. 3, Issue/ 2 December-2014.

[18] Shin Min Lee[a], Han Min Chow[b], Fuang Yuan Huang[a], Biing Hwa Yan[a], "Friction Drilling of Austenitic Stainless Steel by Uncoated and PVD AlCrN and TiAlN Coated Tungsten Carbide Tools", International Journal of Machine Tools and Manufacture, pp 81-88, 2009.

[19] P. Krasauskas,, "Experimental and Statistical Investigation of Thermo- Mechanical Friction Drilling process ", ISSAN 1392-1207, MECHANIKA, 2011.