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MEASUREMENT OF STATIC CHARACTERISTICS PNEUMATIC MOTORS WITH ELASTIC WORKING ELEMENTS

MĚŘENÍ STATICKÝCH CHARAKTERISTIK PNEUMATICKÝCH MOTORŮ S ELASTICKÝMI PRACOVNÍMI ČLENY

Abstract

Into a category of pneumatic motors with elastic working parts belong air bellows, diaphragm motors and fluid muscles. All three types of these motors have some elastic part usually made of rubber. This part is deformed under the pressure of a compressed air or a mass load resulting in a final working effect. This paper deals with measuring of static characteristics of these motors.

Abstrakt

V tomto příspěvku se zabývám měřením statických charakteristik pneumatických motorů s elastickými pracovními členy. Do kategorie těchto pneumatických motorů řadíme měchové motory, membránové motory a fluidní svaly. Všechny tři typy těchto pneumatických motorů obsahují nějakou elastickou část. Tato elastická část je deformována za působení stlačeného vzduchu nebo od hmotného zatížení, čímž je dosažen výsledný pracovní účinek.

1 INTRODUCTION

In this type of motors are in contact two different elastic environments - the compressed air and the elastic part itself. This fact greatly complicates their theoretical analyses and also all drawn conclusions from the analyses require verification on an experimental device. All types of motors were already described in detail in earlier publication [1]. It is necessary to add that these motors are mainly the low-stroke ones and in case of the air bellows and the diaphragm motors working with relatively large forces.

2 EXPERIMENTAL MEASURING DEVICE

The experimental measuring device was designed as part of my dissertation work to measure static and dynamic characteristics of the above mentioned pneumatic motors. The emphasis was given on the versatility of this device in order to measure all three types of motors with considerably different design parameters on one device. This was achieved by selecting a vertical construction. In the Fig. 1 is displayed the pneumatic motor 1, which is firmly attached by a central platform to the frame, above which is the mass load 3. According to the fact, that the air bellows and diaphragm motors are used in applications requiring the low-stroke and large forces in range of *0÷100* kN, it wasn´t possible to achieve the appropriate mass load in laboratory conditions. Therefore it was considered during the design and the realization the possibility of connecting smaller air bellow motor 2 to the upper frame. As the supplementary motor works against the measured motor the appropriate mass load can be achieved.

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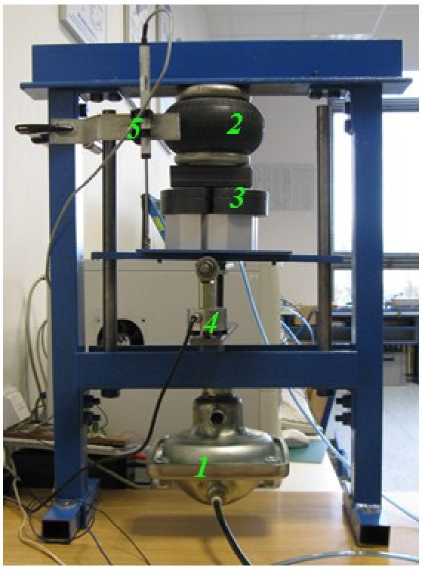

Fig. 1 Experimental device used for measuring pneumatic motors with elastic elements.
1 - measured diaphragm motor, 2 – burdensome air bellows motor, 3 – mass load, 4 – force sensor, 5 – position sensor

In this article I focus on the measurements of the air bellows and diaphragm motors static characteristics. The measurement of the fluid muscles was dismissed as this type of the motor is widely elaborated in a literature [2]. In Fig. 2 is shown a detailed diagram of the experimental device. Behind a source of the compressed air are situated on both branches the 3/2 switchboard valves, which are used to supply the compressed air to the main measured motor. In upper branch is placed a reduction valve FESTO LR-1/8-S, which adjusts the mass load of the motor. The back pressure p_2 is measured by a sensor located in front of the motor.

