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Gazdynamic characteristics of the centrifugal compressor calculation
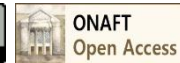
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Gas-dynamic characteristics of the compressor make it possible to evaluate its energy and economic properties, to predict the values of capacity, the generated gas pressure and the power consumption during the compressor operation. For more in-depth consideration of the compressor, it is desirable to have the characteristics of its individual stages. The element-by-element analysis of the characteristics of each stage makes it possible to improve the coordination of the operation of the individual elements with each other and thereby improve the gas-dynamic characteristics of the compressor. The loss factor ζ and the static pressure recovery factor ξ can be used as the values characterizing the properties of the individual elements of the stage. Coefficients ζ and ξ are suitable for evaluating the energy properties of any element of the stage. To assess the effect of the element in question on the economy of the stage, it is necessary to establish what proportion of the work required for compression is the "loss" of energy in a given element, i.e. find the reduction in efficiency stage $\Delta\eta$ due to dissipation of energy into heat in this element. Calculation of performance of the centrifugal compressor is performed from the inlet to the outlet using the equations of state, of process, of continuity and conservation of energy. The initial data are geometric parameters of the compressor, the composition and the initial parameters of compressed gas, the rotational speed of the rotor. The basis of the elementwise calculation of gas-dynamic characteristics is the gas-dynamic characteristics of the stage elements. The calculation can be performed using the characteristics of the stage elements taken from the own bank of experimental data or using the generalized characteristics of the stage elements. To obtain generalized characteristics of the impeller, blade and no-blade diffusers, reverse guide vanes, experimental data were used, published in the works of Galerkin, Den, Rees, Seleznev and others, as well as experimental data obtained by the author. The generalized characteristics are obtained in the form of analytical dependences of the loss coefficients on the angles of attack or flow angles by approximation of experimental data. These dependences were used to analyze the gas-dynamic characteristics of a centrifugal compressor, which made it possible to develop recommendations for their improvement.

Keywords: Centrifugal Compressor, Stage, Elementwise Analysis, Performance, Impeller, Diffuser

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1. Introduction

Gasdynamic characteristics of the compressor make it possible to evaluate its energy and economic properties, to predict the values of capacity, the generated gas pressure, the power consumption during the compressor operation. For more in-depth consideration of the compressor, it is desirable to have the characteristics of its individual stages. The element-by-element analysis of the characteristics of each stage makes it possible to improve the coordination of the operation of the individual elements with each other and thereby improve the gas-dynamic characteristics of the compressor.

The values characterizing the properties of the individual elements of the stage can be the loss factor and the static pressure recovery factor. Coefficients and are suitable for evaluating the energy properties of any element of the stage. To assess the effect of the element in question on the economy of the stage, it is necessary to establish what proportion of the work required for compression is the "loss" of energy in a given element, i.e. find the reduction in efficiency stage due to dissipation of energy into heat in the element under consideration. The elementwise analysis of the compressor's work can be a powerful tool for

improving its flowing part. The creation of software for elementwise calculation of gasdynamic characteristics of a centrifugal compressor is undoubtedly an actuation one.

2. Gasdynamic characteristics calculation method

Calculation of the gasdynamic characteristics of the compressor is carried out in series from the inlet to the outlet, using the equations of state, process, continuity and conservation of energy [1, 2].

The initial data are the geometric parameters of the compressor, the composition and initial parameters of the compressible gas, the rotor speed. The number of calculated compressor operating conditions by flow rate is usually not more than 10.

Initial calculation data. The initial data are:
1) geometric parameters (Fig. 1):
d0 – small diameter at the impeller inlet;
D0 – large diameter at the impeller inlet;
D1 – diameter at the impeller blade inlet;
D2 – diameter at the impeller blade outlet;
D3 – diameter at the diffuser inlet;
D4 – diameter at the diffuser outlet;

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D5 – diameter at the return channel inlet;
b1 – width at the impeller blade inlet;
b2 – width at the impeller blade outlet;
b3 – width at the diffuser inlet;
b4 – width at the diffuser outlet;
b5 – width at the return channel inlet;
β_{b1} – angle at the impeller blade inlet;
β_{b2} – angle at the impeller blade outlet;
α_{b3} – angle at the diffuser inlet;
α_{b4} – angle at the diffuser outlet;
α_{b5} – angle at the return channel inlet;
α_{b6} – angle at the return channel outlet;
z_1, z_3, z_5 – quantity of blades of impeller, diffuser and return channel respectively.

