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STUDY ON THE DYNAMIC COMPRERSSOR CHARACTERISTICS TRANSFORMATION AT THE ASPIRATION PARAMETERS AND ROTATION MODIFICATION

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Abstract: *The fresh calculation of the centrifugal-type compressor characteristics at the aspirations parameters and rotations modification has a significant importance in practice, because the tests of compressors generate high energetic consumptions. The solution of the problem is based on replacement of the velocity triangles similitude condition (practically impossible to achieve during all the stages of the compressor), on condition that maintaining the velocity triangles similitude before the working blade from the "average stage". This approximately allows the condition of maintaining the velocity triangles analogy "the average on the compressor" to be considered as fulfilled.*

Key words*: the centrifugal-type compressor characteristics, fresh calculation of characteristics, number of rotations modification.*

1. Introduction

The gas and steam turbines would permit simple and cost-effective modification of revolution (without a big decrease in their yield), however the synchronic engines used to drive the centrifugal compressor do not permit the modification of this parameter.

The need of characteristics reassessment appears in two cases:

a.) after the manufacturing of the compressor with working gases, there must take place the tests, in the scope of establishment of the concordance between the theoretical parameters and the real ones. If at the manufacturing site the necessary gas does not exist, the tests are accomplished by the use of air. In this case it must be resolved the following problem: which working parameters and compressor's revolution must be used in the case of air fuelling, to assure the theoretic parameters in the case of gas fuelling

b.) the compressor bound for functioning with air will be used later with gas. In this case having the characteristics determined for the air compressor, it will be determined the characteristics for the gas compressor

In the case of replacement of the working fluid with another one the gas constant is changing, the Reynolds parameter, Mach parameter and the adiabatic parameter are also changing.

Thus in the case of n_0 rotations number, the running point of the compressor is in point A(fig. 1) which is the crossing point of the compressor's characteristic with network characteristic I. With the modification of rotations number n, the network characteristic II will change so that the point of running moves to point B, chosen from the condition of speed triangle analogy preservation before the "medium threshold" of the compressor.

With the help of the continuity equation it can be observed that in the case of modifications in the rotations number, but maintaining the analogy of speeds in the medium threshold, the modifications in the working regions of the first and last thresholds are taking place in opposing directions.

Thus, for example the decrease in the rotation number, the angle of incident of the first pallets is increasing, and for the last pallets is decreasing. Correspondent to this, the mechanic labor of the first thresholds is rising, and the mechanic labor of the last steps is decreasing (compared to the mechanic labor of the medium threshold). Thus, with approximation it can be considered that the deformation of the speeds triangle for the first and last threshold compensates reciprocally and the recalculations of the characteristic is done in the same way as in the case of speeds resemblance.

2. Results

The condition of preservation of the speeds triangle resemblance is :

$$\frac{\dot{V}_m}{\dot{V}_{m0}} = \frac{n}{n_0} \qquad (1)$$

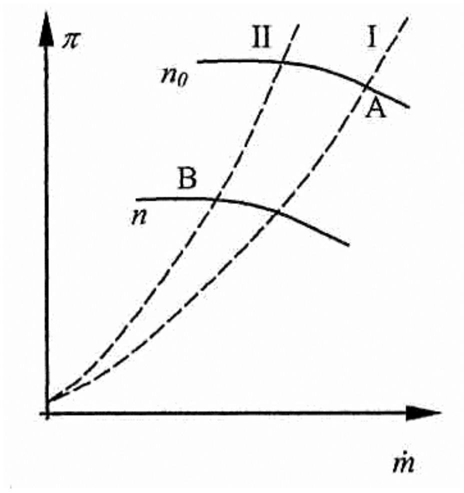

Fig. 1. Diagram π - $\dot{m}$

$$\frac{\dot{m}}{\dot{m}_0} = \frac{n}{n_0} \cdot \frac{\rho_m}{\rho_{m0}} \qquad (2)$$

The m index is referring to the parameters of the air before entering in the medium threshold. The notion of medium threshold it was introduced only for the simplification of the problem's solution understanding. More correctly it is to be taking about the medium section thus for the volumetric flow of air to be:

$$\dot{V}_m^{'} = \frac{\dot{V}_1 + \dot{V}_z}{2} \qquad (3)$$

or

$$\dot{V}_m = \sqrt{\dot{V}_1 + \dot{V}_z} \qquad (4)$$

Where $\dot{V}_1$ and $\dot{V}_z$ are the volumetric flows in the sections of threshold *1* and respectively of the last threshold *z*.

