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Tests of Reversion Filter of KOMAG Design

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Abstract:

In technological systems of many industry branches including the hard coal mining industry, water indispensable for washing, transport of materials, cooling or driving and controlling an operation of equipment, is used. Quality parameters of water have a direct impact on life of the equipment supplied with it. In many cases they have a decisive impact on a technological process. Water quality can be increased by a correct filtration with use of filters operating in a continuous way (without operators), which are subject to verification tests as regards their functionality and operational safety before their delivery to a customer.

Streszczenie:

W ciągach technologicznych wielu gałęzi przemysłu, w tym w górnictwie węgla kamiennego, wykorzystuję się wodę, niezbędną do płukania, transportu materiałów, chłodzenia czy napędu i sterowania pracą urządzeń. Parametry jakościowe wody przekładają się bezpośrednio na żywotność zasilanych przez nią urządzeń. Niejednokrotnie mają decydujący wpływ na proces technologiczny. Jakość wody może być podniesiona poprzez właściwą filtrację, z zastosowaniem filtrów pracujących w sposób ciągły (bezobsługowy), które przed dostarczeniem do klienta poddawane są badaniom weryfikującym pod względem funkcjonalności i bezpieczeństwa pracy.**(Badania filtra rewersyjnego konstrukcji KOMAG)**

1. Introduction

Different types of filters are used in every branch of industry where liquid or air is a working medium. They can be equipped with paper, textile, plastic or steel cartridges. In turn they can be woven, interlaced or made of wire wound on a supporting structure (slotted cartridges). Filters with slotted cartridges, due to their easy cleaning are widely used and they are divided into two basic groups:

- linear – assembled in the supply hose – their cleaning requires switching off the supply and thus interrupting the filtration process,
- with internal cleaning, using a scraping element or reversion rinsing with filtrate stream. The cleaning process can by conducted automaticly or manually, basing on the information about the pressure difference on the filter inlet and outlet.

Filters of the second group are mainly used in the systems of continuous operation. It is not necessary to switch off the equipment to exchange a cartridge, but only short rinsing with the reverse stream is required, so these filters are widely used in:

- conventional power stations for purifying water cooling generators and thus extending the operational time of slide bearings of turbines shafts in water-power plants,
- heat and power generating plants for a protection of heat exchangers through their protection against their chocking and wear,
- chemical industry for a purification of process water,

- metallurgical industry for pressure cleaning of castings made of moulding sand and for cooling iron blast furnaces and rolling mill lines,
- technology of drinking water treatment as filters of preliminary purification,
- environmental protection technology for dewatering of sludges before their sterilization with ultra-violet rays in the process of reverse osmosis or in the process of membrane filtration,
- papermaking industry for supplying water spraying nozzles on paper sieves,
- mining industry in hydraulic installations supplied with emulsion and in water spraying and water-and-air installations of cutting drums of shearers, roadheaders and other systems reducing dust in the run-of-mine haulage processes [1,2,3].

Specific environmental conditions, which occur in the mining industry, force a use of big amounts of water (for spraying and cooling of equipment) and of emulsion (for supplying powered roof support units). The quality of water, delivered to machines and equipment, has a significant impact on their reliability and life which affect an increase of operational safety, a reduction of down-time and a reduction of service and maintenance costs [4,5,6,7,8]. A filtration of the above mentioned media is often conducted with use of filters with slotted cartridges. A construction of this equipment enables their cleaning without a need of their disassembly (self-cleaning filters called reversion ones). A big demand of the mining market for this type of filters (offered by foreign companies so far) caused a start of their production by domestic producers. However, high requirements of their users caused a development of filters' control systems, from manual to automatic. The reasons, described above, made the specialists from the KOMAG Institute undertake an elaboration of the slotted filters' series of types in the scope of operational pressure values from 4 to 40 MPa and capacities from 80 $dm^{3/}$min to 60 dm^3/min, basing on professional experience and an observation of slotted filters' operation in hard coal mines. These filters, ensuring high technical parameters, can be controlled manually (small units) or automaticly.