2) gas parameters:

R – gas constant, J / (kg K);
k – adiabatic index;
c_p – isobaric specific heat, J / (kg K);
z – coefficient of compressibility;
p_{in}, T_{in} – pressure and temperature of gas at the compressor inlet;

3) gasdynamic characteristics of the elements stage:

$\zeta_{imp} = f_1(i_1)$, where ζ_{imp} – loss factor of the impeller; i_1 – angle of attack at the impeller blade inlet;
$\zeta_{dif\,2-3} = f_2(\alpha_2)$, where $\zeta_{dif\,2-3}$ – loss factor of the vaneless diffuser (initial section);
α_2 – angle of the flow at the impeller outlet;
$\zeta_{dif\,3-4} = f_3(\alpha_3)$, where $\zeta_{dif\,3-4}$ – loss factor of the vaneless diffuser (main section); α_3 – angle of the flow at the diffuser inlet;
$\zeta_{v.dif} = f_4(i_3)$, where $\zeta_{v.dif}$ – loss factor of the vane diffuser; i_3 - angle of attack at the diffuser blade inlet;
$\zeta_{c.dif} = f_5(i_3)$, where $\zeta_{c.dif}$ – loss factor of the channel diffuser; i_3 – angle of attack at the channel diffuser inlet;
$\zeta_{RC} = f_6(i_5)$, where ζ_{RC} – loss factor of the return channel; i_5 – angle of attack at the return channel inlet;
$\zeta_{vol} = f_7(\alpha_4)$, where ζ_{vol} – loss factor of the volute; α_4 – angle of the flow at the diffuser outlet.

Algorithm of calculation

1. Volume flow rate of gas at the compressor inlet

$$\overline{V}_{in} = \left[a + \frac{b-a}{N_1 - 1} \cdot (i-1) \right] \cdot \overline{V}_{in.n} .$$

$\overline{V}_{in}$ – volume flow at specified operating condition; $\overline{V}_{in.n}$ – volume flow at nominal operating condition; N_1 – operating conditions quantity; i – operating condition number; a and b – coefficients for minimum and maximum flow rate (for example $a = 0,5$; $b = 1,5$).

2. Gas velocity at the stage inlet $c_{in} = \dfrac{\overline{V}_{in}}{A_{in}}$, where A_{in} – area stage at the inlet.
3. Gas density at the compressor inlet

$$\rho_{in} = \frac{p_{in}}{z_{in} \cdot R \cdot T_{in}} .$$

4. Mass flow of gas $\overline{m} = \overline{V}_{in} \cdot \rho_{in}$.
5. Total pressure loss in the input device

$$\Delta p^*_{in-o} = \zeta_{in} \cdot \rho_{in} \frac{c^2_{in}}{2} .$$

6. Total pressure at the impeller inlet

$$p^*_0 = p_{in} + \rho_{in} \frac{c^2_{in}}{2} - \Delta \eth^*_{in-i} .$$

7. Total temperature at the impeller inlet

$$T^*_0 = T_{in} + \frac{\tilde{N}^2_{in}}{2 \cdot c_{\eth}} .$$

8. Total density at the impeller inlet

$$\rho^*_0 = \frac{p^*_0}{z \cdot R \cdot T^*_0} .$$

9. Static density at the impeller inlet

$$\rho_0 = 0,5 \cdot \left[\rho^*_0 + \left(\rho^{*2}_0 - \frac{2 \cdot a^2_0}{k \cdot R \cdot T^*_0} \right)^{0,5} \right],$$

where $a_0 = 4 \cdot \overline{m} / \pi \cdot (D^2_0 - d^2_0) \cdot \sin \alpha_1$; α_1 – flow angle in absolute motion at the impeller inlet.

