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Parametric Evaluation in Friction Drilling Process: A Review Paper

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Abstract: Friction drilling is non-traditional drilling technique or method to makes holes in a sheet metal object without any formation of chips. For making the holes in an object, heat is generated due to friction between work-piece and tool. This is also known as thermal drilling or form drilling or flow drilling. In this process, a rotating tool is applied on the work-piece with desired speed and feed-rate to produce holes. The rotating conical tool extrudes the material by application of vertical thrust force acting downwards, resulting in the formation of a bush in the bottom of the hole; without generating chip. The parameters of friction drilling will be thickness of work-piece, spindle speed, feed-rate, diameter, tip angle and composition of tool.

***Index Terms* – Friction drilling, tool, bushing, temperature.**

I. INTRODUCTION

Drilling plays a very important role in machining since more than 40% of material removal processes are associated with this type of operation. Traditionally, a drilling tool is generally made of high speed steel (HSS). It generates high temperature during drilling process. Therefore, the drilling tool becomes dull and leads to a shortened service life. Moreover, the work-piece materials have been hardened during drilling process which makes the post-process troublesome. Also, the chips adhered to the exit of a drilled hole damages the surface quality and deteriorates the machining precision. Friction drilling, also known as “thermal drilling”, “flow drilling”, “form drilling”, or “friction stir drilling”, is the best solution to the aforementioned problems.

Friction drilling is a non-traditional hole making method that uses the heat generated due to the friction between a rotating conical tool and the work-piece to soften and penetrate the work-material and generate a hole in a sheet material and at the result a bushing forms. Fig. 1 shows the different stages of friction drilling process. The initial stage is the contact between the tip of conical tool and work-piece. 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. The tool is ready to pierce through the work-piece which is heated and softened, it moves further forward to penetrate and form the bushing using the cylinder part. As the process is completed the shoulder of the tool may contact the work-piece to collar the back extruded burr on the bushing. Finally the tool retracts and leaves the hole with the bushing on the work-piece. This drilling process can be done without using any coolant or lubricant hence it is also known as dry friction drilling.