The significance of manual control at big flows and big operational pressures consists in generating a big force for a valve recontrol. Filters, operated in an automatic cycle, are deprived of this disadvantage and they do not require any supervision from the operator's side.

The equipment, described above, after its full completion, is subject to verification tests which mainly consist in checking the manufacture quality, a determination of flow resistances as well as in conducting functionality, leaktightness and strength tests. Below some tests of a chosen filter item, controlled manually, are described.

2. Test of high pressure WFR-250/40 reversion filter

High pressure WFR-250/40 reversion filter of KOMAG design, produced by the Elektron Company from Bytom, was subject to test (Fig. 1). It is designed for a filtration of water and of water-in-oil emulsion. It is two-chamber equipment, enabling a reverse cleaning of cartridges without a necessity of interrupting a filtration and a disassembly of filtration cartridges. Its construction ensures a safe application in underground mine workings, in which methane or coal dust explosion hazard may occur.

The filter is characterized by the following basic parameters:

- flow rate 250 dm^3/min,
- working pressure 40 MPa,
- max. liquid temperature 50^{o}C,
- filtration 50 μm (100 μm, 200 μm).

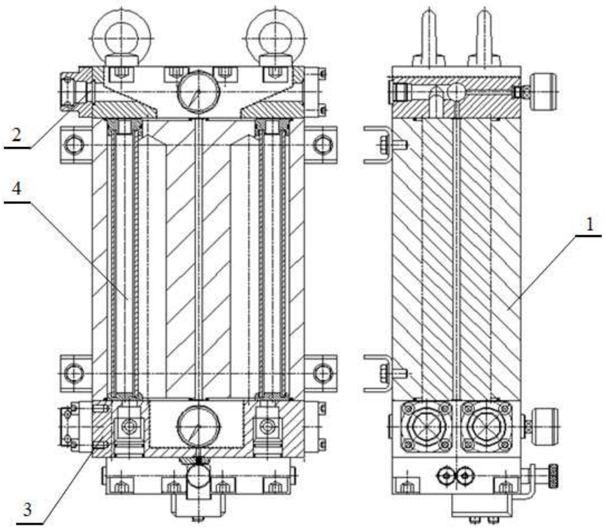

Fig. 1. WFR-250/40 reversion filter
1 – housing, 2 – supplying plate, 3 – flow plate, 4 – filtration cartridge

The filter was subjects to tests at the KOMAG test rig to check its operational correctness and also its manufacture correctness, as both of them are interconnected. These tests incorporated:

- a determination of flow resistances through a high-pressure reversion filter with filtration cartridges,
- a determination of flow resistances through a high-pressure reversion filter without filtration cartridges,
- functionality test during the filter operation:
  – a filtration of the left chamber and a regeneration of the right chamber,
  – a filtration of the right chamber and a regeneration of the left chamber,
- a test of static loading for the pressure of:
  – 40 MPa, i.e. p_{nom} (test of leaktightness),
  – 60 MPa, i.e. p_{nom} x 1.5 (strength test).

A view of the filter on the test rig is shown in Fig. 2.

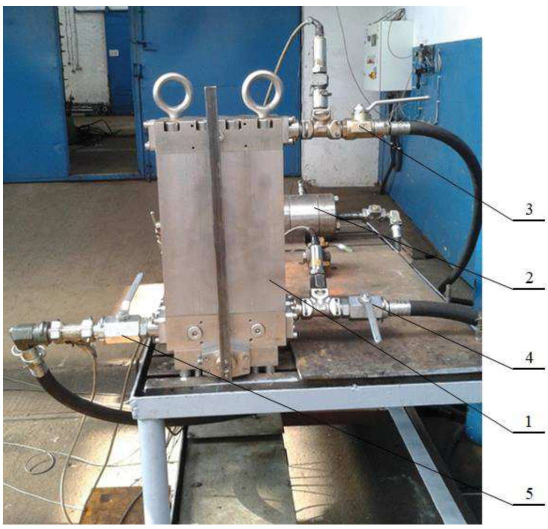

Fig. 2. WFR-250/40 reversion filter on the test rig
1 – filter, 2 – measurement turbine, 3, 4, 5 – hydraulic hoses (respectively: inflow of contaminated liquid, outflow of filtered liquid, outflow of contaminants) with installed pressure transducers and cut-off valves