10. Absolute velocity at the impeller inlet
$$c_0 = a_0 / \rho_0 .$$
11. Volume flow rate of gas at the impeller inlet
$$\overline{V}_0 = \overline{m} / \rho_0 .$$
12. Static temperature at the impeller inlet
$$T_0 = T^*_0 - c^2_0 / 2 \cdot c_p .$$
13. Radial velocity at the impeller inlet
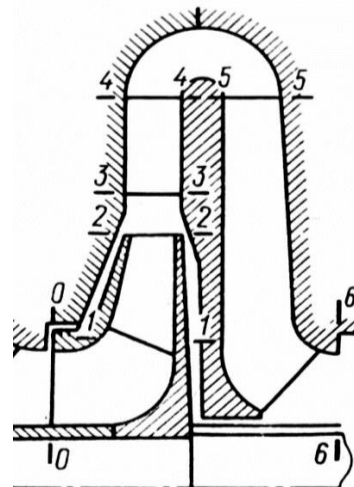$$c_{r1} = \overline{V}_0 / \pi \cdot D_1 \cdot b_1 .$$

Figure 1 – Scheme of centrifugal compressor

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14. Circumferential velocity on the diameter D_1
$$U_1 = (\omega \cdot D_1)/2 .$$

15. Relative flow angle $\beta_1 = arctg\left(\dfrac{c_{r1}}{U_1 - c_{u1}}\right) .$

16. Angle of attack at the impeller blade inlet
$$i_1 = \beta_{b1} - \beta_1 .$$

17. Relative flow velocity $w_1 = c_{r1}/\sin\beta_1 .$

18. Loss factor of the impeller $\zeta_{imp} = f_1(i_1) .$

19. Radial velocity at the impeller outlet
$$c_{r2} = \frac{\overline{V}_0}{\varepsilon_2 \cdot \pi \cdot D_2 \cdot b_2}, \text{ where } \varepsilon_2 = \rho_2/\rho_0 .$$

20. Coefficient of flow $\varphi_{r2} = c_{r2}/U_2 .$

21. Coefficient of theoretical head
$$\psi_{th} = \psi_{th2} - (c_{u1} \cdot U_1)/U_2^2 ,$$

where $\psi_{th2} = 1 - \varphi_{r2} \cdot ctg\beta_{b2} - \dfrac{\pi}{z_2} \cdot \sin\beta_{b2}$ – the equation Stodola.

22. Coefficient of total head
$$\psi_t = \psi_{th}(1 + \beta_{fr} + \beta_{over}) .$$

23. Absolute velocity at the impeller outlet
$$c_2 = U_2 \cdot \sqrt{\varphi_{r2}{}^2 + \psi_{th2}{}^2} .$$

24. Reactivity $\Omega = 1 - \dfrac{c_2^2 - c_0^2}{2 \cdot \psi_t \cdot U_2^2} .$

25. Total temperature at the impeller outlet
$$T_2^* = T_0^* + \frac{\psi_i \cdot U_2^2}{c_p} .$$

26. Static temperature at the impeller outlet
$$T_2 = T_2^* - \frac{c_2^2}{2 \cdot c_p} .$$

27. Density ratio $\varepsilon_2' = \left(\dfrac{T_2}{T_0}\right)^{(\sigma-1)} ,$

where $\sigma = \dfrac{n}{n-1} = \dfrac{k}{k-1}\left(1 - \zeta_{0-2}\dfrac{w_1^2}{U_2^2 \cdot 2 \cdot \Omega_i \cdot \psi_i}\right) .$

28. Static density at the impeller outlet
$$\rho_2 = \varepsilon_2' \cdot \rho_0 .$$

29. Static pressure at the impeller outlet
$$p_2 = \rho_2 \cdot R \cdot T_2 \cdot z .$$

30. Total pressure at the impeller outlet
$$p_2^* = p_2 + \rho_2 \cdot \frac{c_2^2}{2} .$$

31. Total head $h_t = \psi_t \cdot U_2^2 .$

32. Loss coefficient efficiency of the impeller
$$\Delta\eta_{imp} = \zeta_{imp} \cdot \frac{w_1^2}{2 \cdot h_t} .$$

33. Flow angle at the impeller outlet
$$\alpha_2 = arctrg\left(\varphi_{r2}/\psi_{th2}\right) .$$

34. Loss factor of the vaneless diffuser (initial section) $\zeta_{2-3} = f_2(\alpha_2) .$

35. Loss coefficient efficiency of the diffuser (initial section) $\Delta\eta_{2-3} = \zeta_{2-3} \cdot \dfrac{c_2^2}{2 \cdot h_t} .$