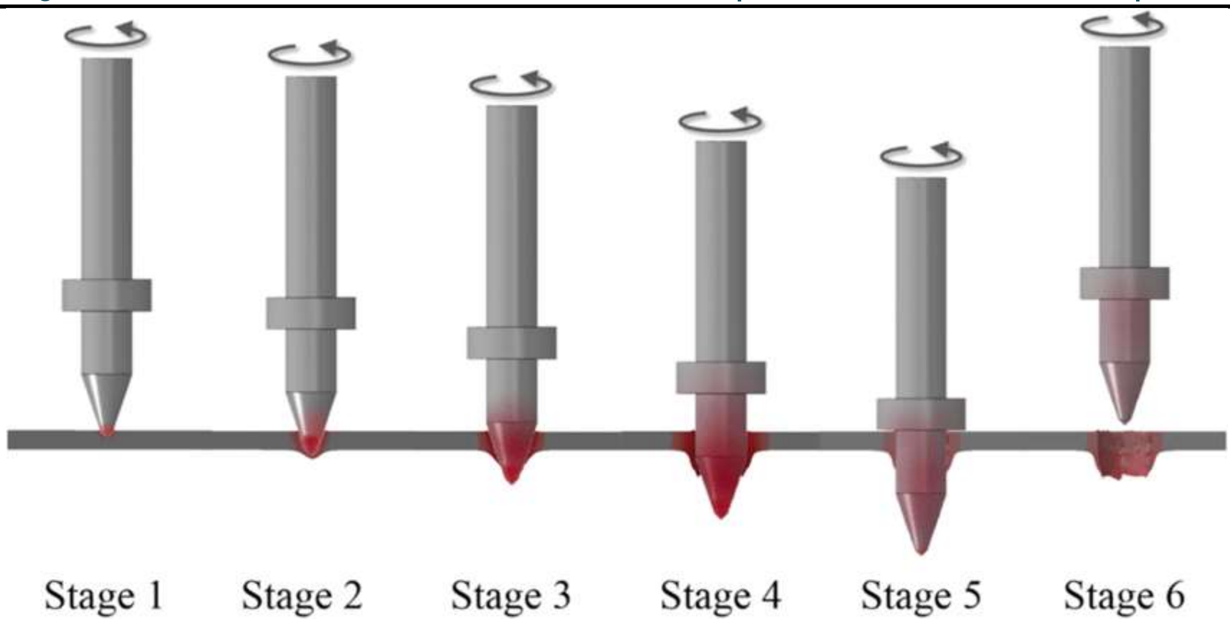

Figure :1 – Stages of Friction drilling process

LITERATURE SURVEY

K. Hanumantha Rao, Dr. A. Gopichand, N. Pavan Kumar and K. Jitendra (2017): Used High Speed Steel (HSS) and Tungsten Carbide (WC) Tool with cone angles 30° and 45° with diameter 12.5 mm and performed friction drilling operation on aluminium and mild steel work-pieces. The assembly modelling of drilling friction tool and work-piece was developed using PRO/E software. Before conducting the actual experiment the analysis of friction drilling is done using ANSYS and get the solution in terms of stress, strain and total deformation. To get the optimum combination of parameters Taguchi method is used, they found that for tool material of Tungsten carbide with cone angle 30°, 40m/s feed and 4000 rpm of spindle speed combination, low stress and maximum deformation was preferential.

Mehmet Tuncay Kaya, Alaattin Aktas, Bertan Beylergil and Hamza K. Akyildiz (2014): Determined an experimental investigation to study the effects of drilling parameters like friction angle, friction contact area ratio (FCAR), feed rate and spindle speed on work-piece surface temperature, thrust force and torque in friction drilling of ST12 steel by using Tungsten Carbide (WC) tool, coated with TiN treatment. They have used instruments like dynamometer, infrared thermometer for measuring the surface temperature of material and MarSurf PS1 surface roughness tester. According to their experimental results thrust force and torque increases with increasing friction angle, feed rate and FCAR while thrust force and torque decreases with increasing spindle speed. As the feed rate increases there is increase in surface roughness although friction angle and FCAR has not responsible for increase in temperature of material on surface but increasing the spindle speed leads to increase the surface temperature of work-piece. As the feed rate increase bushing length increased.

Dr KGK Murti, C. Labesh Kumar, VVSH Prasad, T Vanaja (2015): Designed combined friction drilling and tapping tool of HSS (M35) by using thermo mechanical FEM formulation and manufactured by tool cutter and grinder. The dimensions of tool is 100mm length, 10mm diameter, hl=13.4mm with angle of 30°. Tapping is done on material at an angle of (60) of length (13.4mm) of pitch (M8x1.25) by using dies. The aluminium alloy 6351 used as work-piece material. Modelling and analysis of friction drilling done by using ANSYS WORKBENCH which results in temperature, deformation, effective stress and effective strain. They carried out experimentation on sensitive bench drilling machine with speed of 1400 rpm. This combined tool of friction drilling and tapping helps to increase the productive rate.

Mathew Alphonse, V.K.Bupesh Raja, K.Logesh, N.MuruguNachippan (2017): Determined the recent trends in friction drilling technique and importance of thermography. They showed a typical experimental setup of friction drilling process is on CNC using electric piezo dynamometer and thermometer/sensor on work piece to monitor the damage occurring during operation and minimized. By referring several research papers they provide the various comparative study of friction drilling process and also explain in detail about the terms like Delamination, methodology of Artificial Neural Network (ANN) Modelling, surface roughness, optimization technique, failure mechanism and thermography. Sandwich material is suitable for friction drilling process due to its light-weight, stiffness and durability. Delamination can be reduced by proper cutting speed and low feed rate.

B.Padma Raju, M.Kumar Swamy (2013): Investigates the effect of tool in friction drilling process on case study based. AISI4340 and WC drilling tool and workpiece material aluminium 6061 are utilized to understand the shape of formed bushing. Finite Element Modelling (FEM), thermal as well as mechanical formulation of workpiece presented. A semi empirical analytical model is developed to predict the thrust force and torque in friction drilling. The simulation and effect of tool done using 3D-DEFORM software. Higher feed rate and shorter cycle time for drilling hole was feasible with the reduced thrust force and torque. Improper bush formed with the increasing of speed from 3000rpm to 4000rpm.