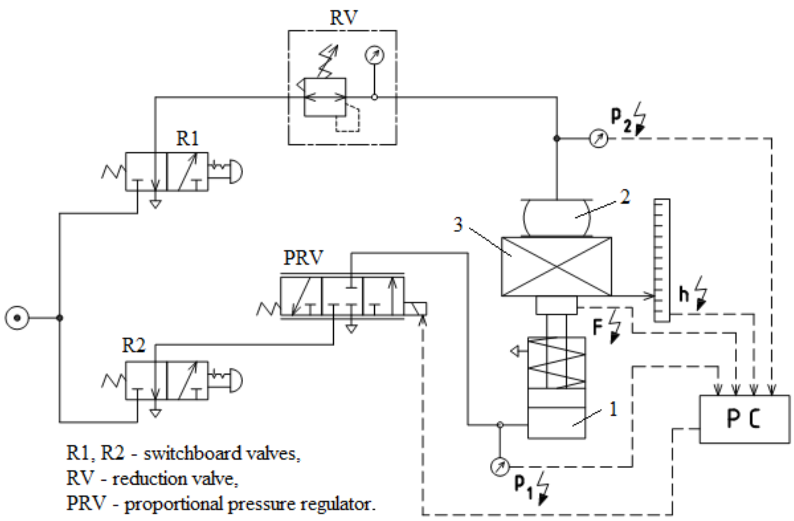

Fig. 2 Scheme of the device measuring static characteristics of pneumatic motors with elastic working elements.

A position sensor is on one end firmly connected to the experimental device frame and on the other end it relies on the part moveable under the physical load. Between the mass load and the measured motor is paced a force sensor. Its measurable range had to be increased by using leverage. In lower branch is located a proportional pressure regulator REXROTH 5610112620, which keeps the pressure p_1 in the measured motor on a constant level. A pressure sensor is placed in front of the motor. Analogue signals of all measured values are transformed to digital signals by a measuring card MF 624 and then transferred into the computer, where the data are processed and recorded by the software Matlab-Simulink. This program also provides the pressure regulation in the measured motor.

3 MEASUREMENT OF STATIC CHARACTERISTICS

The above described device was used to determine the static characteristics. The experiment was conducted on the motor BOSCH REXROTH BCP 0822419002 (with maximal stroke of *54* mm) as representative from the group of air bellows. The motor was kept under the constant pressure p_1 within the scale of *1÷4* bar. The pressure was gradually changed by the use of secondary diaphragm motor by which the stroke on the measured motor was changed. Unfortunately it was not possible to conduct the measurement under higher constant pressure as the only pressure sensor available had the measurable scale up to *5000* N. The total force depending on the stroke was recorded after the stabilization of the whole mechanism. The length of each measurement was *20* second for the given load, while the average values were deducted at the last second of the measurements. It was possible to compare the results with the data supplied in the catalogue [3] by the manufacturer. In the Fig.3 the shown black lines indicate the catalogue data and the measured characteristics at four different constant pressures are indicated by the coloured lines. The differences are apparent especially at higher pressures, where the maximal deviation was about *400* N, which was at the given load nearly 10% of the total force. The deviation between the measured and catalogued data can be explained by a combination of several effects caused by small modifications of the motor in comparison with the it´s original construction design and also by possible manufacture inaccuracies and particularly by the different material properties of the bellow.