36. Total pressure at the cross-section 3–3
$$P_3^* = P_2^* - \zeta_{2-3} \cdot \frac{c_2^2}{2} \cdot \rho_2 .$$

37. Flow angle at the cross-section 3–3
$$\alpha_3 = arctg\left(\frac{b_2}{b_3} \cdot tg\alpha_2\right) .$$

38. Total density at the cross-section 3–3
$$\rho_3^* = \frac{p_3^*}{z \cdot R \cdot T_3^*} .$$

39. Static density at the cross-section 3–3
$$\rho_3 = 0,5 \cdot \left(\rho_3^* + \sqrt{\rho_3^{*2} - \frac{2a_3^2}{k \cdot R \cdot T_3^* \cdot z}}\right) ,$$

where $a_3 = \dfrac{\overline{m}}{\pi \cdot D_3 \cdot b_3 \cdot \sin\alpha_3} .$

40. Velocity at the cross-section 3–3 $c_3 = a_3/\rho_3 .$

Depending on the type of diffuser, the corresponding algorithm is taken.

For vaneless diffuser

41. Loss factor of the vaneless diffuser (main section) $\zeta_{dif 3-4} = f_3(\alpha_3) .$

42. Loss coefficient efficiency of the vaneless diffuser
$$\Delta\eta_{3-4} = \zeta_{dif 3-4} \cdot \frac{c_3^2}{2 \cdot h_t} .$$

43. Flow angle at the diffuser outlet $tg\alpha_4 = tg\alpha_3 \cdot (b_3/b_4) .$

For vane diffuser

44. Angle of attack at the vane diffuser $i_3 = \alpha_{b3} - \alpha_3 .$

45. Loss factor of the vane diffuser $\zeta_{v.dif} = f_4(i_3) .$

46. Loss coefficient efficiency of the vane diffuser
$$\Delta\eta_{3-4} = \zeta_{v.dif} \cdot \frac{c_3^2}{2 \cdot h_t} .$$

For channel diffuser

47. Angle of attack at the channel diffuser $i_3 = \alpha_{b3} - \alpha_3 .$

48. Loss factor of the channel diffuser $\zeta_{c.dif} = f_5(i_3) .$

49. Loss coefficient efficiency of the channel diffuser
$$\Delta\eta_{3-4} = \zeta_{c.dif} \cdot \frac{c_3^2}{2 \cdot h_t} .$$

For vane or channel diffusers

50. Flow angle at the diffuser outlet $\alpha_4 = \alpha_{b4} - \Delta\alpha_4$, where $\Delta\alpha_4$ – angle of lag.

For vaneless, vane or channel diffusers

51. Total pressure at the diffuser outlet
$$p_4^* = p_3^* - 0,5 \cdot \zeta_{3-4} \cdot \rho_3 \cdot c_3^2 .$$

52. Total density at the diffuser outlet

$$\rho_4^* = \frac{p_4^*}{z \cdot R \cdot T_4^*} .$$

53. Static density at the diffuser outlet

$$\rho_4 = 0,5\left(\rho_4^* + \sqrt{\rho_4^{*2} - \frac{2a_4^2}{k \cdot R \cdot T_4^* \cdot z}} \right),$$

where $a_4 = \dfrac{\overline{m}}{\pi \cdot D_4 \cdot b_4 \cdot \sin \alpha_4}$.

54. Velocity at the diffuser outlet $c_4 = a_4 / \rho_4$.

55. Coefficient of friction at the return channel

$$k_{fr} = \left(0,075 \cdot \left(\frac{b_5}{b_4} \right)^2 - 0,15 \cdot \frac{b_5}{b_4} + 1,075 \right)^{-1} .$$

56. Flow angle at the return channel inlet

$$\alpha_5 = arctg\left(tg\alpha_4 \cdot \frac{D_4 \cdot b_4}{D_5 \cdot b_5} \cdot k_{fr} \right).$$

