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THE SURFACE TEMPERATURE IN SLIDING CONTACTS OF GEAR WORKING FLANKS
PART 2 – SURFACE TEMPERATURE IN ACTIVE FLANKS

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Abstract. The paper considers the analytical solution for the surface temperature in active flank. The surface temperature of sliding contact gear and the maximum temperature distribution in active flank was found.

1. INTRODUCTION

The steps followed for solving the equations and the results reveal the fact that must be detailed the concrete mode of variation of contact pressure, sliding velocity between flanks, loading time and lubrication regime. The dimensions of the line contact between involute flanks and the contact pressure distribution can be calculated considering the results obtained by McCool [2]. The relative velocity between active flanks can be found from literature, [1] or specific works, [4]. Data upon lubricant film thickness and lubricating regime from contact between flanks can be obtained by applying the relations obtained by Hamrock and Dowson, [3] for the particular case of line contact
Finally, the paper aims to find the maximum temperature from contact between flanks and the temperature variation during tooth gearing.

2. LOADING INTERVAL AND MAXMUM TEMPERATURE FROM CONTACT

A general case of gears with convex flank teeth is considered. The initial contact is a Hertzian point type one. The ellipse of contact presents a lengthened shape, tending to attain the line contact. The loading interval or time, denoted by t, can be expressed as a function of contact ellipse contour geometry and of mean rolling velocity of the flanks:

$$t = \frac{d}{v_m}, \tag{1}$$

The distance d crossed through contact is shown in Figure 1. The variation range of this independent variable is between 0 and $2y_0$. The contour of the contact ellipse is represented by y_0, given by the relation:

$$y_0 \in b\sqrt{1 - \frac{x^2}{a^2}}. \tag{2}$$

where a and b are the contact ellipse half-axis.
The dimensionless variables X, Y_0 and D can be introduced; they are given by the following relations:

$$X = \frac{x}{a}, \quad Y_0 = \frac{y_0}{b}, \quad D = \frac{d}{b}, \quad Y = \frac{y}{b} \tag{3}$$

where D varies between 0 and $2Y_0$ and Y varies between $-Y_0$ and Y_0.

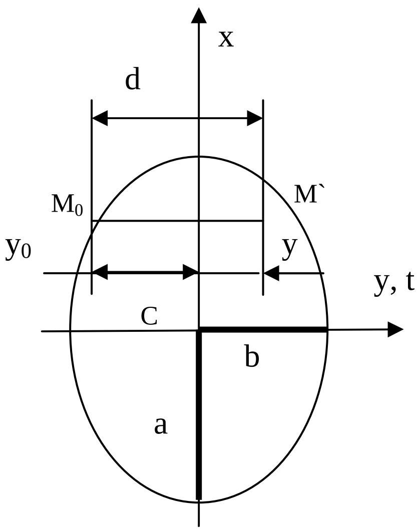

Fig.1 Scheme of coordinate system the contact interface

It is obvious that in the case of Hertzian line contact, the dimensionless distance D varies in the range ∓1. Considering this domain, the Hertzian contact pressure and the absolute surfaces temperature can be fount using the following relations:

$$p = p_0\sqrt{1-U^2}$$

$$\frac{T_S}{T_0} = 1 + \frac{\mu p_0 \Delta v}{T_0}\sqrt{\frac{b}{\pi c_s \rho_s k_s v_m}}\int_{-1}^{Y}\sqrt{\frac{1-U^2}{Y-U}}\,dU \tag{4}$$

where p_0 is the maximum pressure and T_0 represents the environment temperature.

The shape of dimensionless temperature plot on the width of contact strip is presented in Figure 2. After some computation and from the graphical plot one can observe that the maximum dimensionless temperature is reached towards the contact exit, at co-ordinate Y=0,652 and has the value 2,188. Therefore, the maximum temperature is:

$$\frac{T_S}{T_0} = 1 + 2.188\frac{\mu\, p_0\, \Delta v}{T_0}\sqrt{\frac{b}{\pi\, c_s \rho_s k_s v_m}} \tag{5}$$

The variation of the maximum temperature during active gearing between two working flanks will be analysed subsequently.

3. SURFACE TEMPERATURE OF WORKING FLANKS GEAR

Figure 3 presents the scheme of chosen co-ordinate system and calculus of flanks temperature variation.

