IJDIAS International Journal of Discoveries and Innovations in Applied Sciences

| e-ISSN: 2792-3983 | www.openaccessjournals.eu | Volume: 3 Issue: 2

Roots Design Compressor

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Abstract:

A compressor of the Ruts type is a volumetric vane pump that works by pumping liquid with a pair of engaging blades resembling a set of stretched gears. The liquid is retained in the pockets surrounding the blades and is transferred from the inlet side to the outlet.

Keywords: Blower, blades, blast furnace, isochoric compression, Otto cycle, concentric circles, fine oil mist.

The most common use of a Roots-type blower was an induction device on two-stroke diesel engines, such as those produced by Detroit Diesel and Electro-Motive Diesel. Roots-type superchargers are also used to boost four-stroke engines with an Otto B cycle, while the supercharger is driven by the engine's crankshaft through a toothed or V-belt b a roller chain or a gear train.

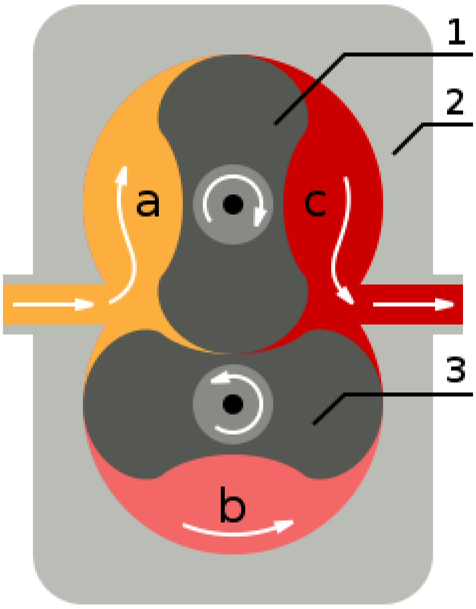

Fig.1. A Roots blower with a two-bladed rotor. The rotors of most real Roots blowers have three or four blades. 1. Rotating blade 1; 2. Pump housing; 3. Rotating blade 2; a. Consumption; b. Pumping; c. Injection of air or air-fuel mixture into the intake manifold

The Roots type blower is named after American inventors and brothers Philander and Francis Marion Roots, founders of the Roots Blower Company from Connersville, Indiana, USA, who in 1860 patented the basic design of an air pump for use in blast furnaces and other industrial applications. In 1900, Gottlieb Daimler incorporated a Roots-type blower into a patented engine design, making the Roots-type blower the oldest of the various designs now available. Roots blowers are commonly referred to as blowers or PD (direct displacement) blowers. The Roots

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blower pump is a rotary piston pump of the volumetric type, which works by pumping liquid using a pair of engaging cams, not much different from a set of stretched gears. Then the liquid enters the pockets surrounding the petals and is transferred from the inlet side to the outlet.

Three-bladed blowers. Why is a rotary-blade blower called a "Roots blower"? The rotary blower with positive blades was developed in the 1850s by brothers Francis and Philander Roots. Later in 1860, the brothers patented it, and the name Roots became the name of the design.

The basic principle of operation of "Roots Blower". The principle of operation of the Roots blower is as follows: the process begins with the intake of air from the inlet into the element chamber. Timely rotation of the rotors relative to the chamber wall creates the so-called "air flow direction". At this moment, atmospheric pressure is still maintained in these chambers. As soon as the first lobe passes through the opening to the discharge side, the pressure in the system is adjusted. This is called isochoric compression. The rotors seal each other inside, which prevents pressure changes.

Working principle of «Roots Blower». The Roots blower operates on the principle of isochoric compression, also known as external compression. The pressure increase is achieved due to the periodic supply of a gaseous medium (for example, atmospheric air) to the system. By pumping a medium from atmospheric conditions into a system with a given resistance (for example, a water column, a distribution network), a corresponding increase in pressure is achieved. The roots blower will operate at a controlled power level to overcome this resistance. Robuschi "Roots Blower"; called RBS, consists of three rotors in the form of mated blades that rotate inside a pre-processed chamber. The chamber is sealed with rotating rotors, and the rotors are synchronized using a 1:1 gear ratio located at the ends of the shafts. The bearings are located outside the compression chamber with an oil lubrication system. The drive shafts have labyrinth-type oil seals, so named because of the maze of grooves through which the oil must pass. In the spray lubrication system, a fine oil mist is used for lubrication.

