

# Research on the friction plate groove structure of wet friction clutch

Dongyue Qu<sup>1, a</sup>, Chunhua Zhao<sup>1, b</sup>, Xiuming Li<sup>1</sup> and Chunyu Zhang<sup>1</sup>

<sup>1</sup>School of Harbin engineering University, Harbin 150000, China

<sup>a</sup>qudongyue@hrbeu.edu.cn, <sup>b</sup>zhaochunhua@hrbeu.edu.cn

**Keywords:** Clutch, Friction plate, Flow field, Temperature field, Numerical modeling.

**Abstract:** Wet friction clutch is widely applied in shipping, heavy truck and other heavy machinery because of it has many advantages that smooth start reversing, big transmission torque, wear small, long life etc. It will improve the friction plate service life of car. Besides, there are many characteristics that the twist, heat dissipation, drag torque, and thermal are affected by the groove structure form of wet friction clutch. This paper establishes the finite element model of wet friction clutch which has different forms of double circular arc and waffle groove. Moreover, we analyses the flow field and temperature field of the two different friction plate that mentioned above. Finally, the research can provide reference to the man who wants to study on the structure design, optimization, and application of friction plate.

## 1. Introduction

Because of the overheating of clutch, the wet friction clutch usually have the problem of thermal failure when it works. Depending on the research, we can find two main reasons that relative friction and heavily drag contribute to the phenomenon. In the touch processing of wet friction clutch, friction plate generates friction heat between the friction disc rub and the steel disk. Based on the reason what we have said, friction pair will generate some forms of failure like warp, burning, surface stripping of material and surface heat crack when the heat accumulate. Moreover, there are a certain amounts of oil tank at the surface of friction plate which not only can improve surface friction coefficient of the friction plate and accelerate the friction debris to be discharged, but also improve the effect of friction pair for cooling heat dissipation. As we all know that different form of groove have different effect for controlling the temperature of friction plate. There are many forms friction plate such as Spiral line with radial oil tank, ring line with radial oil tank, waffle groove, single circular arc groove, double circular arc groove, but waffle groove and double circular arc groove can ensure enough oil through the tank and generate eddy in the intersection of oil tank which can improve the cooling performance of friction plate. So we regard the two forms of friction plate as the research object. Two kinds of groove form are shown in figure 1.

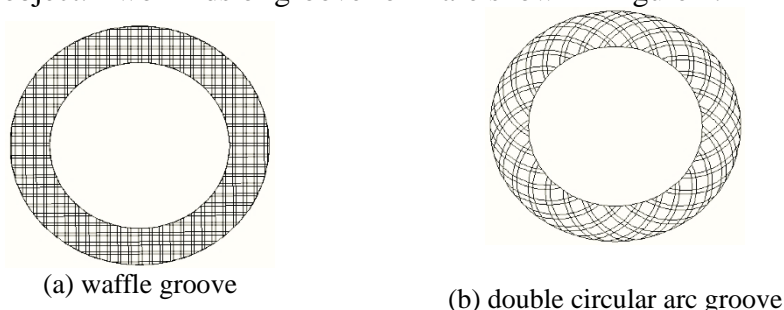


Figure1 finite element model

## 2. The analysis theory of Wet friction clutch

### 2.1 The analysis theory of flow field.

As we all know that different forms of oil tank have different influence to temperature of friction plate, the reason is that complex structure of oil tank make the flow condition more complex and flow has different convective heat transfer coefficient with different flow velocity of oil which will

affect result of the heat dissipation. From what we have said, we use the software of Fluent to simulate the flow field of two forms friction plate. This paper applies three layers of fluid domain which we regard the middle one as the rotary region and the two other region as the stationary domain. Besides we establish the two forms finite element model of friction plate and apply hexahedral element to mesh the model which we refine the grid in the region where oil tank crossover each other. Moreover, we set the turbulence model with the RNG k- $\epsilon$  and the rotary velocity value is 600 rpm in rotary region. The oil inlet is the internal profile and outlet pressure value is zero at the lateral profile. After inputting the density and viscosity of flow, we can calculate the result [1,2].

