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# Design and Development of Friction Stir Drilling and Tapping

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**Abstract:** ***Friction stir drilling and tapping is a process in which drilling the hole and tapping is performed with the help of combination tool. The mechanism of hole formation in friction drilling is due to thermal softening followed by the penetration of tool into work. Drilling is traditionally a hole making process. Friction drilling work is performed by a sharp cone of circular shanked high speed steel. The tool is rotated at high speed to develop sufficient temperature and thrust is applied to form a hole without chips, hence some investigators prefer to call this method as form drilling, thermal drilling, flow drilling, or friction stir drilling.The sequence in friction drilling process, a rotating conical tool contacts the workpiece and heat is generated due to friction between mating surfaces, owing to this the work softening occurs and on further advancement of tool into the workpiece, the softened material is pushed side ward and forms the bushing. The shoulder of tool contacts the workpiece and does the trimming. The present work is to design the combination tool, modelling and experimentation validation is carried out using this combination tool and results are obtained.***

**Keywords:** Friction Stir, Drilling and Tapping, Combination Tool, Tool Design

## 1. Introduction

The mechanism of hole formation in friction drilling is due to thermal softening followed by the penetration of tool into work. Drilling is traditionally a hole making process. The mechanism of material removal is due to combination of extrusion and negative rake cutting. However, all traditional drilling methods suffer from various disadvantages they inherit from the machining processes. Friction drilling in the present work is performed by a sharp cone of circular shanked high speed steel. The tool is rotated at high speed to develop sufficient temperature and thrust is applied to form a hole without chips, hence some investigators prefer to call this method as form drilling, thermal drilling, flow drilling, or friction stir drilling

The formation of shoulder is a bonus in this method, which can be used as a natural bush in sheet metal or it can be used for tightening screws after tapping. The bush thickness is observed to be three times thickness of sheet metal further no cutting fluid is required for friction drilling. The sequence in friction drilling process, a rotating conical tool contacts the workpiece and heat is generated due to friction between mating surfaces, owing to this the work softening occurs and on further advancement of tool into the workpiece, the softened material is pushed side ward and forms the bushing. The shoulder of tool contacts the workpiece and does the trimming.

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. The bushing thickness can be threaded, providing a more solid connection for attachment than attempting to thread the original sheet. It produces bushes for a tapped and untapped hole. All work material from the hole contributes to form bushing. In addition, no cutting fluid or lubricant is necessary, which makes friction drilling a totally clean, environmentally friendly process.

**Figure 1:** Friction Drilling

## 2. Tool and Drilling Parameters

As visualized, the tool consists of three regions. The first one is the centre region. It has an angle α and height hc. This region provides the support in the radial direction for the friction drilling process and keeps the drill from walking at the start of the drilling process. The tools used in this study has α = 90 and hc = 1 mm. The second one is the conical region. It has a sharper angle than the centre region.

The tool in this region rubs against the workpiece to generate the friction force and heat, and pushes the work-material side ward to shape the bushing. The friction angle and length of the cone-shape conical region are marked as β and hn, respectively. The friction angle 30◦ is considered. Lastly, the cylindrical region is the third region. It helps to form the hole and shape of the bushing. The length and diameter of this region are designated as hl and d, respectively. The tool with d = 6.7 mm and hl = 13.4 mm.

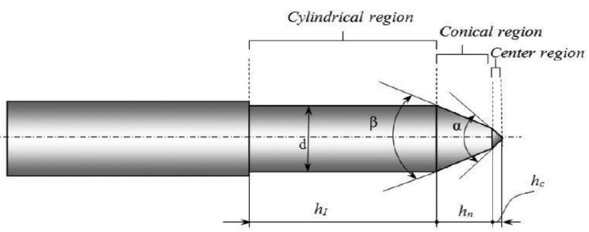


**Figure 2:** Shape of the typical friction-drillingtool

A bench drilling machine was used for friction drilling tests. The thrust force could be more accurately maintained constant with manual operation than using a constant feed rate in a conventional CNC machine, which generates high peak force. This method helped to minimize denting the sheet metal workpiece and to improve the bushing quality.

The spindle speeds used for sheet material of different metals as variation in rpm. These were determined experimentally to enable the penetration and forming of the hole. For titanium, with low thermal conductivity, most of the frictional heat is retained in the tool-workpiece interface. The effect of frictional heating is relatively prominent. This causes excessive temperatures in the workpiece and results in undesired material damage and improper bushing formation. For the aluminium alloy, the thermal conductivity is high. A large portion of the frictional heat is transferred into the workpiece and the effect of friction heating is relatively small. Low temperature causes insufficient increase in ductility and softening, resulting in high thrust force, denting of the workpiece, and improper bushing formation. These effects dictated the selection of low and high spindle speed for titanium and aluminium, respectively.