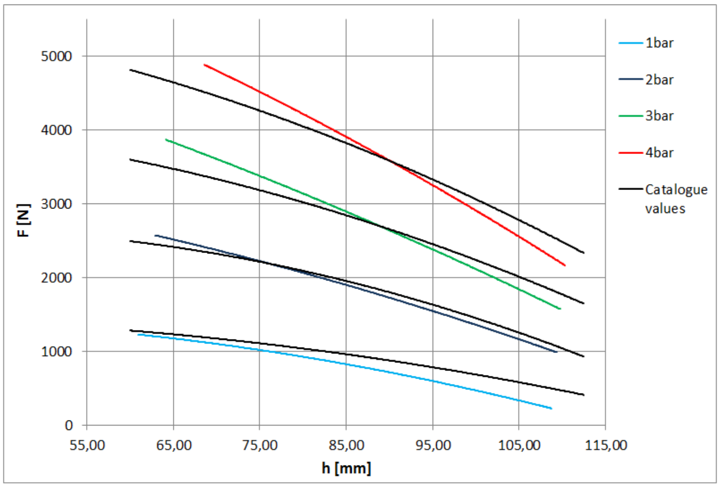

Fig. 3 The comparison of the measured static characteristics of the air bellows motor with the catalogue values.

For further testing of the diaphragm motor was used BOSCH REXROTH with a membrane´s diameter of *113* mm and the maximum stroke of *50* mm. The measurement principle was the same as for the air bellows motor. The constant pressure was maintained in the measured diaphragm motor and the additional load was delivered by the secondary air bellows motor. The measurements were conducted in steps, where each measurement step had the pressure *0,5* bar higher than the one before, in the scale of the constant pressure of *1÷3,5* bar. This method was chosen for the better illustration of the resulting curves. The resulting characteristics at various constant pressures shown in Fig. 4 are in their shapes similar, but the considerable decrease of the force at the maximal stroke is intriguing.

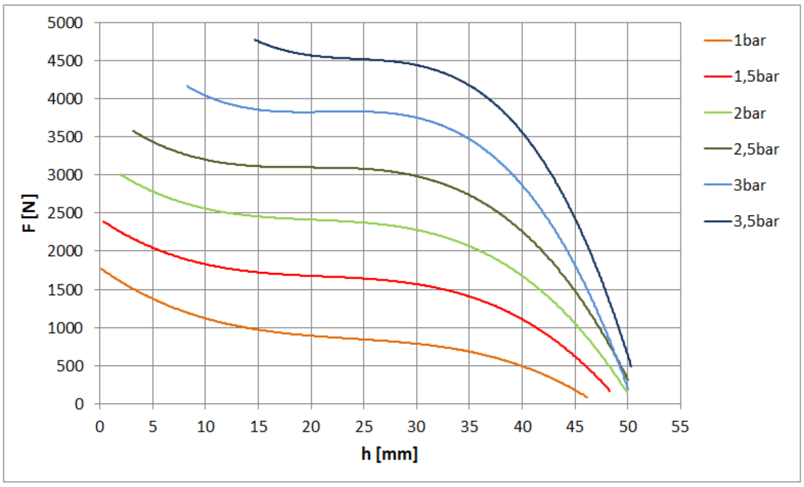

Fig. 4 The measured static characteristics of the diaphragm pneumatic motor.

4 CONCLUSIONS

I have conducted the measurements of the static characteristics of the air bellows and diaphragm pneumatic motors. There are evident divergences of the measured data of the air bellows motor and the data provided by the manufacturer. These deviations are affected by the whole group of factors, ranging from a stiffness of the measuring equipment and possible changes in the construction of the manufactured motors to the material changes of the elastic parts causing its different characteristics. It is necessary to take in count, that the measurements were conducted on one concrete motor. By measuring more motors of the same type we could surely achieve much more accurate outcomes, which would describe precisely the characteristic of the given type. Together with the measurement of the air bellows motor the preliminary informative measurement of the diaphragm motor was conducted. The outcomes from this measurement needs to be confirmed and will be intriguing and important keystones for the choice and use of the given type of the motor as the manufacturer doesn´t disclose any motor characteristics. The introduced characteristic doesn´t have the typical waveform as needed for the fastening device, but it is acceptable for the given working stroke extent. I will devote myself to the further and wider measurement of the given air-bellows motor and to the detailed testing of the diaphragm motor. In my future I count with a creation of mathematical models of the pneumatic motors with the elastic working elements.

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