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# Development of software to calculate of friction process parameters used in friction drilling process

## Sürtünme delme sürecinde kullanılan sürtünme süreç parametrelerinin hesaplanması için yazılım geliştirilmesi

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*Öz*
Sıcak şekillendirme işlemlerinde sürtünme delme işlemleri sıklıkla kullanılmaktadır. Bu işlem delme işlemlerine benzer ancak talaşsızdır ve ince cidarlı metal bileşenlerin birleştirilmesi için kullanılır. Oluşturulan sürtünme ısısı malzemeyi plastikleştirir ve zımba türündeki takımın malzeme yüzeyine girmesini sağlar, böylece sürtünmeyle ek ısı oluşturur. Besleme aleti basıncı ile bir delik oluştururken malzeme yüzeyine ilerlemektedir. Sürtünme delme işlemi parametrelerinin tork ve eksenel güç, sürtünme delme işlemi için ısı transfer katsayısı olarak hesaplanması amacıyla analitik bir model ve yazılım geliştirilmiştir.
***Anahtar Kelimeler:*** *Sürtünme delme süreci, yazılım, ısı transferi katsayısı. Visual Basic 6.0*

*Abstract*
Friction drilling processes are used frequently in hot forming operations. This process is similar to drilling processes but it has not chips and used to join of thin-walled metal components. The created frictional heat plasticizes the material and allows the punch type tool to enter the material surface, thus creating additional heat by friction. By the feeding tool pressure, it is advancing into the material surface while creating a hole. An analytic model and software was developed to calculate the friction drilling process parameters as torque and axial power, heat transfer coefficient for friction drilling process in this study.
***Keywords:*** *Friction drilling process, software, heat transfer coefficient, Visual Basic 6.0*

## 1. Introduction

The friction drilling process is a hot forming process used for drilling holes of thin-walled metal components. This process is called as friction drilling process. The friction drilling process is similar to a conventional drilling process [1]. A cutting tool is used namely as centerdrill in this process and it rotates both its own axis and it is applied a pressure in axial direction. Mechanical power under this pressure is converted to heat energy. Thus, a forming process without chip is performed via heat energy. This method is used in many areas of industry such as automotive industries, metal furniture manufacturers, exercise equipment manufacturers, spa and fitness equipment manufacturers, machine tool manufacturers, cleaning system and washing machine and washing system manufacturers, solar energy system manufacturers and related industries, industrial lightening system and light fixture manufacturers, agricultural machine manufacturers, bicycle manufacturers and related industries, manufacturers making any type of tubular products or equipment, building industry, conveyor system manufacturers, lifting system manufacturers, fixturing system manufactures [1] These applications is seen in Figure 1.

Figure 1. Application examples done using friction drilling process [1].

There are not many studies in relation with friction stir welding (FSW) and friction drilling process in the literature. There are available experimental and FEA studies. A FSW study [2] is to investigate the process of friction stir welding (FSW) by using finite element method (FEM). Acoustic Emission (AE) method proposed in another paper as a novel approach was used to evaluate residual stress in friction stir welding (FSW) of 5086 aluminum plates using a FEM by [3]. In another paper, an attempt has been made to develop a thermo-mechanical finite element model to analyze the formation of drilled hole and bushing on the workpiece by [4]. Overy [5] and Bak [6] discussed the design aspect of the friction drilled holes. Kerkhofs et al. [7] studied the performance of coated friction drilling tools. Miller and Albert [8] demonstrated that the thermomechanical behavior of the workpiece and advantages of 3D FEM to study of work-material deformation in friction drilling. Miller et al [9] researched that the mechanical and thermal aspects of friction drilling process this time. Two models were developed for friction drilling. They are thermal finite element model and force model. Raju and Swamy [10] investigated the FEM of large plastic strain and high-temperature work-material deformation in friction drilling. Bilgin et al. [11] an analytic model is developed, which calculate the process parameters as torque and axial power, heat transfer coefficient. A comparison was also made for temperature, torque and axial force obtained from experimental and numerical analyses.