## 2.2 The theory of transient temperature field.

The oil slick among the friction pair is compressed by the slave ram which will join the prime motor with the driven shaft when the wet friction clutch is working. In the process of join, the form of friction becomes dry friction from fluid friction which will generate quantity of heat that can cause failure of friction plate when the heat accumulated together. So we use the finite software of ANSYS to analyze the temperature field. To facilitate the calculation, we assume that generated heat is completely absorbed and ignore the influence of thermal radiation. Besides we regard the heat flux as the friction heat in the process of analysis and the formulation of heat flux shown in formula 1.

$$q(r,t) = \begin{cases} (-0.24t^4 + 1.3t^3 - 2t^2 + 1.6t - 0.037) \cdot 0.09 \\ \cdot r \cdot 2\pi \cdot \frac{600}{60} \cdot (1 - \frac{t}{2.5}) \cdot 10^6, & 0 < t < 2.5 \\ 0 & t > 2.5 \end{cases} \quad (1)$$

Where  $q$  represents the heat flux,  $r$  represents radius of friction plate,  $t$  represents time. From the formula, we can know that the value of heat flux changed with the  $r$  and  $t$ . Besides we should pay more attention to the parameter of  $r$  which we should apply cylindrical coordinate system when define the function of heat flux. Only in this way can we simulate the working processes of plate accurately. Because of the difference physical property of friction plate and dual disc, the heat distributed to the friction plate and dual disc are different which submit to some relationship shown in formula 2.

$$K_q = \frac{\sqrt{k_m \rho_m c_m}}{\sqrt{k_d \rho_d c_d}} \quad (2)$$

Where  $K_m$ ,  $K_d$  represents the coefficient of heat conduction of friction plate and dual disc respectively.  $\rho_m$ ,  $\rho_d$  represents the density,  $C_m$ ,  $C_d$  represents the specific heat. According to practical work situation, we apply the heat flux at the outside surface and apply the convective heat transfer coefficient at the surface of oil tank [3,4].

## 3. The Wet friction clutch result of calculation and explain.

### 3.1 The result of flow field and explanation.

The flow condition and velocity of flow play an important role in heat convection. This paper analyzes the characteristic of flow. The velocity vector graph of flow are shown in figure 2

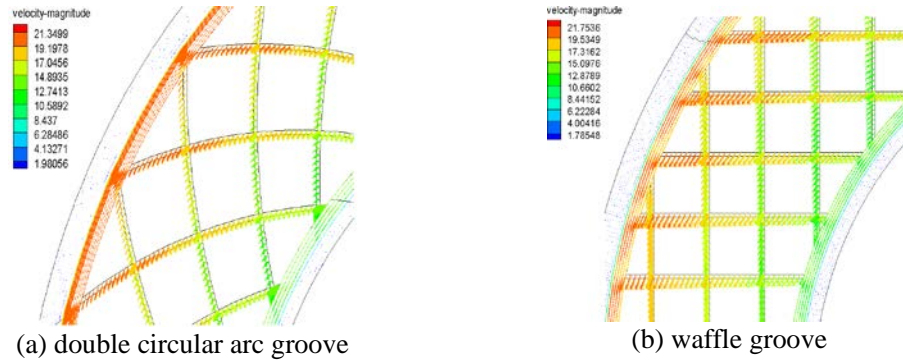


Figure 2 vector graph of flow

As shown in figure 2, corresponding to the two forms of flow groove, we can know that the maximum velocity value of flow is 21.3499m/s, 21.7536m/s respectively. Besides, the velocity value of oil increase along with the radius increases. The velocity of oil in which locates in tank that the angle between entrance direction and flow direction of rotation is acute angle is greater than the oil that obtuse angle. From that, we can see the red region like the figure show. Moreover, there will appear obviously the phenomenon of disturbed flow and collision in oil tank's intersections, its speed is smaller than other location.

### 3.2 The result of temperature field and explanation.

The temperature field cloud picture of highest temperature is shown in figure 3.

