PRESSURE DROP IN THE SUCTION LINE OF TK R16/8 TURBO COMPRESSOR

ION DOŞA[1]

Abstract: Pressure drop in the suction line of the turbo compressor will affect the pressure in the inlet section of the compressor. Lower inlet pressure will require higher drive power. As a result, energy consumption for compressed air production will be higher because turbo compressors are machines with continuous operation.

Key words: turbo compressor, pressure drop, suction line, inlet pressure.

1. INTRODUCTION

Study of the influence of intake air pressure and temperature on drive power of the turbo compressor is important because the turbo compressor has the largest share in energy consumption of an underground mine [4] [2], due its high power motor drive, and continuous operation.

In the literature relationships can be found that indicate how the driving power changes according to intake flow rate [3] in relation to the rated intake air parameters.

The solution of using a suction fan to provide intake air at parameters close to the rated value in order to save energy by reducing power drive is given in [2].

In order to evaluate efficiency of using suction fans, a mathematical model for calculating pressure drop in the suction line of the turbo compressor must be developed.

2. PRESENTATION OF SUCTION LINE OF TK R16/8 TURBO COMPRESSOR

In figure 1 the suction line of TK R16/8 turbo compressor is presented. In the figure has been denoted by: 1 – grate of the air intake case (2), 3 - filter cloth, 4 - square cross-section duct 5 – convergent section for transition from square to circular

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duct, 6,7,8 - S-shaped bend (fluid moves in two perpendicular planes), 9 - intake flap, 10 - straight pipe section, 11 elbow (90 °), 12 – actual inlet section of the compressor.

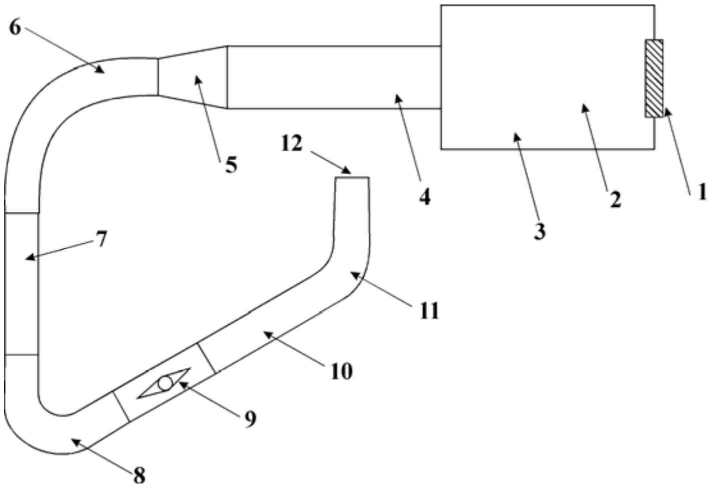

Fig. 1. The suction line of TK R16/8 turbo compressor.

Dimensions of suction line were measured resulting:

- Grate (1) of the air intake case: height of the grate 1.03 m; width 1.5 m; width of a blinds 80 mm; thickness of a blinds 15 mm; distance between blinds 50 mm; angle of blinds 45°; roughness of wood k_r = 0.15 mm [5]; number of blinds n = 12 with clean cut edges.
- Air intake case (2) hight of case H = 2 m; width of case B = 2 m; length of case L = 3 m; roughness of walls k_r = 0.22 mm [5].
- Square cross-section duct: edge size 0.8 m; duct lenght 3 m;
- Diameter of suction duct 0.5 m, duct roughness k_r = 0.03 mm [5].
- S-shaped bend with fluid moving in two perpendicular planes (elbows are the same): diameter d = 0.5 m; the radius of curvature R_0 = 1.45 m; the length of the straight section l = 2 m.
- Intake flap (fig. 2): circular flap (disc), chamfered; flap thickness b = 40 mm; length of the duct section where is located l = 1 m.
- The length of the straight portion after the flap is l = 1 m, and the elbow has the same characteristics as that make up the S-shaped bend.