First of all the filter was subject to tests connected with a measurement of flow resistances. Two tests were conducted, for the filter equipped with filtration cartridges (Fig. 3) and with no cartridges (Fig. 4). The measured pressure drop during the first test was Δp = 1.13 MPa at the flow rate Q = 104.6 dm^3/min. During the second test the measured pressure drop was Δp = 1.06 MPa at the flow rate Q = 103.15 dm^3/min.

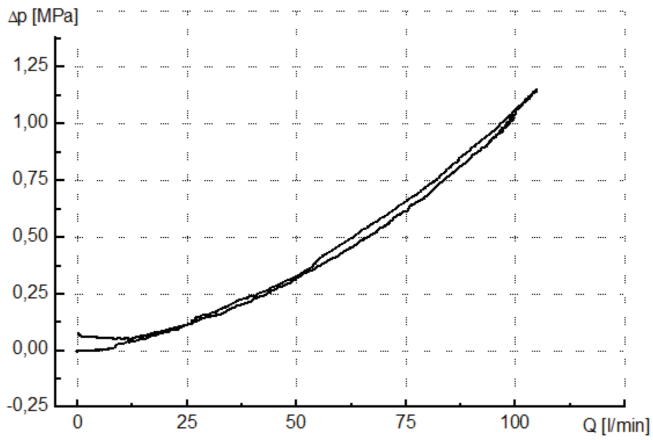

Fig. 3. Graph of flow resistances through the filter with filtration cartridges

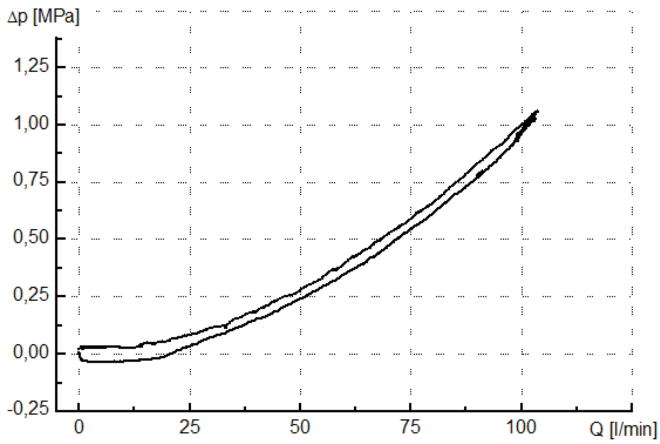

Fig. 4. Graph of flow resistances through the filter without filtration cartridges

Basing on the conducted tests, it was concluded that a construction of the filter meets the design requirements in the scope of liquid flow resistances. The pressure drops during the flow through filtration cartridges were minor and comparable with the pressure drops during the liquid flow through the chamber without any installed cartridges. It confirms a correct selection of the filtration surfaces of cartridges. The next test was the functionality test. It consisted in conducting filtration in both filtration chambers, manual switching of the filter operation into the rinsing mode of one chamber cartridge and then a manual recontrol into the mode of rinsing the other chamber cartridge. An exemplary graph in the case of a filtration through both chambers is shown in Fig. 5.

Due to the fact that the outflow from the filter was not loaded (a direct overflow to the tank), the filtration pressure (course in the graph is marked in black) in each case had the value close to 1 MPa, resulting from flow resistances. The regeneration pressure (in red) had a similar value. In the graph the moment of the valve opening and closing, in the line supplying the filter (in blue), can be clearly seen.