Under the constant feed speed, a peak thrust force of occurs and tool travel from the initial contact with the workpiece. This position of maximum thrust force is marked as A. A separate friction drilling test was conducted to stop and move back the tool at position A. The workpiece was sectioned and polished to reveal the deformation shape. The sheet metal workpiece was bent and dented but not perforated. This reveals that the mechanical indentation of the workpiece by the tool tip is the key deformation mechanism at the start of friction drilling. Insufficient heat was generated to soften the work-material due to the low tool peripheral speed at the tip. No discoloration at the indentation of the workpiece was observed to confirm increased workpiece temperature. Low peripheral speed also accounted for the small torque in the beginning of the contact. The torque rapidly rise to after the tool reached position A.

The time to penetrate the workpiece varies depending on the feed rate. The high peak force is not desirable since it deforms the sheet workpiece and may shorten the tool life.

Bushing shapes, which were generated at the result of drilled aluminium alloys in Fig.2.1.3. The bushings, which were generated in friction drilling aluminium alloys at required spindle speed and required feed rate. The bushing heights were measured with a depth micrometre at four different positions, owing to the HSS tool working temperature is under 6000C, the St 37 steel material could not frictional drilled with HSS tools.

Owing to the lower t/d ratio there was barely adequate flow material, which providing bushing shape, in friction drilling 2 mm aluminium alloy bushings were generated as petal. With increasing the t/d ratio the bushings were shaped cylindrical, which include less cracks. Bushing sheet thickness, due to the provided the threading strength, it was an important result in friction drilling. According to the tools, which were used in this experimental study, diameter (10 mm) it was threaded with M12. M12 threading teeth height is 1.07 mm. The more bushing sheet thickness was greater than 1.07 mm, the more threading strength was gained.

**Figure 3:** Bush formed after drilling

First, the tool comes into contact with the workpiece. Then, at the main thrust stage, the tool penetrates the workpiece and high axial force is encountered. The friction force on the contact surface produces heat and softens the work-material. Then, in the material separation stage, the tool penetrates the workpiece and makes a hole. The ductile work-material encompasses the tool. Finally, the tool retracts and leaves a hole with a bushing. Cross sections of several holes friction drilled with a 6.7 mm diameter of HSS tool in aluminium alloy workpiece.

Tool wear in friction drilling is a concern because it affects the characteristics and tolerances that are achievable. It is promoted by the high temperature and forces generated in the process. We have observed high peaks in the experimentally measured thrust force, torque, and temperature. A preliminary study of performance of tool wear for coated and uncoated friction drilling tools has been reported however, there is a lack of additional published research on the wear of friction drilling tools. The goals of the current research were to quantify the wear and surface degradation of HSS tools used in friction drilling of Aluminium using changes in tool shape and mass, to characterize worn tool surface features, and to analyse the surface chemistry of the worn tool tip. Thrust force, torque, and hole inside diameters were also measured as the tool wear progressed. An important effect of tool wear is the dimensional alteration of friction drilled holes. As the number of holes drilled in the workpiece, then tool wear will also increase. Small change in diameter near the top of the hole is because of the lack of wear in the cylindrical region. An important observation in this study is that, even with the tool worn in the centre and conical regions, the hole diameter is largely determined by the tool cylindrical region, which does not exhibit a significant wear. Therefore, the hole diameter in the top of the hole, where connects to the thin workpiece, does not change drastically.

The wear of a friction drilling tool was minimal after producing more number of holes in an Aluminium workpiece. Precise measurements of tool dimensions indicated that the wear was concentrated at the tool centre region and at the intersection between the conical and cylindrical regions. The tool tip self-sharpened during friction drilling, which reduced the thrust force as tool wear progressed. The torque did not display any obvious changes at different stages of tool wear. Adhesive, oxidative, and abrasive wear all occur to some extent during friction drilling; however, it is difficult to determine their proportional contributions. The relative influence of these wear modes, especially those associated with diffusion wear, may change as the tool continues to wear out.