57. Angle of attack at the return channel

$$i_5 = \alpha_{b5} - \alpha_5 .$$

58. Loss factor of the return channel $\zeta_{RC} = f_6(i_5)$.

59. Loss coefficient efficiency of the return channel

$$\Delta \eta_{RC} = \zeta_{RC} \cdot \frac{c_4^2}{2 \cdot h_t} .$$

60. Loss factor of the volute $\zeta_{vol} = f_7(\alpha_4)$.

61. Loss coefficient efficiency of the volute

$$\Delta \eta_{vol} = \zeta_{vol} \cdot \frac{c_4^2}{2 \cdot h_t} .$$

62. Efficiency of the stage $\eta_{p.st} = 1 - \sum_j \Delta \eta_j$.

63. Conditional coefficient of flow

$$\Phi_0 = \frac{4 \cdot \overline{V_0}}{\pi \cdot D_2^2 \cdot U_2} .$$

64. Coefficient of polytropic head of the stage

$$\psi_{p.st} = \psi_t \cdot \eta_{p.st} .$$

Calculation of gas parameters at the stage outlet

65. Total pressure at the stage outlet

$$p_{0'}^* = p_4^* - 0,5 \cdot \zeta_{4-0'} \cdot \rho_4 \cdot c_4^2 .$$

66. Total density at the stage outlet $\rho_{0'}^* = \dfrac{p_{0'}^*}{z \cdot R \cdot T_{0'}^*}$.

67. Static density at the stage outlet

$$\rho_{0'} = 0,5\left(\rho_{0'}^* + \sqrt{\rho_{0'}^* - \frac{2a_{0'}^2}{k \cdot R \cdot T_{0'}^*}} \right),$$

where $a_{0'} = \overline{m}/A_{out}$.

68. Static pressure at the stage outlet

$$p_{0'} = p_{0'}^* - 0,5 \cdot \rho_{0'} \cdot c_{0'}^2 .$$

69. Pressure ratio for stage $\ddot{I}_{st} = p_{0'}/p_0$.

70. Pressure ratio for compressor $\ddot{I} = p_{out}/p_{in}$.

71. Efficiency of the compressor

$$\eta_{p.c} = \frac{\sum \psi_{t.st} \cdot \eta_{p.st}}{\sum \psi_{t.st}} .$$

According to the results of calculations the following graphic charts can be done $\ddot{I} = f(\overline{V}_{in})$ and $\eta_{p.c} = f\left(\overline{V}_{in}\right)$ [2, 3, 4].

3. Obtainment of the gasdynamic characteristics of the stage elements

The basis of the elementwise calculation of gasdynamic characteristics is the gasdynamic characteristics of the stage elements. The calculation can be performed using the characteristics of the stage elements taken from the own bank of experimental data or using the generalized characteristics of the stage elements.

For convenience of calculation automation, the experimental data [2, 3, 4, 5, 6, 7] were approximated using the program «UniAprox2.04» and the analytical form of the generalized characteristics was obtained.

The results of approximation for the loss factors of the stage elements are represented below.

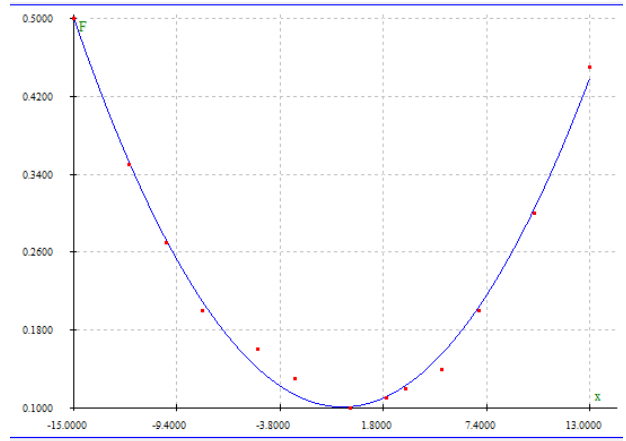Dependence of the loss factor on the angle of attack of the impeller are represented on figure 2.

Figure 2 – Dependence of the loss factor on the angle of attack of the impeller $\zeta_{imp} = f_1(i_1)$

The equation for loss factor of the impeller $\zeta_{imp} = 1,876 \cdot 10^{-3} \cdot i_1^2 + 1,53 \cdot 10^{-3} \cdot i_1 + 0,101$.

The angle of attack i_1 in this equation is measured in degrees. Coefficient of determination $R^2 = 99,713$ %.

The initial segment of the vaneless diffuser is determined according to the recommendations of prof. Yu. Galerkin [2]. Dependence of the loss factor of the vaneless diffuser (initial section) on the angle of the flow at the impeller outlet are represented on figure 3.