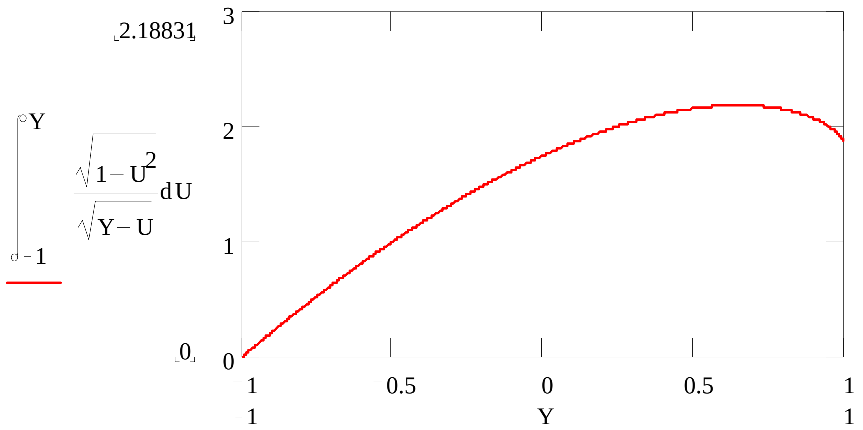

Fig. 2. Dimensionless temperature

The sliding coefficient between flanks is defined using the relation:

$$\xi = \frac{\Delta v}{v_m} = \frac{v_1 - v_2}{v_m} = \frac{\omega_1 \rho_1 - \omega_2 \rho_2}{v_m} = \Delta\rho \frac{\omega_1 + \omega_2}{v_m} \quad (6)$$

where v_m denotes the average velocity, described by the relation:

$$v_m = \omega_1 \rho_{10} = \omega_2 \rho_{20} \quad 7$$

The theoretical premise regarding the sliding coefficient is that it varies between the limits: $-\frac{1+i}{i} \le \xi \le 1+i$, where i is the gear ratio.

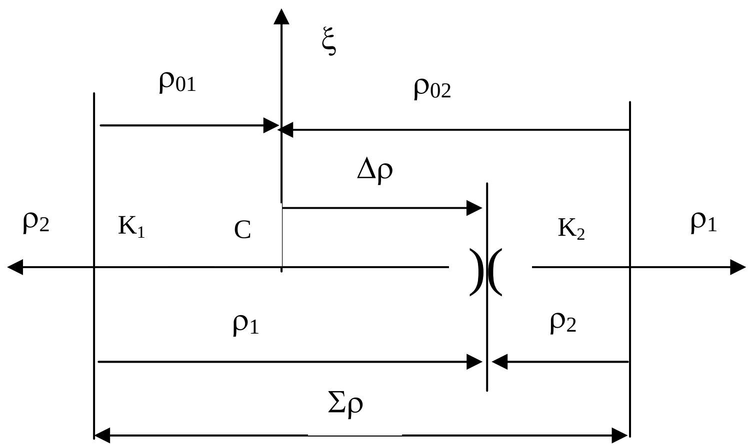

Fig. 3. Scheme of co-ordinate system of contacting flanks

The temperature of the surfaces of the flanks takes the final form:

$$\frac{T_S}{T_0} = 1 + 2.188 \frac{\mu\, p_0 \, |\xi|}{T_0} \sqrt{\frac{b\, v_m}{\pi\, c_s \rho_s k_s}} \tag{8}$$

The plot of temperature variation on the surface of the flank for a sliding coefficient with values in the range +0,5 and 1 has the shape presented in Figure 4.

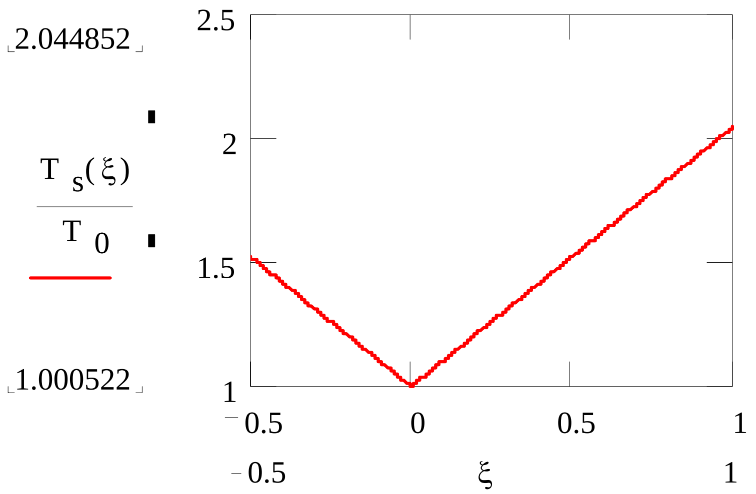

Fig. 4 Flank temperature

3. CONCLUSIONS

From the plot shown in Figure 4, it is seen that the temperature increases appreciably towards the regions near to the entrance and the exit of the contact. The calculus was made considering a traction coefficient closed to dry friction. The lubrication regime was not evidenced in the paper.

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