For the medium section we can say{*3*}:

$$\dot{V}_m = \sqrt{\dot{V}_1 \cdot \dot{V}_z} \quad \text{and} \quad \pi_m \cong \sqrt{\pi} \qquad (5)$$

The last equation with the polytropic equation and defined state allows us to say :

$$p = T^{\frac{k-1}{k} \cdot \eta_p} \quad \text{and} \quad p = \rho \cdot R \cdot T \qquad (6)$$

Thus the ratio of densities becomes:

$$\frac{\rho_m}{\rho_{m_0}} = \frac{p_m}{p_{m_0}} \cdot \frac{T_{m_0}}{T_m} = \frac{p_1}{p_{1,0}} \cdot \frac{T_{1,0}}{T_1} \cdot \left(\frac{\pi_m}{\pi_{m,0}} \right)^{1 - \frac{k-1}{k \cdot \eta_p}} \qquad (7)$$

or

$$\frac{\rho_m}{\rho_{m_0}} = \frac{p_1}{p_{1,0}} \cdot \frac{T_{1,0}}{T_1} \cdot \left(\frac{\pi}{\pi_0} \right)^{\frac{1}{2} \cdot \left(1 - \frac{k-1}{k \cdot \eta_p} \right)} \qquad (8)$$

The above equation formulates the condition of preservation of speeds triangle resemblance in the medium section. It is understood that in the case of small degrees of compression we obtain as in the case of fans{*1*}:

$$\frac{\dot{m}}{\dot{m}_0} = \frac{n}{n_0} \cdot \left(\frac{\pi}{\pi_0} \right)^{\frac{1}{2} \cdot \left(1 - \frac{k-1}{k \cdot \eta_p} \right)} \qquad (9)$$

or with approximation:

$$\frac{\dot{m}}{\dot{m}_0} \cong \frac{n}{n_0} \qquad (10)$$

where without index there are the given characteristics.

To obtain a new base equation, it will be considered that "in average per compressor", the speeds triangles are preserved as being analogue. From Euler equations results that in the case of such simplification it can be written:

$$\frac{L}{L_0} = \left(\frac{n}{n_0} \right)^2 \qquad (11)$$

Neglecting the changes in compressor's yield and the changes of kinetic energy in compressor we will obtain{*1,3*}:

$$\frac{L_{ad}}{L_{ad_0}} = \frac{T_1}{T_{1,0}} \cdot \frac{\pi^{\frac{k-1}{k}} - 1}{\pi_0^{\frac{k-1}{k}} - 1} = \left(\frac{n}{n_0} \right)^2 \qquad (12)$$