## 3. Material of Tool and Work

Friction stir drilling is a process that uses friction to produce bushings in metal tubing and flat stock. The combined rotational and downward force of our special friction stir Drilling tool bit creates frictional heat. Temperatures can reach 900°C for the tool, and 700°C for the work piece. The material is transformed into a "Super plastic" state, allowing the tool to displace material and form a bushing. The height of the bushing is roughly 3 to 4 times the original metal thickness. These bushings are ideal for threaded applications, as the number and strength of threads is significantly increased. It is an excellent alternative to weld nuts or threaded inserts. The bushing can also be used as a support hole for welded, soldered or brazed connections as well as for a load-bearing surface. The Thermal Drilling System can be used in most ferrous and nonferrous metals including mild steel, stainless steel, copper, brass and aluminium, with material thickness up to 12 mm. No special equipment is required. A standard drill press, milling machine or CNC machining centre is suitable. Thermal Drilling is also ideal for automation because it is a chip less process, produces accurate holes, and has a long tool life. Thermal 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.

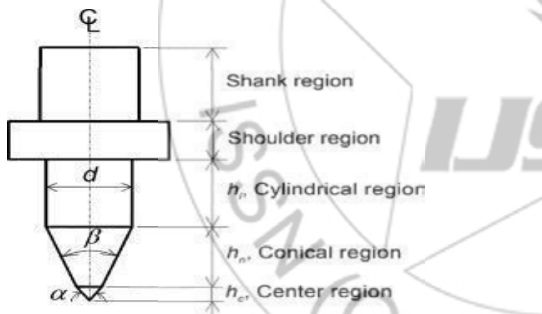


**Figure 4:** Key dimensions of the frictional drilling tool

Aluminium alloys are used in many applications in which the combination of high strength and low weight is attractive in air frame in which the low weight can be significant value. Al 6351 is known for its light weight ($\rho$ = 2.7g/cm3) and good corrosion resistance to air, water, oils and many chemicals. Thermal and electrical conductivity is four times greater than steels. The chemical compositions of Al 6351 are shown in table 3.1.1. It has higher strength amongst the 6000 series alloys. Alloy 6351 is known as a structural alloy, in plate form. This alloy is most commonly used for machining. Though relatively a new alloy the higher strength of 6351 has replaced 6061 alloy in many applications. Mechanical properties can be easily obtained at tension tests, with great accuracy. Thus, alloy such as 6351 have significantly more silicon than magnesium or other elements, but find themselves in the Mg2Si series.

**Table 1:** Chemical composition of Al Alloy (6351)

| *Chemical composition* | *Content (%)* |
|---|---|
| Aluminium, Al | 97.8 |
| Silicon, Si | 1 |
| Manganese, Mn | 0.6 |
| Magnesium, Mg | 0.6 |

**Table 2:** Physical properties

| *Properties* | *Metric* | *Imperial* |
|---|---|---|
| Density | 2.6-2.8 g/cc | 0.0939- 0.101 lb/in3 |

The AA 6351 aluminium alloy is used in manufacturing due to its strength, bearing capacity, ease of workability and weldability. It is also used in building boat, column, chimney, rod, mould, pipe, tube, vehicle, bridge, crane and roof. One of the most important properties of AA 6351 aluminium alloy is that the treatment of solid solution is not so critical. One of the major areas of Al 6351 for investigating crack phenomena is the gas cylinders made of this material often prone to crack at various tensile residual stresses. Sustained load cracking, a metallurgical anomaly, occasionally develops in 6351 aluminium alloy high-pressure cylinders. The alloy in use in Australia and other countries was changed from 6351 in T6 temper to 6061 T6 in the early 1990s. Al 6351 H 30 series alloy can be used in structural and general engineering items such as rail & road transport vehicles, bridges, cranes, roof trusses, rivets etc. with good surface finish. Also it is observed from research that for the wrought aluminium alloy AA6351-T6 show the lowest and most stable strain amplitude.

Molybdenum high-speed steels are designated as Group M steels according to the AISI classification system. Over 95% of high speed steels manufactured in the US are group M steels. Tungsten is present in all types from M1 to M10, except M6, and cobalt is not present in any of these steels. Molybdenum high-speed steels have similar performance when compared to tungsten high-speed steels. However, the initial cost of molybdenum tool steels is lower. Titanium nitride, titanium carbide and several other coatings can be used in tools made of this kind of steels through physical vapour deposition process to improve the performance and life span of the tool. HSS friction drill as shown in fig 3.2. The chemical composition of HSS(M35)