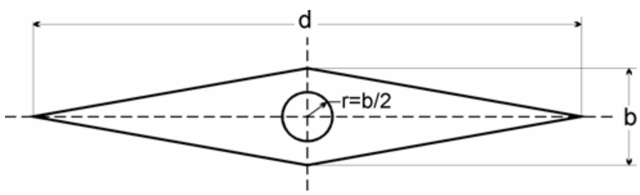

Fig. 2. Intake flap.

These data will be input to the program that will calculate the pressure drop of the suction line.

3. THE MATHEMATICAL MODEL OF SUCTION LINE

In order to establish the mathematical model for calculating pressure drop, major and minor losses must be taken into account for every component of the suction line.

The assumptions for determining air flow parameters in suction line are: adiabatic flow, flow losses are neglected and fully turbulent flow occurs.

Based on these assumption minor loss coefficients are calculated [4], using equations found in literature [5].

Minor loss coefficient of the grate at the air intake case can be found using equation [5]:

$$\xi = k \cdot \xi' + \Delta\xi \tag{1}$$

where: k - correction coefficient with values $k = 1.0$ for intake edges cut vertically and $k = 0.6$ for those cut horizontally; ξ' - minor loss coefficient:

$$\xi' = \left[0.85 + \left(1 - a \cdot \frac{A_g}{A_0} \right) + \xi_d \right] \cdot \frac{1}{a^2} \cdot \left(\frac{A_0}{A_g} \right)^2 \tag{2}$$

where: a is the ratio between the area of the openings in grate A_{or} and grate area A_g; A_0 is the area of intake case; ξ_d – coefficient of distributed drag:

$$\xi_d = \lambda \cdot \frac{l}{b_1'} \tag{3}$$

where: λ is the friction coefficient; l the length of blinds in the direction of air flow; b'_1 distance between blinds.

In case that the distance between two blinds is not optimal as given by:

$$\left(\frac{l}{b_1'} \right)_{opt} = 11 \cdot (1 - a) \tag{4}$$

a correction coefficient $\Delta\xi$ is used:

$$\Delta\xi = 0.5 \cdot \left[11 \cdot (1 - a) - \frac{l}{b_1'} \right] \tag{5}$$

Relationship for other minor losses can be easily found in literature. After completing the mathematical model with equations found for all minor losses a program was developed for easily calculating air parameters in inlet section of the turbo compressor.

4. MEASUREMENTS AND RESULTS

The control panel of the turbo compressor [1] [4] provides data on: pressure drop of intake flap Δb, air temperature at inlet T_a, compressed air pressure at outlet p_c, pressure of the compressed air network p_r; air flow rate at inlet $\dot{V}_a$, cooling water pressure p_w, air temperature after the first and second stage intercooler T_{I} and T_{II}, air temperature at discharge at the outlet of aftercooler T_f, temperature of cooling water at inlet of cooling circuit T_{wi} and at outlet T_{we}, voltage U, current I, power factor cosφ and drive power P_{act} of electric engine. In addition, the ambient temperature and pressure was measured, and using compressor performance curves the inlet air flow rate was calculated [4].

Using data above along with the program developed for calculating pressure drop of the suction line, the pressure drop and the air parameters in the actual inlet section of the turbo compressor were found.

Results are presented in fig. 3 and 4, namely the pressure drop of suction line against inlet air flow rate at 14 °C inlet air temperature (fig. 3) and pressure drop of suction line against inlet air flow rate at 12 °C inlet air temperature (fig. 4).