In literature, there are also available several developed software for calculate of the process parameters of manufacturing applications. Gok [12] a software and an analytic model were developed to calculate the required mechanical power and the friction coefficient at the tool-chip interface as well as heat transfer mechanisms and coefficients between cutting tool, work piece and environment for using in finite element (FE) simulations of the turning processes. Gok et al. [12] a software, analytic model and FEM that calculates these processes parameters have been developed for using in the sawbones drilling simulations using K-wire. Erdem et al. [13] an analytic model and software have been developed for calculating the screwing power, thrust power and the heat transfer coefficients in the bone screwing processes. There is not found any software developed for friction drilling process. In this study, software was developed for calculating the torque power, axial power and the heat transfer coefficients in the friction drilling processes.

## 2. Analytic of Friction Drilling Process

The torque occurs due to the rotation movement and axial force occurs due to the axial movement on the centerdrill during the friction drilling process. The torque creates the torque power given in Equation (1). $\omega$ in (Eq. 1) numbered power equation, expressed the angular velocity of the centerdrill. It can be defined as taken from the road per unit time of the centerdrill. For this, (2) numbered equation can be written. With unit conversions, the Equation (3) is acquired. If this expression written in (1) numbered Equation, (4) numbered Equation is acquired [11].

$$P_c = M_c \, . \, \omega \quad (1)$$

$$\omega = 2\pi \, . \, n \quad (2)$$

$$\omega = \frac{\pi \, . n}{30} \quad (3)$$

$$P_c = M_c \, . \frac{\pi \, . n}{30} \quad (4)$$

With conversion of units, Equation (5) is acquired. Thus it is converted into the unit of power (Watt).

$$P_c = \frac{M_c \, . \, n}{9.55} \quad (5)$$

Besides the torque power, there is also axial power occurs due to from the axial force and feed rate velocity through along the axial direction of the centerdrill given in Equation (6).

$$P_f = \frac{F_t \, . \, V_f}{60 \, . \, 1000} \quad (6)$$

Most of the torque power and axial power resulting because of the forces ($F_c$ *and* $F_t$ ) occurring on the centerdrill during friction drilling processes are converted into heat energy. By using Eq. (1) and Eq. (6), torque power and axial power occurred during friction drilling process are calculated. For the heat transfer mechanism occurred between centerdrill and the workpiece during friction drilling processes, a planar differential control volume (dv) in unit volume. If the conservation of energy, which is the 1st law of thermodynamics, is applied to this control volume, Equation (7) is developed [11].

$$E_{input} - E_{output} + E_{generated} - E_{convection} = \Delta U \quad (7)$$

In equation (9) the general equation of heat conduction is acquired by writing thermal expansion coefficient, $\alpha$, as in Equation (8) [14].

$$\alpha = \frac{k}{\rho . c_p} \quad (8)$$

$$\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right) + \frac{Q}{k} - \frac{h_t.(T - T_o)}{k} = \frac{1}{\alpha} . \frac{\partial T}{\partial t} \quad (9)$$

## 3. Development of Software

The heat mechanism produced during the friction drilling process has a rather complex structure. This structure can be made easier by some estimation. The heat produced during the friction drilling process is considered to be distributed by the transfer between centerdrill, environment and the workpiece. According to these conditions, an algorithm is developed, which calculates the mechanical energy (torque power+axial power) generated during the friction drilling process using centerdrill, heat transfer coefficient between centerdrill and environment, heat transfer coefficient between workpiece and environment, heat transfer coefficient between centerdrill and workpiece, by using Visual Basic 6.0 program as seen in Figure 2.

```
Private Sub CommandButton1_Click()
Dim Vc As Double
Dim z As Double
Dim d As Double
Dim Mc As Double
d = CDbl(TextBox1)
Vc = CDbl(TextBox3)
Mc = CDbl(TextBox4)
n = (1000 * Vc) / (3.14 * d)
Pc = (Mc * n) / 9.55
MsgBox "KESME GÜCÜ" & " " & Pc & "W"
End Sub
```