For modeling, it is necessary to mathematically define the profiles of the rotors – for this you need to split the rotor profile of the Roots blower. We will do this with the help of concentric circles (Fig. 2) in polar coordinates (R; α) centered at point O. We will determine the α_i corresponding to R_i in Fig. 1, and make an array based on them, presented in Table 1.

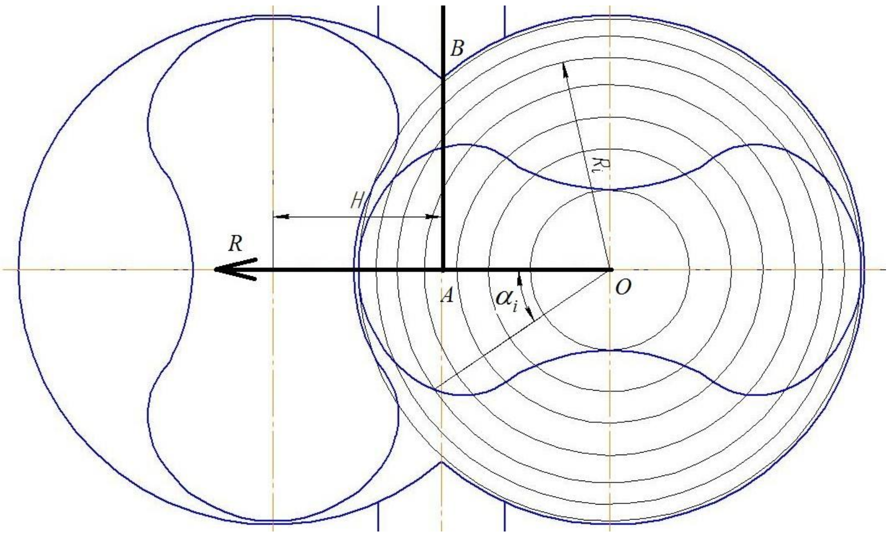

Fig. 2. The breakdown of the rotor using concentric circles

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Table 1. Data array

	R_i	α_{i1}	α_{i2}	α_{i3}	β_i
1	R_1	α_1	$180^0 - \alpha_1$	$-\alpha_1$	β_1
-	-	-	-	-	-
i	R_i	α_i	$180^0 - \alpha_i$	$-\alpha_i$	β_i
-	-	-	-	-	-
N	R_N	α_N	$180^0 - \alpha_N$	$-\alpha_N$	β_N

The verification installation of gas flow meters was investigated. In order to develop an effective design of the silencing chamber in the room with the installation (Fig. 3), it was necessary to calculate the flow pulsations in the pumping line of the installation and build their spectrograms.

Fig.3. Stand equipped with Roots blowers

The calculation was performed using the above model, which was implemented in Excel. Figures 4, 5 show the dependences of the instantaneous supply of two different Roots blowers installed on the test stand of JSC "Metrology and Automation" on the angle of rotation of the drive shaft. Using the fast Fourier transform, spectrograms of flow pulsations of both blowers were obtained, which are shown in Fig. 6, 7.

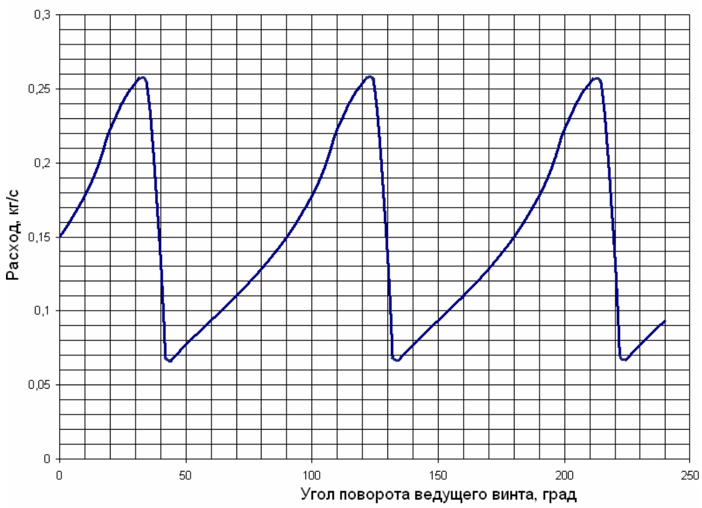

Fig. 4. Instantaneous feed of the Roots blower 2AF53M2-MH 50-10,68-3-11 (3000 rpm). The coefficient of unevenness for this unit was 2