**Table 2:** Physical properties

| *Element* | *Content (%)* |
|---|---|
| C | 0.93 |
| Cr | 4.2 |
| Co | 4.9 |
| Fe | 76.52 |
| Mo | 5 |
| Si | 0.3 |
| W | 6.25 |
| V | 1.9 |

**Table 3:** Chemical compositionof HSS(M35)

| *Properties* | *Metric* | *Imperial* |
|---|---|---|
| Density | 2.6-2.8 g/cc | 0.0939- 0.101 lb/in3 |

## 4. Design of Combined Tool with Thermo Mechanical Fem Formulation

The friction and plastic deformation generate heat and elevate the workpiece temperature. The high temperature softens the workpiece and allows material to flow and form the hole and bushing. The governing equation for the thermal model is: ∴ρC ∂T/∂t=K[(∂^2 T)/(∂x^2 )+(∂^2 T)/(∂y^2 )]+G

where ρ is the density, c is the specific heat, k is heat conductivity, T is the temperature, t is the time, G is the heat generation rate, and x, y, and z are spatial coordinate. The ρ, c, and k are functions of temperature, which is important for accurate thermal modelling. Both T and G are function of x, y, z, and t. The heat generation rate, G, in friction drilling consist of the heating by the friction between tool and workpiece, qf and heating from irreversible plastic deformation inside the workpiece:

$$G = qf + qp$$

This study assumes that friction between the tool and workpiece follows Coulomb's friction law.

The frictional force Ff is directly proportional to normal force, Fn., by the coefficient of friction, μ i.e., Ff = μ Fn. The frictional heat generation rate, is equal to Ff times the surface velocity of the tool (V). At the local contact point with tool radius, R, V = 2πRN, where N is the tool rotational speed. The frictional heat generation rate, qf is $qf = 2\Pi RN\mu Fn$

The heat generation rate can be formulated as:
$qp = \eta\sigma\varepsilon pl$

Where η is the inelastic heat fraction, σ is the effective stress, and ἑ Pl is the plastic straining rate [14]. Most of the elastic portion of the energy in large plastic deformation in the workpiece of friction drilling is small. In this study, η was set to 0.7.
Horse power is,

HP=(2πN(μF×r))/4500
3=(2×π×374×0.61× f_f×3.35)/4500
∴ff=2.81 KN

Frictional force is,
ff=μ×F_n

Normal force is,
Fn= ff/μ
=2.81/0.61
=4606 N

Rotational velocity is,
V =2πrN
=2×π×3.35×374
=7.872 m/sec

Heating friction between tool and work piece is,
qf=2ΠRNμF_n
=2×3.14×(3.35×〖10〗^(-3))×374×0.61×4606
=22107

Heating from irreversible plastic deformation inside the work piece,
qp=ησε^pl
=0.7×(2.81×〖10〗^3)/(π×6.7×1.5×〖10〗^(-6) )×0.001
=62300.05

Heat generating rate is,
G =qf+qp
=22107+62300.05
=84407.05

Governing equation for thermal model is,
∴ρC ∂T/∂t=K[(∂^2 T)/(∂x^2 )+(∂^2 T)/(∂y^2 )]+G
2700×941×∂T/∂t= K [1/α (∂^2 T)/(∂t^2 )]+G
(∴α=K/ρC) (∴∂T/∂t=D,(∂^2 T)/(∂t^2 )=D^2)
D=D^2+84407.05
D^2- D+84407.05=0
(∴from (-b±√(b^2-4ac))/2a)

The roots are real, these are
m_1=0.9656
m_2=0.03438

Generalized equation is,
T=c1 ℯ^0.9656t+c2 ℯ^0.03438t
If T=0, t=0 then,
c1+c2=0
If T=150, t=60sec then,
150=c1 ℯ^(0.9656×60)+c2 ℯ^(0.03438×60)
150=c1 ℯ^(0.9656×60)-c1 ℯ^(0.03438×60) (∴c2=-c1)
c1=1.034680241×〖10〗^(-23)
c2=19.06463969

We can get the values of time and temperature by getting the boundary conditions from above equation.