Kuan-Yu Su, Torgier Welo, Jyhwen Wang (2018): Determined the experimental study on the effects of feed rate and spindle speed on the thrust load curve in friction drilling. Their main focus was examining the thrust force and improving the bushing quality.

Experimental results shows that spindle speed and feed rate affect the thrust force. They have designed, fabricated and used counter bore die for material flow control so that cracking and petal formation can be avoided and bushing quality increased. It is also possible to perform friction drilling through two metal sheets to create a weld joint, under an appropriate process.

M.Boopathi, S.Shankar, S.Manikandakumar, R.Ramesh (2013): Performed experiment on brass, aluminium and stainless steel (1.5mm thick) with using tungsten carbide drilling tool. Thrust force is measured using drill tool dynamometer for three feed rates of 80, 100 & 120 mm/min with three different speeds 2500. 3000 & 3500 rpm. Temperature of these material are measured by thermometer. Brinell hardness test is performed on the various locations on the surface of the wok piece near to the hole. The microscopic observation of the drilled holes is examined using scanning electron microscope (SEM). Experimental results shows that Aluminium requires low peak thrust force of 1512N, Brass requires a peak thrust force of 1798N and Stainless Steel requires a peak thrust force of 2745N for the hole penetration. Friction drilling on steel was smooth process as compared to other materials.

D. Biermann, Y. Liu (2014): Determined an experimental investigation of flow drilling on mangnesium Alloy Wrought AZ31 (4mm & 5mm thick) by using two WC drill tool of D1=5mm and D2=5.4mm. GROB BZ 40 CS machining center is used for this process with infrared camera for determining the temperature during the operation. Thread tapping and forming have been used to produce threads with size M6 ISO metric. The thread flank shows the micro fracture due to insufficient formability of magnesium alloy at low temperature. To overcome from such problem forming tool or work-piece should be pre-haeated.

Cebeli Ozek, Zulkuf Demir (2013): Explained a comparative study of friction drilling according to the thermal conductivity of Aluminium alloy (A1050, A6061, A5083, A7075 T651) by using High Speed Steel (HSS) drilling tool geometry with dia 8mm, h_1=16 mm tool cylindrical height, conical angle 36^0. They investigated the generated frictional heat, surface roughness, and bushing height according to spindle speeds, feed rates, and thermal conductivity coefficient of the materials. The frictional heat increases as the thermal conductivity of material decreases. The maximum heat was measured as 241.8^0C at 1 mm far from the surface of the friction drilled hole to A5083 aluminium alloy, which has the lower thermal conductivity coefficient, at 25mm/min feed rate and 4200 rpm spindle speed. The incomplete softening temperature of work-piece leads to surface roughness of hole. Due to high thermal conductivity coefficient of A1050 alloy surface quality was increased.

Eliseev A.A., Fortuna S.V., Kolubaev E.A., Kalashnikova T.A (2017): Investigates the modification of Aluminium Alloy 2024 (6mm thick) microstructure which is produced by friction drilling. They have explained the role of deformation, high temperature and friction on microstructure of material. The grain structure (grain size, grain shape) of AA2024 examined by optical microscopy using microscope (METAM LV-31). The structural phase composition was analysed by Scanning Electron Microscope (SEM). They also used micro-hardness tester for measurement and to estimate the relationship between microstructure and mechanical properties of the material. It was found that near the edge of hole there is recrystallized layer of fine equiaxial grain. The maximum microhardness was detected in recrystallized material layers in the stir zone (SZ)

CONCLUSION

This study elaborates the friction drilling effects on surface temperature, thrust force, torque. Several experimental in the mentioned study shows, Thrust force and torque increases gradually with increasing friction angle, feed rate Thrust force and torque decreases with increasing spindle speed. As the spindle speed increases, the work piece surface temperature increases. Increasing or decreasing the friction angle and FCAR has no significant effect on work piece surface temperature. There is an increase in surface roughness as the feed rate increases. The bushing length depends on the feed rate of the process. Also this process can be performed on various types of materials.

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