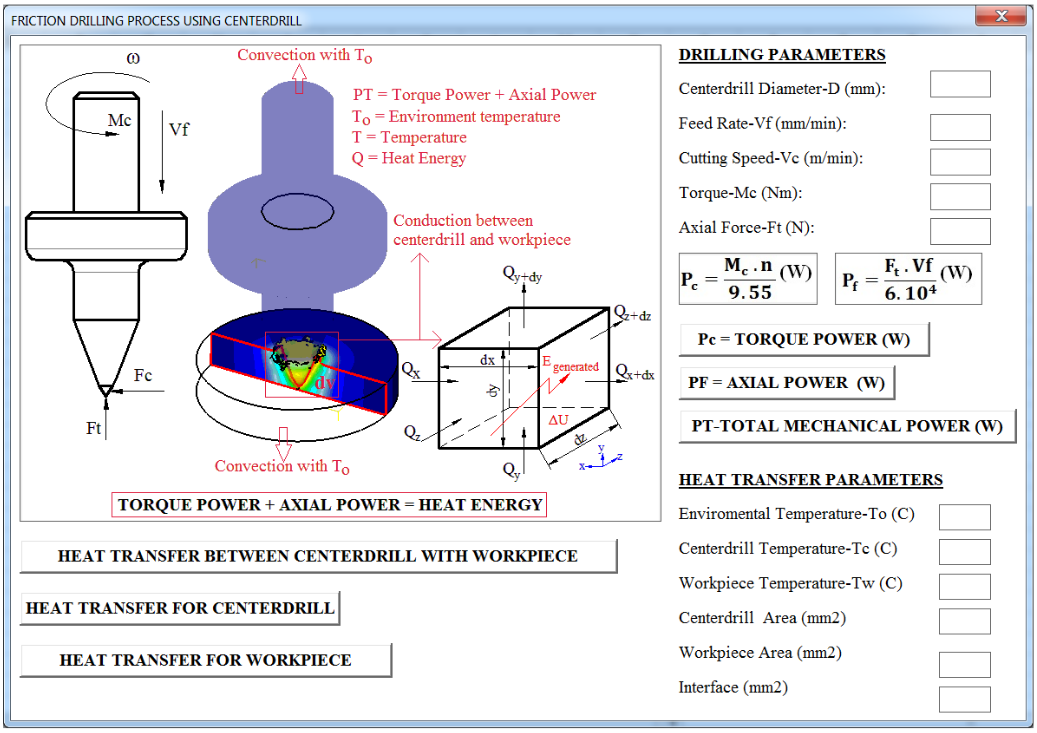


Figure 2. Interface of software

## 4. Results and Conclusion

An analytic model and software were also developed to calculate the friction process parameters such as torque power and axial power, heat transfer coefficients in order to determine the temperature distributions occurring in the centerdrill and workpiece material during friction drilling process. The friction drilling processes were carried out by using friction drilling process parameters in Table 1. The drilling depth is 2.7mm. It is also seen that the comparison for different material to support reliability of software in Table 2. The torque power was calculated as 3853.5 Watt, axial power was calculated as 22.53 Watt for AISI 1020 material. The torque power was calculated as 444.6 Watt, axial power was calculated as 24.64 Watt for AISI 1045 material. This software will be useful for friction drilling process.

Table 1 Centerdrill process parameters

| Centerdrill dia Ø (mm) | Cutting Speed (m/min) | Feed rate (mm/min) |
|---|---|---|
| M6 – Ø5.4 | 40 | 150 |

Table 2 The comparison for different material to support reliability of software

| Material | EXPERIMENTAL | | FEM | |
|---|---|---|---|---|
| | Torque (Nm) | Thrust Force (N) | Torque (Nm) | Thrust Force (N) |
| AISI 1020 | 15,6 | 9012 | 14,48 | 9264 |
| AISI 1045 | 18 | 9856 | 17,67 | 1027 |

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