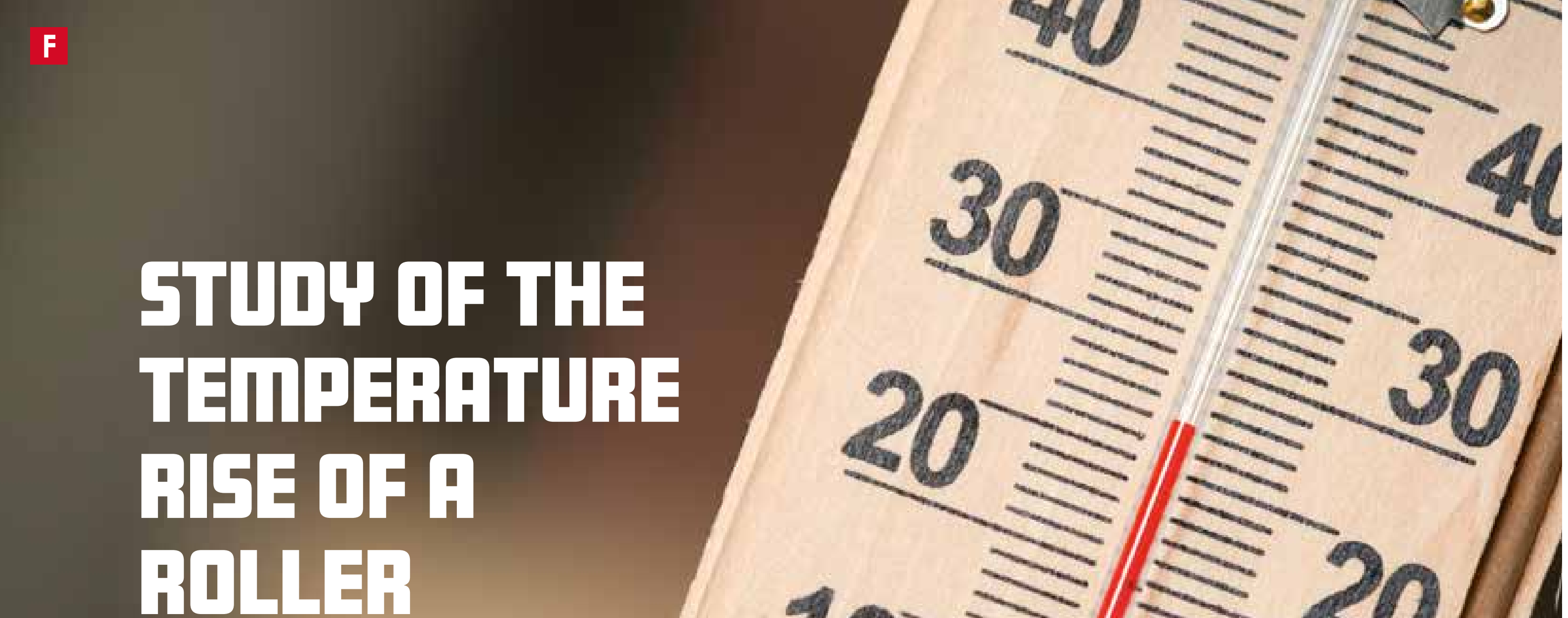

STUDY OF THE TEMPERATURE RISE OF A ROLLER MILL

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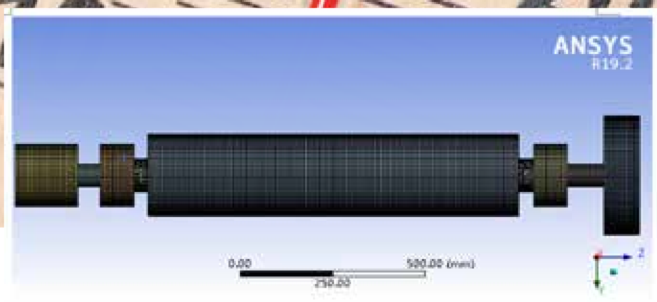

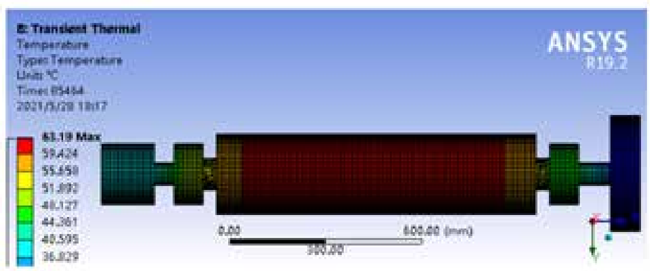

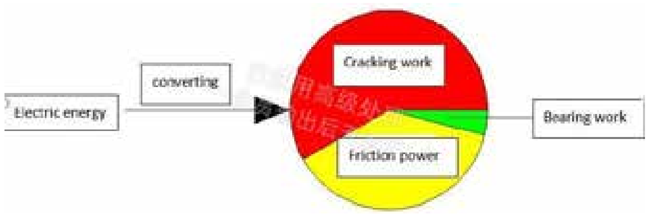

China is a big country, and in terms of wheat production and consumption, and its flour output ranks the country first in all of the world. After hundreds of years of evolution, the most used piece of flour processing equipment is the roller mill.