The equation for loss factor of the vaneless diffuser (initial section)

$$\zeta_{dif2-3} = 3,92 \cdot 10^{-4} \cdot \alpha_2^2 - 2,3 \cdot 10^{-2} \cdot \alpha_2 + 0,437 .$$

The angle α_2 in this equation is measured in degrees. Coefficient of determination $R^2 = 99,843$ %.
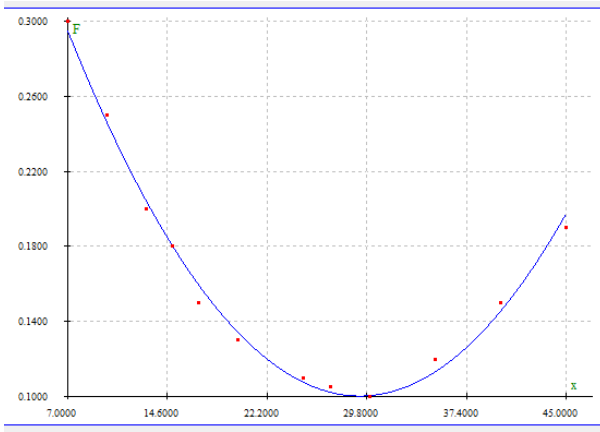
Figure 3 – Dependence of the loss factor of the vaneless diffuser (initial section} on the angle of the flow at the impeller outlet $\zeta_{dif\,2-3} = f_2(\alpha_2)$

Dependence of the loss factor of the vaneless diffuser (main section} on the angle of the flow are represented on figure 4.
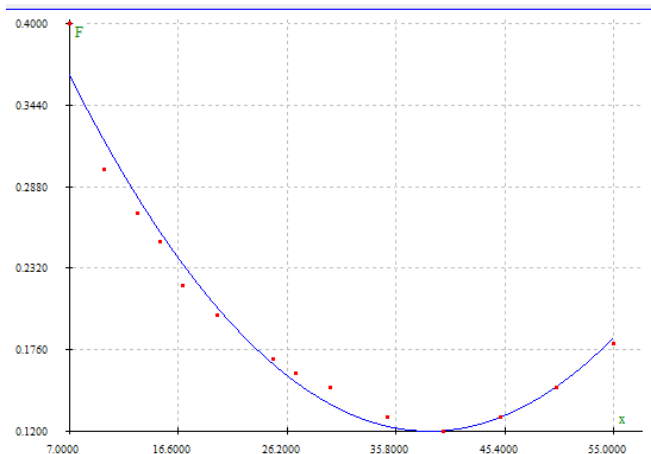

Figure 4 – Dependence of the loss factor of the vaneless diffuser (main section} on the angle of the flow $\zeta_{dif\,3-4} = f_3(\alpha_3)$

The equation for loss factor of the vaneless diffuser (main section)

$$\zeta_{dif\,3-4} = 4,3 \cdot 10^{-4} \cdot \alpha_3^2 - 1,88 \cdot 10^{-2} \cdot \alpha_3 + 0,484 \ .$$

The angle α_3 in this equation is measured in degrees. Coefficient of determination $R^2 = 99,628$ %.

Dependence of the loss factor of the vane diffuser on the angle of attack are represented on figure 5.

The equation for loss factor of the vane diffuser

$$\zeta_{v.dif} = 1,87 \cdot 10^{-3} \cdot i_3^2 + 1,39 \cdot 10^{-2} \cdot i_3 + 0,238 \ .$$

The angle of attack i_3 in this equation is measured in degrees. Coefficient of determination $R^2 = 98,925$ %.

Dependence of the loss factor of the return channel on the angle of attack are represented on figure 6.

The equation for loss factor of the return channel

$$\zeta_{RC} = 1,19 \cdot 10^{-3} i_5^2 + 1,2 \cdot 10^{-2} i_5 + 0,33 \ .$$

The angle of attack i_5 in this equation is measured in degrees. Coefficient of determination $R^2 = 99,192$ %.

