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The fluid power elements and systems made of plastics

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Abstract

The Fluid Power Research Group from Wroclaw University of Technology have been concentrating their research and development activity on the application of plastics for the construction of hydraulic components. Their work focuses primarily on the gerotor pump, the pressure relief valve, the manifold and the hydraulic cylinder. The paper presents the theoretical basis of designing those elements, examples of the design solutions, as well as the experimental research results. A prototype of the hydraulic system featuring the plastic elements has been assembled and tested, and it proves to work properly.

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Keywords:hydraulic components; plastics; gerotor pump; production

1. Introduction

Application of plastics instead of metals is a currently observed tendency in the making of fluid power elements and systems. The use of plastics is advantageous both for the construction and operational reasons, as it leads to: reduction of weight and size, reduction of vibration and noise, improvement of tribological properties, capability of self-sealing, increase in resistance to impurities, ability to work with a variety of working media including water and aggressive chemicals.

It is also advantageous for technological reasons as it enables: manufacture of complicated profiles of the fluid power elements using a simple method of injection molding, simplifying and shortening of the production process.

The application of plastics is profitable also for economic reasons as it: lowers the material costs,lowers the

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manufacture costs and reduces the production time.

Nevertheless, along with the advantages, the use of plastics has some disadvantages, and those are: decrease in strength of the elements and the narrowing of the working pressure range, occurrence of the elements' size instability resulting from the change in the working fluid temperature and from the absorption of water solved in the working fluid.

Hence, the researchers look for plastics which would be more useful in the making of fluid power elements and systems [1], as well as give examples of their application [2]. They also provide rules of designing plastic machine units such as, for instance, bearings [3]. In papers [4, 5], rules of designing and manufacturing plastic gear systems used in gerotor pumps were presented. The experimental research described in [6] proved the plastic gear system in the pump to work properly. In [7], a possible application of plastics as the material for the making of the slipper in the piston pump was shown. A plastic has also been successfully used for the making of hydraulic cylinders [8]. In [9], high applicability of plastics as well as special manufacture technologies of the plastics for the making of the high-pressure tanks and hydraulic cylinders are described.

In that situation, the Fluid Power Research Group Wroclaw - FPRGWroclaw (www.fprg.pwr.wroc.pl) from Wroclaw University of Science and Technology, took up systematic research and development work aiming at:

- the development of the design and the manufacturing of the models of a set of the basic hydraulic elements made of plastics combining a gerotor pump, pressure relief valve, and a 2 position/2way directional control valve, and a hydraulic cylinder,
- the development, manufacturing, and testing of an exemplary fluid power system including those elements.

Prior to the research and development work, it was assumed that at least half of the hydraulic machines' and elements' parts would be made of plastics. At the same time, they were supposed to be the essential parts, in terms of the design and operation of those units.

2. Plastics as the material for the construction of hydraulic components

Analysis and selection of the plastic is the first and crucial stage of designing the fluid power components. The following selection criteria for the plastic were applied: possibly high strength manifested by high yield strength Re and a high Young's modulus, resistance to high temperature (T), high dimensional stability understood as a small linear elongation (W) and low material shrinkage (S) resulting from the injection process, small absorption (A) of water from the working fluid, low price and availability on the market, the processability by injection molding.

For the construction of the hydraulic components, three types of material were selected, namely POM, PPS and PEEK. Their properties are presented in table 1. POM was treated as the base material featuring sufficient mechanical properties, the processability by the injection molding, as well as a low price and availability on the market. Another material used was PPS which showed higher strength but, at the same time, was harder for processing and more expensive. The material of the highest strength was PEEK, which was mechanically processed and, simultaneously, the most expensive. It is also possible to compose a special material combining the base material and additives.

Tab. 1. Properties of the chosen plastic materials (polyoxymethylene - POM, polyphenylsulfone - PPS and polyetheretherketone – PEEK)

No	Parameter	Symbol	Unit	POM	PPS	PEEK
1.	Yield strenght	Re	MPa	60	180	230
2.	Young's modulus	E	MPa	3000	16000	12700
3.	Maximum work temperature	T	^{o}C	100	160	240
4.	Shinkage	S	cm/cm	0.0285	0.005	0.005
5.	Coefficient of linear expansion	W	cm/^{o}K	0.0001	0.00005	0.00004
6.	Coefficient of water absorption	A	%	0.7	0.02	0.4

3. Gerotor pump with plastic gears

The design of the gerotor pump of q = 10 cm^3/rev displacement has been presented in figure 1. The body of the pump consists of three parts, namely of the front part (1), the central part (2) and the back part (3). All the three parts