The load acting by normal force,
P = f_n/A
=2.81/(π×6.7×1.5)
=0.8904 N/m^2
For conical region,
The thrust force is
F=πp(h_2^2-h1^2 ) tan^2⁡〖θ/2〗+μapΠ(h_2^2-h1^2 ) tan⁡〖θ/2〗
=π×0.8904×(〖(9.77)〗^2-(1.5)^2)tan^2(30/2)+0.4×0.8904×π×((9.77)^2-(1.5)^2) tan⁡〖30/2〗
=46.66 N

The torque developed is,
T=(2πμP(h_2^3-h_1^3 ) tan^2⁡〖θ/2〗 )/(3cos θ/2)
=(2×π×0.61×0.8904×((9.77)^3-(1.5)^3)×tan^2⁡〖30/2〗 )/(3cos 30/2)
=7.88 N-m

For straight cylinder area,
Thrust force is,
F=2πμ_aPRh_3
=2×π×0.4×0.8904×3.35×19

=142.3N

Torque is,

$T=2\pi\mu pR^2 h_3$

$=2\times\pi\times0.6\times0.8904\times 〖3.35〗^2\times19$

=715.74 N-m

For h*,

$$h^* = h_C \tan〖45/2〗/\tan〖30/2〗 - h_C$$

$$(\therefore \alpha=45°, \beta=30°)$$

$$=0.54 \text{ mm}$$

**Table 4:** Thermo Mechanical Fem Formulation

| DIAMETERS &HEIGHTS | SPEED(N) In RPM | FORCE(F) In Kgf | TORQUE In N-m | HEAT ENERGY(Q) In Joules | SURFACE VELOCITY (Vs) in N-m/sec |
|---|---|---|---|---|---|
| $d_1$ =1mm | $N_1$ =306 | $F_1$ =1881.9 | $T_1$ =5.74 | | $V_1$ =0.016 |
| $h_1$ =1mm | $N_2$ =510 | $F_2$ =1380.3 | $T_2$ =4.21 | 13.36J | $V_2$ =0.0267 |
| | $N_3$ =704 | $F_3$ =999.6 | $T_3$ =3.049 | | $V_3$ =0.3686 |
| $d_2$ =3mm | $N_1$ =306 | $F_1$ =627.3 | $T_1$ =5.74 | | $V_1$ =0.0480 |
| $h_2$ =2.99mm | $N_2$ =510 | $F_2$ =460.1 | $T_2$ =4.21 | 34.9J | $V_2$ =0.0801 |
| | $N_3$ =704 | $F_3$ =332.2 | $T_3$ =3.049 | | $V_3$ =0.1105 |
| $d_3$ =6.7mm | $N_1$ =306 | $F_1$ =280.89 | $T_1$ =5.74 | | $V_1$ =0.1073 |
| $h_3$ =9.77mm | $N_2$ =510 | $F_2$ =206 | $T_2$ =4.21 | 586.4J | $V_2$ =0.1789 |
| | $N_3$ =704 | $F_3$ =149.2 | $T_3$ =3.049 | | $V_3$ =0.2469 |

## 5. Manufacturing of Combined Tool

High speed steel material is most widely used in industries of their wide variety properties and applications. High speed steel of grade M35 is used.

Diameter (10mm) and length (100 mm) of the tool material(HSS) is taken as per the requirement. By using cutter and tool grinder machine operations the material gets a required cylindrical region length (13.4mm) and diameter (6.7mm). At an angle (45) of length (1 mm) of material is grinded by a cutter and tool grinder machine. From this we get tool tip and the centre region. Through this the penetration of workpiece is started. At an angle (30) of length (8.77mm) of material is also grinded. from this we get the conical region. In this region shearing is takes place. At an angle (60) of length (1 mm) of material gets chamfered.Tapping is done on material at an angle of (60) of length (13.4mm) of pitch (M8x1.25) by using dies.Tool and cutter grinder is used to sharpen milling cutters and tool bits along with a host of other cutting tools. It is an extremely versatile machine used to perform a variety of grinding operations: surface, cylindrical, or complex shapes. It is manually operated setup.The operation of this machine (in particular, the manually operated variety) requires a high level of skill. The two main skills needed are understanding of the relationship between the grinding wheel and the metal being cut and knowledge of tool geometry. The illustrated set-up is only one of many combinations available. The huge variety in shapes and types of machining cutters requires flexibility in usage. A variety of dedicated fixtures are included that allow cylindrical grinding operations or complex angles to be ground. The vise shown can swivel in three planesThe table moves longitudinally and laterally; the head can swivel as well as being adjustable in the horizontal plane. This flexibility in the head allows the critical clearance angles required by the various cutters to be achieved. In this project we used PRAGA TOOL AND CUTTER GRINDING MACHINE (MODEL 414)

**Figure 4:** Tool processing

**Figure 5:** Combination tool bit

## 6. Modelling and Analysis

ANSYS WORKBECH is the software is used for analysis and simulation of friction drilling.