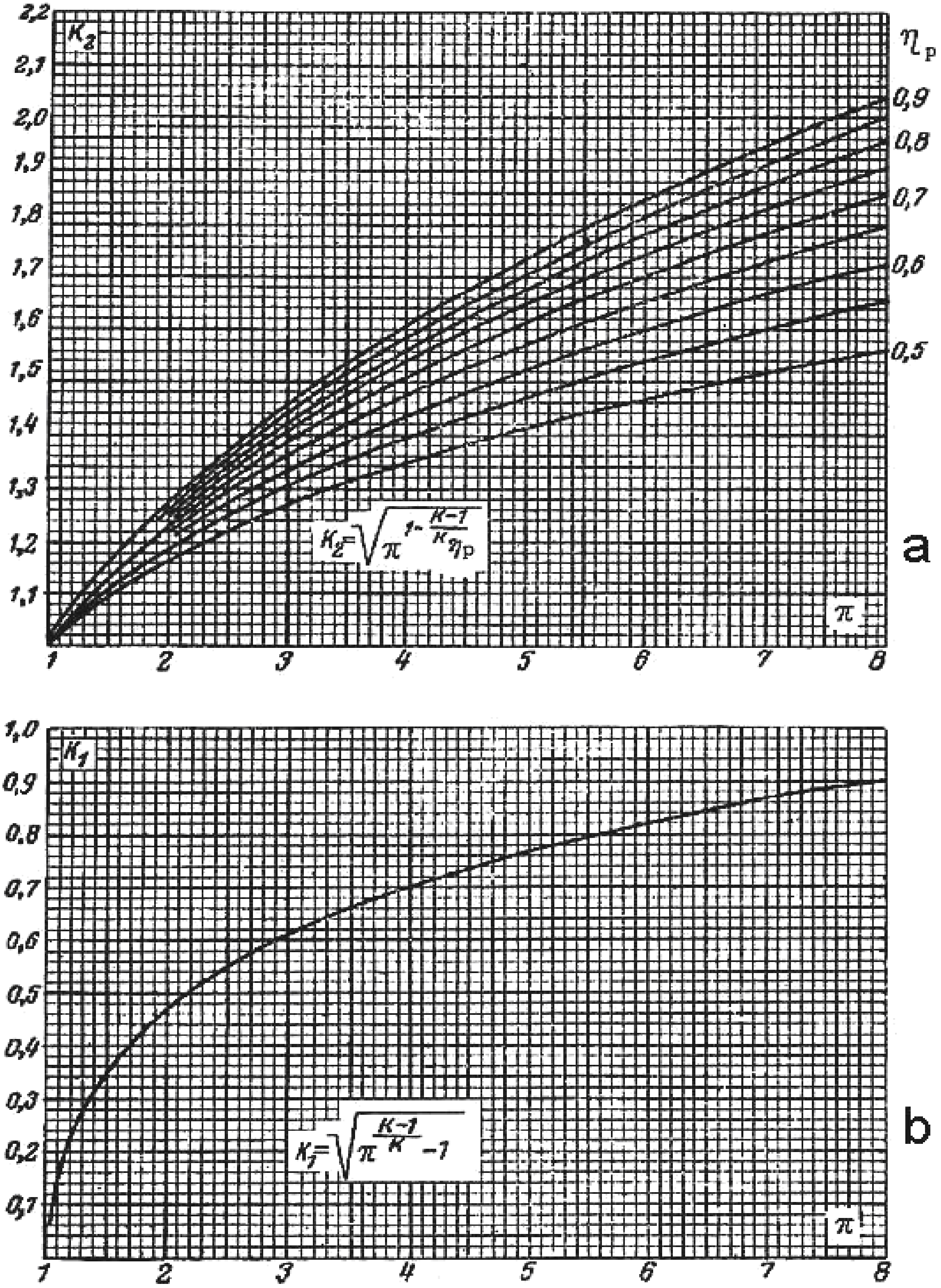

Fig. 2. Charts of K_1 and K_2 coefficients

or

$$\frac{n}{n_0} = \sqrt{\frac{\pi^{\frac{k-1}{k}} - 1}{\pi_0^{\frac{k-1}{k}} - 1}} \qquad (13)$$

The (9) and (13) equations resolve the problem of compressor's characteristics reassessment in the case of modification of rotations number or gas temperature. To simplify the calculations, in fig. 2 a, b, there are represented the helping charts adopting the following notations{*1*}:

$$K_1 = \sqrt{\pi^{\frac{k-1}{k}} - 1}\,;\; K_2 = \sqrt{\pi^{1-\frac{k-1}{k\cdot\eta_p}}}\;;k = 1{,}4 \qquad (14)$$

The methodology of calculation consists in the following:on the characteristic of compressor at an initial number of rotations n_0 there are chosen some points on which are situated the working parameters of the compressor($\dot{m}_0$, π_0, η_p).

From fig. 2 a, b, for every value of π_0 there are determined $K_{1,0}$ and $K_{2,0}$ coefficients. Knowing the given number of rotations *n*, for which we do the reassessment of the characteristics it is determined the value of the K_1 coefficient in the correspondent points for the new characteristics:

$$K_1 = K_{1,0} \cdot \frac{n}{n_0} \qquad (15)$$

Now for K_1 from the chart (fig. 2, b) it will be determined the degrees of pressure increase π and η_p and after the coefficient K_2. The flow amount $\dot{m}$ will be:

$$\dot{m} = \dot{m}_0 \cdot \frac{n}{\dot{n}_0} \cdot \frac{K_2}{K_{2,0}} \qquad (16)$$

Constructing the points obtained in the coordinates π , $\dot{m}$ and unifying them using a smooth curve it is obtained the compressor's characteristic for the new revolution *n*.

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STUDIUL MODIFICARII CARACTERISTICILOR TURBOCOMPRESORULUI LA SCHIMBAREA PARAMETRILOR LA ASPIRAŢIE ŞI A TURAŢIEI

Recalcularea caracteristicilor turbocompresorului la schimbarea parametrilor la aspiraţie şi a turaţiei are o mare importanţă practică, deoarece încercările compresoarelor generează mari consumuri energetice. Soluţia problemei se bazează pe înlocuirea condiţiei de similitudine a triunghiurilor vitezelor(practic imposibil de îndeplinit în toate treptele compresorului), cu condiţia păstrării similitudinii triunghiurilor vitezelor înaintea paletei de lucru din ″treapta medie″. Aceasta permite cu aproximaţie să se considere îndeplinită condiţia păstrării analogiei triunghiurilor vitezei în medie pe compressor.