Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 152 (2016) 389 – 394

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Oil and Gas Engineering, OGE-2016

Influence analysis of flow entry conditions on the centrifugal compressor impeller blades to integral gasodynamic characteristics in a combine regulation method.

Vanyashov A.D.[a], Karabanova V.V.[b], Vasenko E.M.[b]*

[a]*Omsk State Technical Univerity, 11 Mira Pr., Omsk 644050, Russian Federation*
[b]*JSC «Sibneftetransproekt», 10 let Oktyabray str., 180B, Omsk, 644009, Russian Federation*

Abstract

Experimental data analysis for testing centrifugal compressor stage on control modes by the rotor speed and the turning angle of the inlet guide vane blades changing was completed. The attack angles distribution in inlet section of the impeller along the blade height was received. A major difference in the attack angle from the head to the periphery is found to affect the polytropic efficiency stage. Recommendations for improving the regulating mechanism of the inlet guide vanes unit were given.

Peer-review under responsibility of the Omsk State Technical University

Keywords: inlet guide vane, impeller, centrifugal compressor, gasodynamic characteristics.

1. Introduction

The most common used methods of centrifugal compressors (CC) operating modes regulation are the rotor speed, the turning angle of the inlet guide vane (IGV) blades variation for changing the flow spins in front of the impeller; inlet or outlet throttling. The necessity to use a combined regulation, for example, a simultaneous changing the rotor speed and the turning angle of the inlet guide vane blades or inlet throttling etc. occurs when there is need in changing the gas-dynamic characteristics (GDC) of the compressor under some low for technical process maintenance, for example, in units of turbo internal combustion engines, gas-compressor units at compressor stations, low-temperature plants and other.

* Corresponding author. Tel.: +7-962-051-6402.
E-mail address: adv@omgtu.ru

Peer-review under responsibility of the Omsk State Technical University
doi:10.1016/j.proeng.2016.07.719

The experimental method is regarded to be the most reliable way of getting GDC, and the curve form of input pressure and pressure ratio is obtained for a number of the throttle flap states from a fully open state to steady operation limit for the determined speed and the turning angle of IGV blades. Changing the CC speed or turning the IGV blades for the assigned position of the throttle flap (i.e. specified net characteristics) leads to displacement in position of operating points along so called "mode lines". In summation, points on the mode line (net characteristics) are known as "similar"; and kinematic and dynamic analogy is performed for them according to self-similarity conditions for Mach and Reynolds numbers. Self-similarity conditions for call Mach numbers are performed for $M_U < 0.6 \dots 0.8$, in this case, polytropic efficiency on similar modes may be considered constant, that allows to use a recalculation method of GDC obtained at the same rotation frequency, on the other frequencies in the specified M_U range.

Deviation from the execution conditions of dynamic similarity particularly under operating at high peripheral speeds ($M_U < 0.8$) leads to efficiency calculation and correcting, as well as non-dimensional coefficients of pressure and flow rate.

The aim of the work was to establish the entry conditions influence into impeller through the attack angle change along the blade height to integral stage gas-dynamic parameters (efficiency, coefficients of pressure and flow rate) in the regulation by rotor speed and turning the IGV blades and receiving recommendations to improve the compressor operation efficiency under regulation modes.

2. Study subject

Study subject was centrifugal compressor stage with axial inlet guide vane unit (IGVU), semi-open axial-radial impeller (I), vaned diffuser (VD) and axial ring-type diffuser.

Basic impeller parameters are: outer diameter is $D_2 = 0.268\,m$; impeller-width ratio on outlet is ${b_2}/{D_2} = 0.0285$; outlet angle of vanes is $b_{b_2} = 71.3°$, number of vanes is $z_2 = 32$; hub-tip ratio is ${D_{\text{hub}}}/{D_2} = 0.3874$; inlet diameter of the vanes peripheral part to outer diameter ratio is ${D_1}/{D_2} = 0.5618$. Initially the IGV blades are turned chordwise to $\theta_{b0} = +25.2°$ and tangent towards to the vane median line in its outlet section to $\theta_{b0} = +39.8$.

The centrifugal stage scheme is shown in Fig. 1, 3D model of the impeller with IGV blade system is shown in Fig. 2.

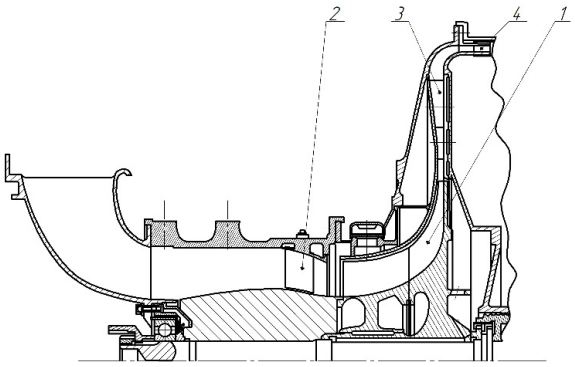

Fig. 1 centrifugal compressor stage scheme: 1 is semi-open axial-radial impeller; 2 is blade of inlet guide vane; 3 is radial blade diffuser; 4 is axial blade diffuser.

Fig. 2. 3D model of the impeller and inlet guide vane unit.