**Figure 6:** Modelling of friction drilling

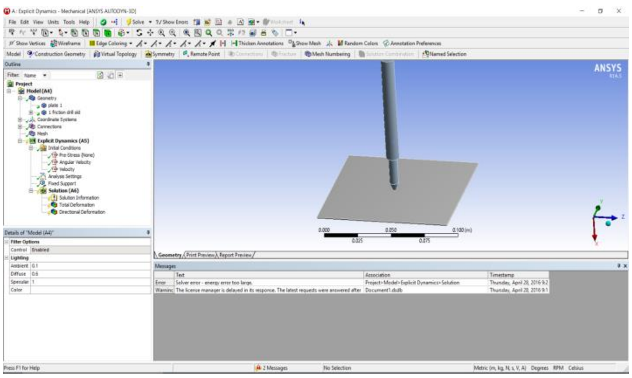

**Figure 6:** Model imported

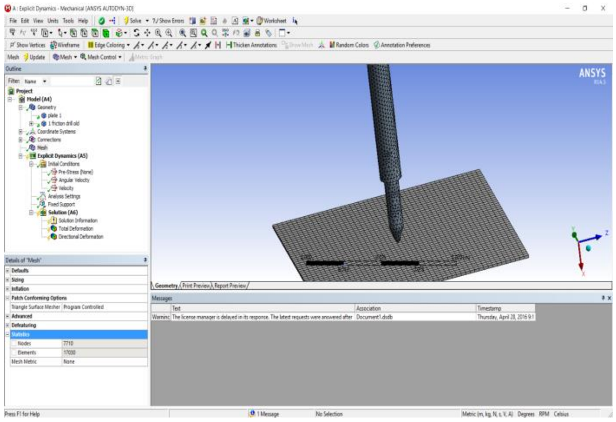

**Figure 7:** Meshing

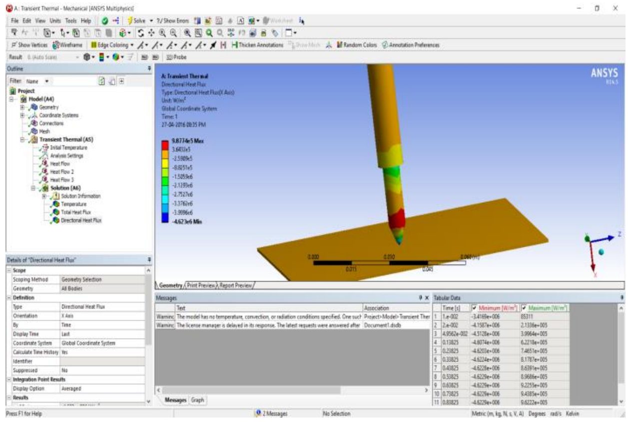

**Figure 10:** Directional heat flux

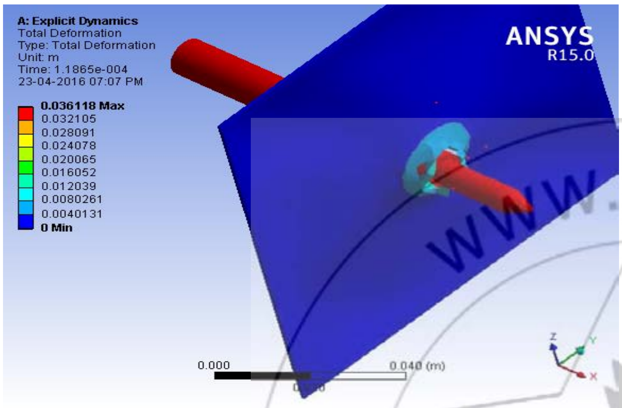


**Figure 8:** Total deformation

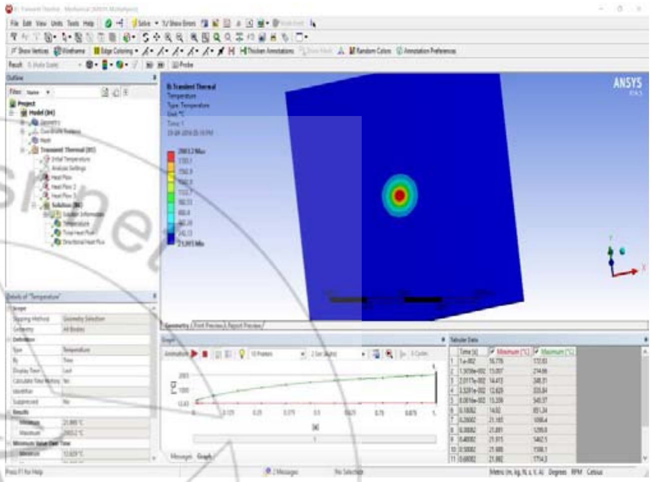

**Figure 11:** Temperature on work piece

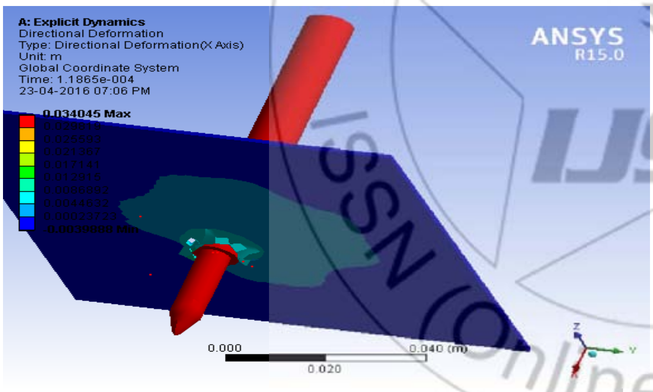


**Figure 9:** Directional Deformations

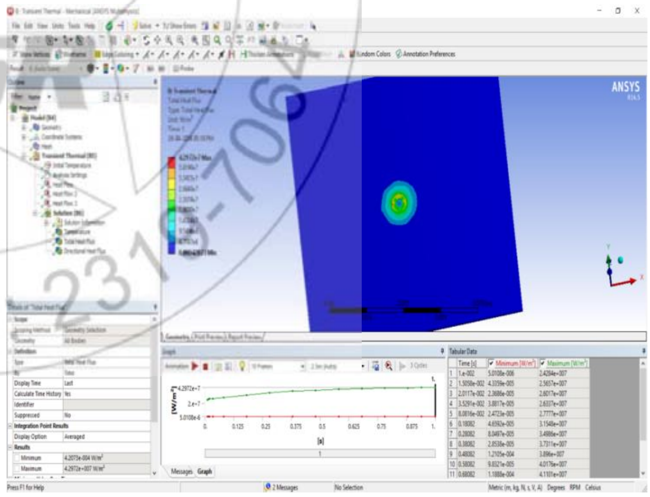

**Figure 12:** Total heat flux on work piece

## 7. Ansys Results

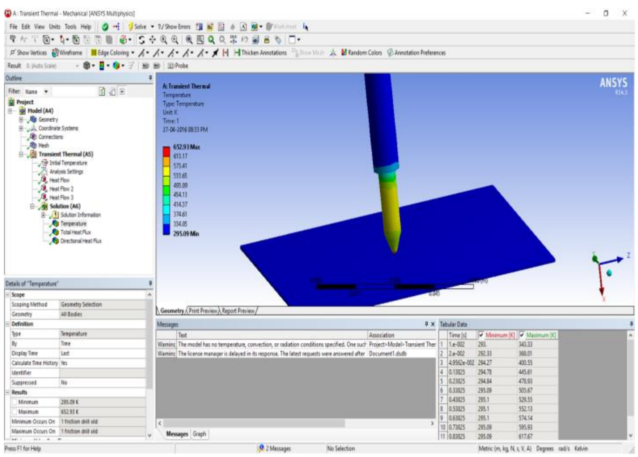

**Figure 9:** Temperature in tool

The influence of different machining parameters like spindle speed, feed, composition percentage and thickness of the work piece on roundness error have been analysed based on the developed mathematical model and discussed below.

**Influence of spindle speed on hole quality**

Hole quality and tapping quality which is minimal at and above 3000 rpm owing to the heat generated, which is sufficient for the penetration of the tool with less thrust force and torque. This trend indicates that; the increase of spindle speed increases the errors up to 3000 rpm and then reduces. 3000 rpm may be considered as a critical speed and after that the roundness error will reduce in friction drilling of Al alloy material. The reason being at higher speed, the matrix and particles are pushed out easily there by producing good roundness.

**Influence of tool feed on hole quality**
Hole quality and tapping quality is minimum at the middle range owing to the reduced contact time of the tool with the work piece and the associated heat generated is sufficient for the penetration of the tool with less thrust force and torque. Further increase of feed increases thrust force, associated vibrations and thereby increases the errors in hole quality and threads.

