RESEARCHES ON HEAT PROPAGATION IN THIN EXTERNALLY - HEATED DISKS AND RECORDING OF ITS EFFECTS

RADU N. Gheorghe, COMANESCU S. Ioana

Transilvania University of Brasov

rngh@unitbv.ro; ioanacom@unitbv.ro

Abstract: The present paper presents the theoretical and experimental method for determination the deformations and the loss of stability of the disk stressed by an axial symmetric termic field, variable according to disk radius and thickness, superposed with a field of membrane tensions given by the rotational motion. The experimental results confirm the theoretical hypothesis.

Key words: disks,. thermal field, stress, membrane tension, stability..

1. INTRODUCTION AND THE DISTRIBUTION OF TEMPERATURE

The present paper shows how to determine the “size” of deformations, how the disks come to losing their stability, and how to determine the law of heat propagation on the disk radius. Disk stress is given by an axial-symmetrical termic field, variable according to disk radius thickness, on which the field of membrane tensions, given by the rotational motion of the disk, is superposed. Loss of elastic stability takes place after a loading-deformation curve which, in its first part, has a stable equilibrium (with a behavior almost allied to the linear one) up to the critical point (cross point), then it passes into the secondary curve of equilibrium.

The disk cannot be perfectly plane; it always has small geometrical flaws. In this situation, the field of membrane tensions produces displacements w perpendicular to the median surface of the disk, even if the field level is below the stability loss value. This dependence is not linear. According to the nature and size of inhomogenies, loss of stability may take place by "axial-symmetrical modes" (with nodal circles) or "axial-unsymmetrical modes" (with nodal diameters). Generally one can assume that the two (membrane and bending) loadings are independent and can be studied separately. If the plate is thin, the membrane tensions exert a strong influence on flexures; this influence is also notable on natural frequencies and buckling tensions. Theoretically the study has been carried out with von Karman's equations which represent a dynamic version of the non-liniar theory of plates. The study has been done by using the finite differences method employing the central finite differences. Von Karaman's equations describe the behaviour of thin plates liable to membrane stress, bending stress as well as to the reciprocal influences of the two type of stress (calculus of order 2).

The disk rotational motion, heated on their out contour have been studied. Since the distribution of temperature on the disk radius depends on many factors, both the equation of "heat propagation"

$$\frac{\partial\theta}{\partial t} = \frac{\partial}{\partial x}\left(m\frac{\partial\theta}{\partial x}\right) \tag{1}$$

and the experimental measurements have been employed. The above equation has been studied in "finite differences" like von Karman's equations.

For solving, the explicit method is used. Notation $\lambda=\Delta t/(\Delta x)^2$ is made and the system of equations takes the form:

$$\begin{cases} \theta_{i,j+1} = \lambda(\alpha\theta_{i,j} + \beta)(\theta_{i-1,j} - 2\theta_{i,j} + \theta_{i+1,j}) + \theta_{i,j}; \\ \theta_{i,j} = \theta_0, pentru\, j = \overline{1,N}; \\ \theta_{M,j} = \theta_1; \\ \theta_{i,1} = \dfrac{\theta_1 - \theta_2}{l} x_i + \theta_0, pentru\, i = \overline{1,M}. \end{cases} \tag{2}$$

The system given by (2) is non-linear and for solving it a calculation program has been compiled. For the generality of the problem, "formula functions" have been used in the program so that the limit and initial conditions can be arbitrary. Theoretical distributions in the nature of those shown in fig. 1,a have been obtained. From the technical literature it was used the law

$$T = T_0 (\frac{r}{b})^{\gamma}, \, unde \; T_0 = \frac{\Delta T}{1-(\frac{a}{b})^{\gamma}} \tag{3}$$

By comparing the theoretical results with the experimental ones (the four situations shown above)m it has been found that the temperature variation on the radius varies after the law of grade 2:

$$T(r) = T_1 + (T_2 - T_1)\left[\frac{r-r_1}{r_2-r_1}(1-c) + (\frac{r-r_1}{r_2-r_1})^2 c\right] \tag{4}$$

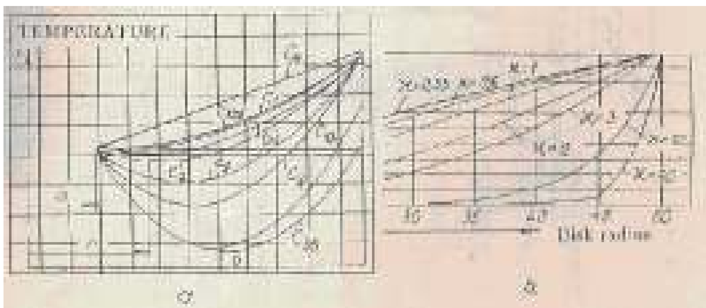

Figure. 1. Temperature variation on disk radius

on which basis the curves shown in fig. 2,a have been plotted; T_1 and T_2 stand for the temperatures on the two contours of the disk, and c is a coefficient. For c=0, a linear distribution of temperature is obtained. From the experimental records, it has been found that c=-0,65…+0,6.

For the same disk at different rotational speeds, different values for c have been obtained.

The experimental plant provides the possibility to envince the way in which loss of disk stability takes place (by nodal diameters or nodal circles), both qualitatively by observation and stroboscopic shooting, and quantitatively by measurements taken with displacement transducers. From the experimental measurements, a very important conclusions has been drawn : if the field of membrane tensions is constant during the bending stress, the dependence between the bending loading and the displacement measured perpendicularly to the plate w, is liniar. This is, in fact, a "theoretical hypothesis" commonly used in calculi and proofs in the case that the "buckling level" of the membrane tension field is not exceeded.

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