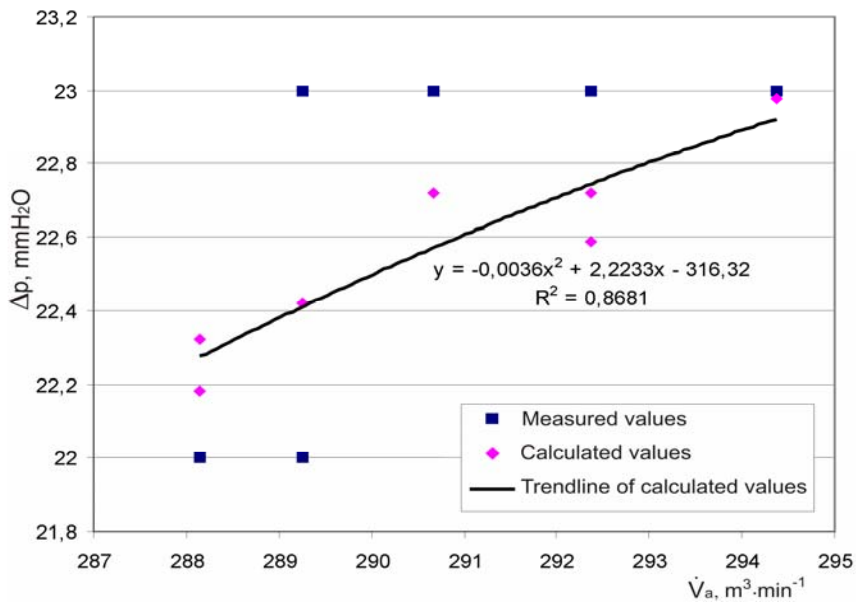

Fig. 3. Pressure drop of suction line against inlet air flow rate at 14 °C inlet air temperature

Analyzing data in figures 3 and 4 some conclusions can be drawn. Although at first glance the difference between measured and calculated data looks quite large, this differences are in the range of 1 mmH_2O pressure.

As a result, the error of calculating pressure drop for the suction line, using the developed mathematical model is in range of -2.5 to 1.5%.

This difference is quite small and we can say that the mathematical model is correct.

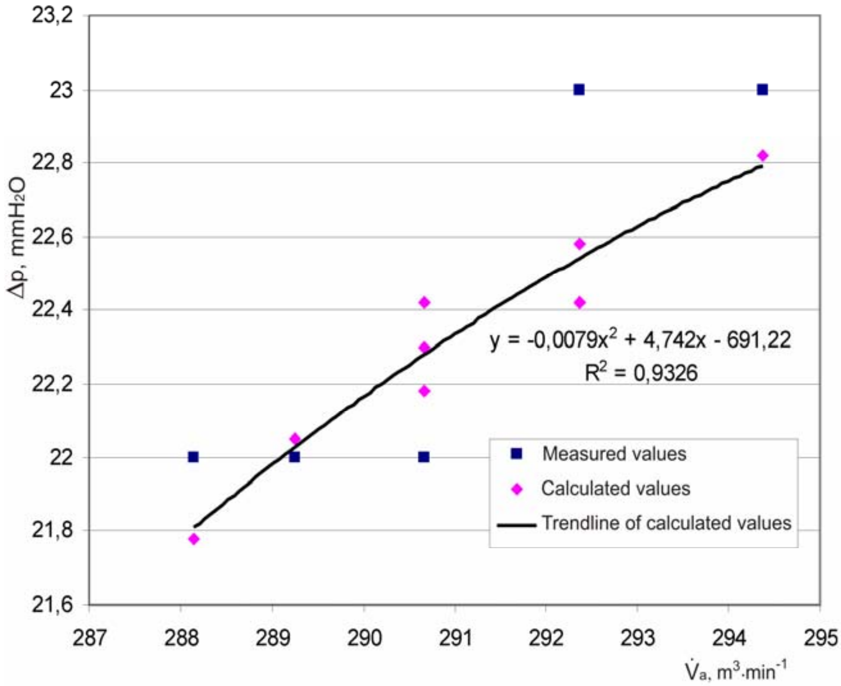

Fig. 4. Pressure drop of suction line against inlet air flow rate at 12 °C inlet air temperature

5. CONCLUSION

Using results above a mathematical model for different configurations of suction line can be determined and therefore the effect of using suction fan can be calculated, resulting air parameters in the inlet section of the turbo compressor.

The mathematical model can be used to obtain preliminary data on how any change that needs to be done to the suction line will influence the operation of the tubo compressor.

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