At present, domestic wheat processing technology has been quite mature, with flour market demand close to saturation.

In order to further develop and improve flour quality, enterprises will need to consider reducing the cost of flour production, reducing electricity consumption and reducing the temperature of grinding roller.

When the roller mill produces flour, the temperature of the roller surface of the core mill will reach 60 - 80°C. The higher the temperature of the roller surface is, the lower the utilisation rate of electric energy will be, and the more serious the waste of electric energy will be.

In addition, the flour temperature is more than 50°C, flour internal broken starch rate will exceed the average level, and reduce the use value of flour, and the temperature is too high will make flour protein denaturation, the destruction of flour nutrients.

At the same time, high temperature will accelerate the wear of the roller, affect the precision of the roller, and then affect the roller life. This is because flour contains moisture, so high temperature will also lead to flour batter on the roller surface, affecting the flour processing process.

With the aim of solving the above problems, this paper studied the roller temperature rise of roller mill, determined the heat source, established the mathematical model of grinding power and transformation of wheat in the process of flour processing. We then carried out a specific simulation analysis.

Heat source analysis & electric energy conversion

When the crushed material passes through the crushing zone, it is crushed by the extrusion, shear and grinding action of the two grinding rollers. The internal changes of particles during material crushing are roughly described as follows.

External load effect makes the particle deformation, particle inside the particle will resist the deformation, thus building a space stress field within the particles, the stress field in the accumulation of strain energy as the load increases, internal material inhomogeneity of the structure of particles, such as impurities, dislocation, cracks and other defects, which can all lead to stress concentration.

When the local stress exceeds material strength, the particles begin to 'fail' and break up. The grinding heat of roller mill is mostly converted from the electric energy consumed in the working process of the mill.

Through research and analysis, mill roller heat source comes from three aspects: one is because of the heat released by the grinding wheat, namely after the wheat into the compression zone, as the roller run, wheat material layer thickness is more and more thin, wheat grinding roller pressure is more and more big, until the wheat shattered, releasing heat in the process of wheat for crushing.

The other is the heat produced by friction of wheat. When the wheat is crushed, the wheat is squeezed by the roller, and friction is generated between the roller and wheat and between wheat and wheat.

The work done by this friction on wheat is converted by electric energy. Third, in the normal rotation process of the roller, the electrical energy consumed by the friction of the bearing and the electrical energy consumed by the friction between the two ends of the roller are converted.

The heat source of grinding roller is analysed, and it is concluded that the heat source of grinding roller is wheat heat generated by grinding, heat generated by friction, and heat generated by friction of bearing and roller. Two ends of the belt wheel friction heat three parts. Among them, the former two are relatively large.

$$P_1 = \frac{R^2 LE(\pi - 2\theta_0)(v_1 + v_2)}{2\cos(\theta_0)\left[2R + e - 2R\sin(\theta_0)\right]}\left[\frac{1}{2}\cos(2\theta_0) + 2\sin^2(\theta_0) + \frac{1}{2} - 2\sin(\theta_0)\right]$$

P1 - Grinding power of roller on wheat

According to Equation 1, it can be seen that the grinding power of roller on wheat is affected by roller speed, roller length, roller radius, rolling gap, rolling angle and average elastic modulus.

When other parameters remain unchanged, the grinding power of roller on wheat decreases with the decrease of roller speed, roller length, increase in rolling gap, average elastic modulus and roller radius.

Friction heat generation power between roller & wheat feed layer

According to the classical formula for heat of friction:

$$Q = \mu N \Delta S$$

The sum of frictional heat generating power (unit, W) between the roller surface and the wheat feed layer is found in Equation 2.

The ratio of heat generating power of friction between roller surface and wheat is equal to the ratio of equivalent friction coefficient.

$$q = q_1 + q_2 = \frac{R(\mu_1 + \mu_2)(v_1 - v_2)}{2R + e - 2R\sin(\theta_0)}\int_{\theta_0}^{\theta_a}\left[1 - \frac{\sin(\theta_0)}{\sin(\theta)}\right]E(\theta)LR\,d\theta$$

$$\frac{q_1}{q_2} = \frac{\mu_1}{\mu_2}$$

q1---Friction heat generating power of fast roller wheat layer

U1--Equivalent friction coefficient of fast roll

q2---Friction heat generating power of slow roll wheat layer

Simulated analysis of roll

Through ANSYS19.2 simulation analysis, the temperature rise values of different parts of the roller are obtained. The steady-state temperature of the roller surface is, which is not much different from the actual temperature, and the simulation results show that the temperature rise heat of the 1M1 fast roller of the roller mill almost comes from the friction heating between the fast roller and wheat.

Based on the above mathematical models of wheat grinding power and wheat friction heat generation power, three temperature control measures were proposed: (1) reducing the radius of the roller mill; (2) Reduce the equivalent friction coefficient between the mill roller and wheat appropriately; (3) Decrease the average elastic modulus of wheat.