**Influence of work piece thickness on hole quality** Hole quality and tapping quality is minimum at and above 3 mm owing to the tool stability due to the presence of the newly drilled surface and heat retained by the plate for easy plastic deformation. The temperature of the work piece throughout the experiment is between 180°C and 320° C.

## 8. Experimentation

A sensitive bench drilling machine is used with max spindle speed of 1400 rpm, with max spindle power of 0.75kw/1HP is used for the friction drilling experimentThe workpiece is square shaped duralumin with the length of 10mm and thickness of 1.5mm. The chemical composition of AL alloy (6351)

Choose the perfect drill (diameter and length). Make sure your machine meets the tool requirements for speed and power. Assemble the tool holder correctly. Insert the Friction drill into the tool holder and tighten the nut very tightly Insert the tool holder in the machine spindle. Clamp your work piece securely. Make sure the distance between work piece and drill bit is limited. Set the correct spindle speed for the tool. Set the correct drilling depth. Perform the drilling operation in a constant downward motion (no dwelling).When depth is reached retract the tool as fast as possible. Observe cycle time, drill colour and threaded bushing shape Adjust when needed the speed and repeat the experiment with different thickness of material. Flow drilling with tapping this means that the drilling and tapping are all done in a single step. It is quite similar to that normal friction drilling, but the difference is that it doesn't changing the tool for further operations i.e., drilling and tapping is done in single step. The advantage of this tool is taking less time for producing the holes with threads, increasing production rate.

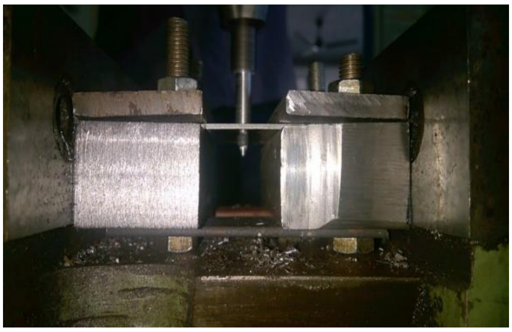

**Figure 12:** Trials with the tool

**Figure 12:** Cut section

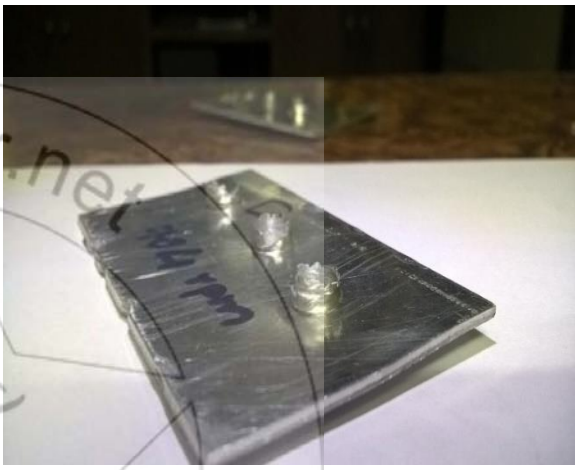

**Figure 12:** Bush

**Figure 12:** Bushing with M8

## 9. Results and Discussion

Friction drilling, friction drilling and tapping tool (Combined tool) has been manufactured and fabricated, trails are done on different thickness of work piece Extended tool life is observed in friction drilling process in comparison with conventional twist drilling process. Drilling and tapping is done in single step process results increase in production rate. Only concern of friction drilling is the higher thrust force, clamping force and elevated temperature that were within tolerable level in this experimentation. The increase in speed will increase the heat in work piece which do not improve the bushing Formation. Thrust force and torque increases gradually with increasing friction angle, feed rate and FCAR. Thrust force and torque decreases with increasing spindle speed. Increasing or decreasing the friction angle and FCAR has no significant effect on workpiece surface temperature. The FEM provided a more complex model for friction drilling. FEM meshing techniques enabled the large deformation of the workpiece. A constant coefficient of friction of 0.7 was most suitable for the model. Modelling and ansys work is done which results in temperature deformation, effective stress and effective strain.

## 10. Conclusion

The friction stir drill and tapping process is ideally suited for sheet metal fabrication and fastening of members. The tool designed facilitating combined drilling and tapping was successfully used for the Aluminium work pieces. Friction drilling and tapping tool (Combined tool) has been manufactured andfabricated, trails are done on different thickness of work piece Extended tool life is observed in friction drilling process in comparison with conventional twist drilling process. Drilling and tapping is done in single step process results increase in production rate. The application of this tool will be much appreciated in the manufacturing industries for fabrication of sheet metal work.

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