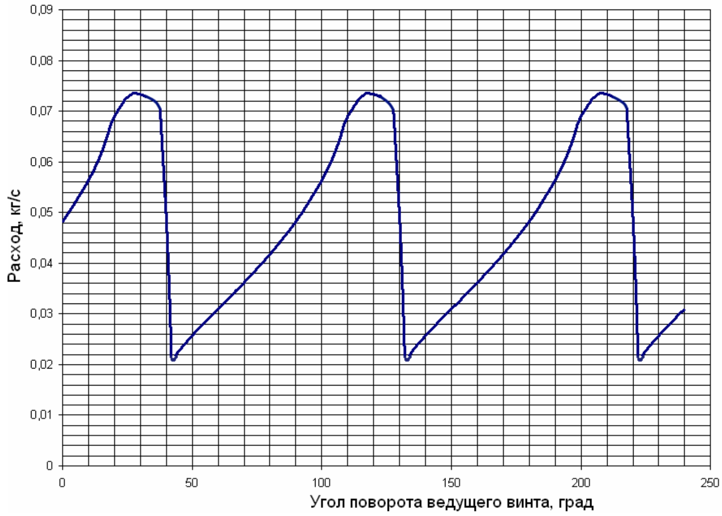

Fig. 5. Instantaneous feed of the Roots blower 2AF51M1-MH 50-2,52-1,5-4 (1500ob/min). The coefficient of unevenness for this unit was 1.5

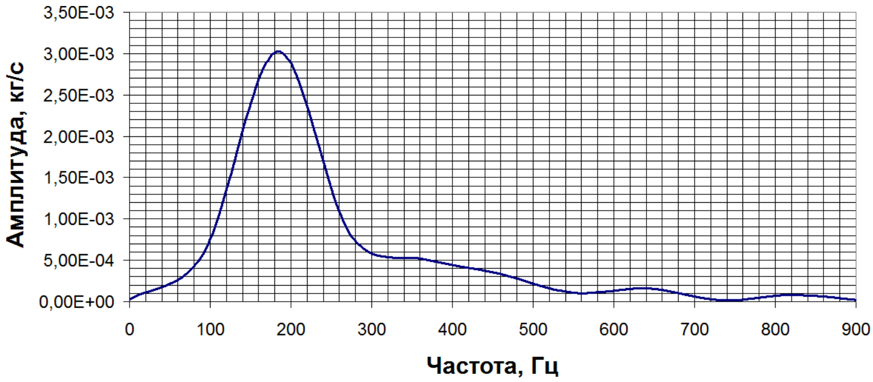

Fig. 6. Instantaneous feed spectrum of the Roots blower 2AF53M2-MH 50-10,68-3-11

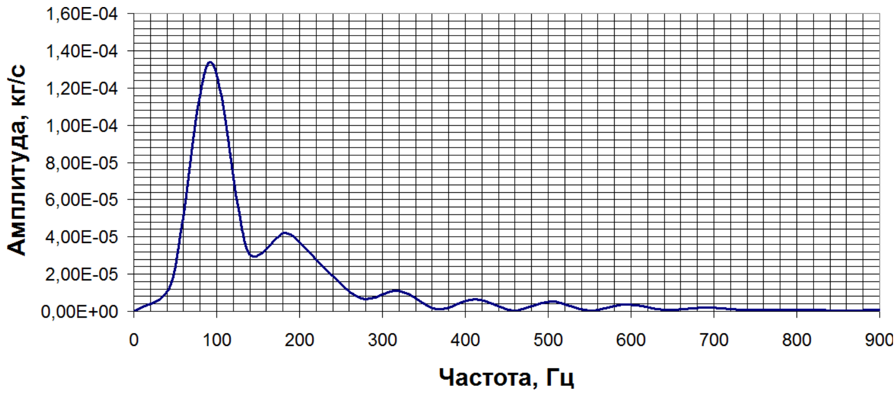

Fig. 7. Instantaneous feed spectrum of the Roots blower 2AF51M1-MH 50-2,52-1,5-4

Noise measurement directly on the object showed the predominance of harmonics in the noise spectrum at frequencies of 100 and 200 Hz, which indirectly confirms the developed mathematical model.

A jamming chamber was proposed for installation, which allows reducing air noise. Analysis of the data presented in Fig. 6, 7 showed that the maximum amplitudes of harmonics with frequencies of 100 Hz, 200 Hz. This corresponds to the harmonics produced by the Roots blowers. The main part of the sound energy in such cases is usually transmitted through pipes and creates a lot of noise on the exhaust, as evidenced by measurements. But do not forget that the compressor housing and the electric motor, vibrating during operation, as a rule, create noise at the same frequencies. That is why compressor manufacturers themselves often complete or offer noise-insulating casings for a fee.

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