Dependence of the loss factor of the volute on the angle of the flow at the diffuser outlet are represented on figure 7.
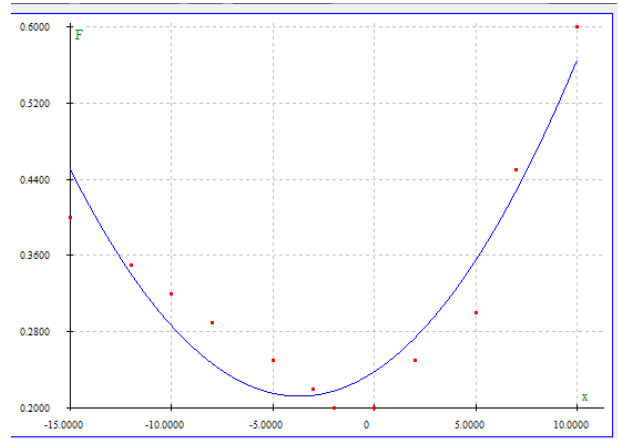

Figure 5 – Dependence of the loss factor of the vane diffuser on the angle of attack $\zeta_{v.dif} = f_4(i_3)$
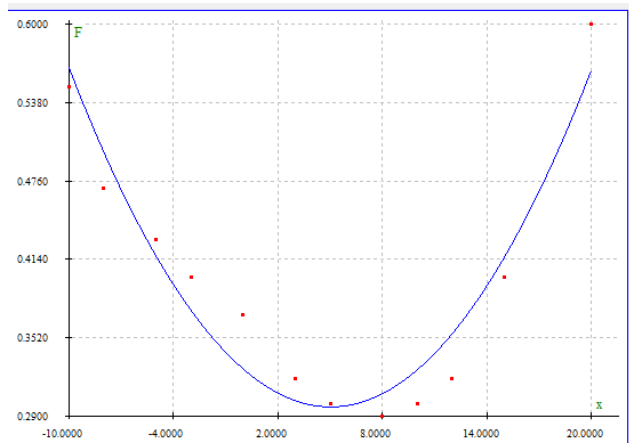

Figure 6 – Dependence of the loss factor of the return channel on the angle of attack $\zeta_{RC} = f_6(i_5)$
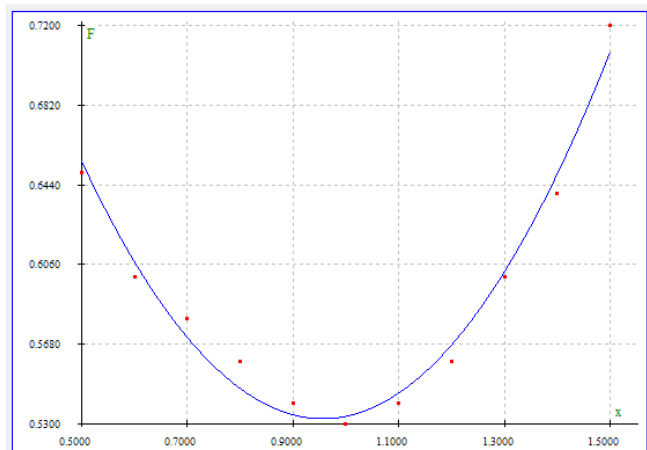

Figure 7 – Dependence of the loss factor of the volute on the angle of the flow at the diffuser outlet $\zeta_{vol} = f_7(\mathrm{tg}\,\overline{\alpha}_4)$

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The equation for loss factor of the volute

$$\zeta_{vol} = 0,59\left(\overline{tg}\alpha_4\right)^2 - 1,13\overline{tg}\alpha_4 + 1,024 .$$

In this equation $\overline{tg}\alpha_4 = tg\alpha_4 / tg\alpha_{4n}$. Coefficient of determination $R^2 = 99,734$ %.

4. Results

For example, an elementwise analysis of the compressor 16GTS2-340 / 60-85M is performed. The most effective operating condition is the 4th. Figure 8 shows the data that allows you to determine how aligned the operating condition of the compressor stages are.