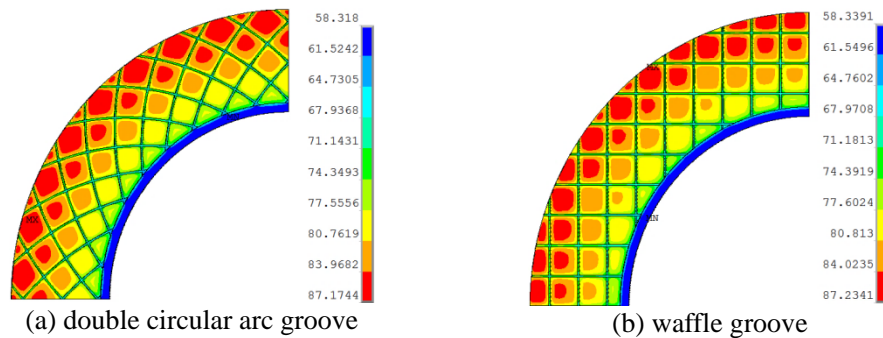


Figure 3 temperature field cloud picture

From the result picture we can see that the temperature increase along with the increase of radius, the highest temperature value of waffle groove is 87.2341°C at 1.815s and the highest temperature value of double circular arc groove is 87.1744°C at 1.8015s. For researching the heat dispersion characteristics of friction plate, we set the monitoring points in friction plate upper surface and surface of groove as shown in figure 4.

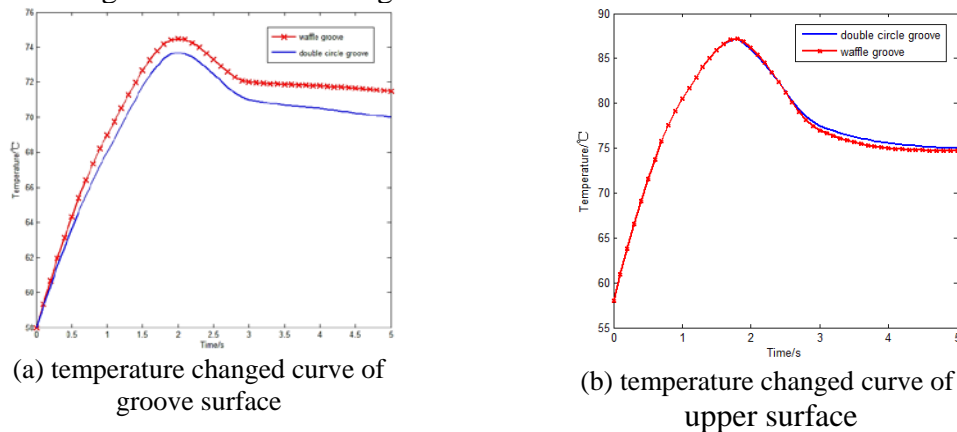


Figure 4 changed curve of monitoring points along with the time

From the figure 4, we can know that the temperature of friction plate increase firstly and then decrease. The reason of it is that plate generate amount of heat in the initial joint, but then the heat decrease when the relative velocity decrease between friction plate and dual disc. After 3 second,

the process of joint is ending and the heat will not generate and the heat is taken away by the oil. Compare figure (a) and figure (b), the surface of oil tank can't apply heat flux which cause the maximum temperature is little than the temperature at surface of friction plate but the change tendency is same. Besides Due to the complexity of double circular arc groove and waffle groove structure, shorter flow channel, fluid will generate collide and countercurrent in the area of oil tank's intersections and low utilization rate of oil, which will lead to lubricating oil at low temperature, cooling degree is weak.

#### **4. Conclusions**

This paper analyses the flow field and temperature field of friction plate. From that, we can get some conclusions are shown as follow:

(1) The flow field changed tendency of two forms friction plate is same. The velocity of oil in which locates in tank that the angle between entrance direction and flow direction of rotation is acute angle is greater than the oil that obtuse angle.

(2) The temperature field changed tendency of two forms friction plate is same. Besides the temperature at the surface of oil tank is smaller than temperature at outside surface of friction plate. The oil tank length of the two forms is short which cause the low efficiency of oil, but the waffle groove is suitable to production and low cost.

#### **5. References**

- [1] Lin T J, Pan L, Zhang S J. Fluid Dynamic Analysis and Experimental Study on Wet Friction Clutch . *Applied Mechanics and Materials*, 2011, 86: 792-796
- [2] H.S. Lv, T.j. Lin and S.J. Zhang. 3-D Flow Analysis of Oil Channel in Wet Multi- disc Friction Clutch.
- [3] L. Afferrante, M. Ciavarellab, P. Decuzzia etc. Transient analysis of frictionally excited thermoelastic instability in multi-disk clutches and brakes. *Wear*, 2003, 254: 136 – 146
- [4] Xie F W, Hou Y F. Transient temperature field of a friction pair in a HVD device of a belt conveyor. *Mining Science and Technology(China)*, 2010, 20(6): 904-907