The loss factors of the elements of the 1st stage of the compressor are close to the minimum, but for the elements of the second stage, it is possible to reduce the values of the loss factors (increase in the efficiency). To do this, it is needed to reduce the angle of attack at the entrance to the impeller by 3–4 ^{0}, increase the angle of the flow to 20 ^{0}, reduce the angle of attack at the entrance to the vane diffuser by 4–5 ^{0}. The correction of the size of the flow part, which ensures the required changes in the flow parameters, can be performed in various ways, for example by changing the width of the channels.
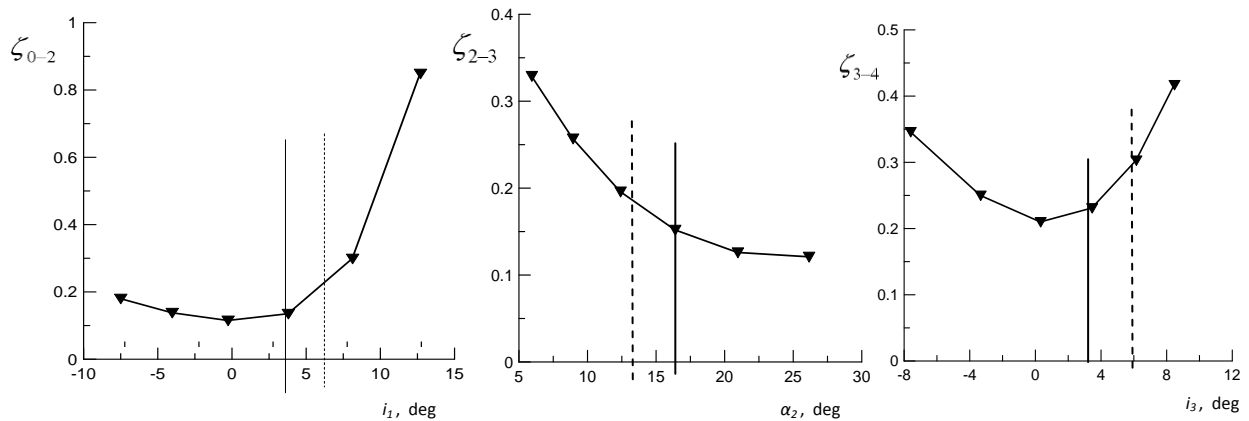

Figure 8 – The loss factors of the elements of the 1st and 2nd stages of the compressor:
——1st stage; – – – 2nd stage

5. Conclusions

Elementwise analysis makes it possible to improve the coordination of the work of individual elements of the stages of a centrifugal compressor with each other and, consequently, to increase its efficiency.

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Розрахунок газодінамічних характеристик відцентрового компресора

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Газодинамічні характеристики компресора дозволяють оцінювати його енергетичні та економічні властивості, передбачати значення продуктивності, тиску стискуваного газу, споживання енергії під час

роботи компресора. Для детальнішого розгляду робочого процесу компресора бажано мати характеристики окремих елементів. Поелементний аналіз характеристик кожного ступеня дозволяє покращити узгодження роботи окремих елементів між собою та за рахунок цього досягти покращення газодинамічних характеристик компресора. В якості характеристик елементів ступеня зазвичай використовують коефіцієнти втрат і коефіцієнти відновлення статичного тиску. Коефіцієнти придатні для оцінювання енергетичних властивостей будь-якого елемента проточної частини. Для визначення впливу елемента ступеня на економічність ступеня необхідно визначити яку частину роботи, що витрачається на стиснення газу, складають "втрати" енергії в даному елементі, тобто знайти величину зменшення ККД ступеня внаслідок дисипації енергії в тепло в даному елементі. Розрахунок параметрів відцентрового компресора здійснюється від входу до виходу з використанням рівнянь стану, процесу, неперервності та енергії. Вихідними даними є геометричні параметри компресора, склад та початкові параметри стискуваного газу, частота обертання ротора. Основою поелементного розрахунку газодинамічних характеристик є газодинамічні характеристики елементів ступеня. Розрахунок можна виконати з використанням характеристик елементів ступеня, взятих із власного банка експериментальних даних, або з використанням узагальнених характеристик. Для отримання узагальнених характеристик робочого колеса, лопаткового та безлопаткового дифузорів, зворотного напрямного апарата використані експериментальні дані, що опубліковані в роботах Гальоркіна, Дена, Ріса, Селезньова та ін., а також експериментальні дані, отримані автором. Узагальнені характеристики одержані у вигляді аналітичних залежностей коефіцієнтів втрат від кутів атаки або кутів потоку шляхом апроксимації експериментальних даних. Ці залежності використані під час аналізу газодинамічних характеристик відцентрового компресора, що дозволило розробити рекомендації з їх поліпшення.

Ключові слова: відцентровий компресор; Ступінь; Поелементний аналіз; Продуктивність; Робоче колесо; Дифузор.

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