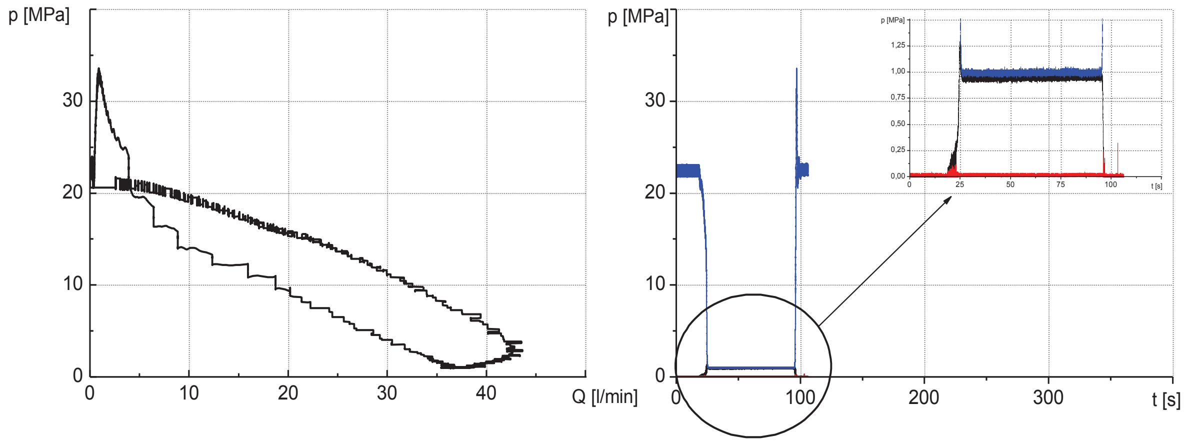

Fig. 5. Graph of pressure in the function of time during the functionality tests. A simultaneous filtration of both filtration subassemblies: in blue – supply pressure, in black – filtration pressure, in red – regeneration pressure

Fig. 6 shows a filtration process with one chamber, whereas the other one is being rinsed (regenerated). In this case a clear increase of regeneration pressure (in red) and the moment of the valve opening and closing, in the line supplying the filter (in blue), can be noticed.
In this case the conducted tests also confirmed the design correctness, switching of the direction of filtration/regeneration did not cause any problems and the flow resistances were similar to those obtained in the former test.

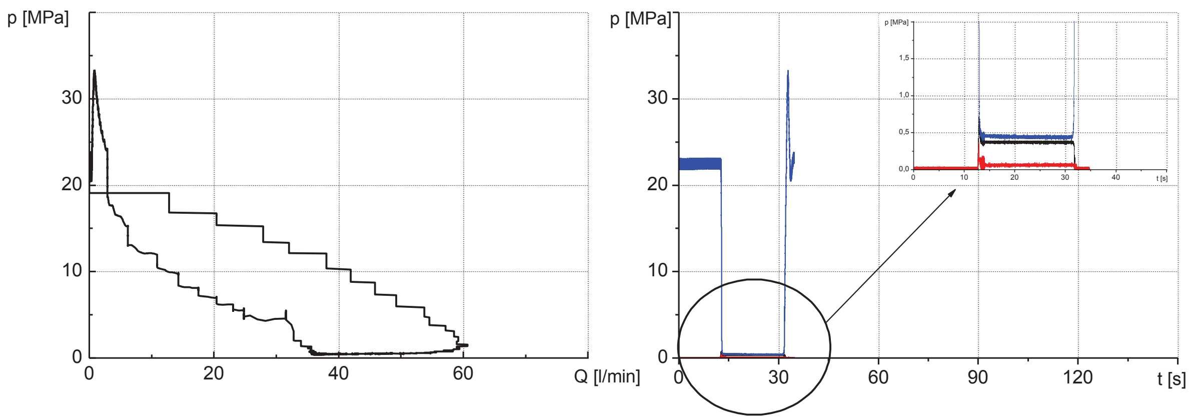

Fig. 6. Graph of pressure in the function of time during the functionality tests – filtration of right chamber and regeneration of left one: in blue – supply pressure, in black – filtration pressure, in red – regeneration pressure

The last test included filter leaktightness and strength tests. During the filter loading with nominal pressure, an outflow of the sealing from the space between the housing and the flow plate (Fig. 7) was noticed. An analysis of the filter housing screw joint with the plates: supply and flow ones showed that such a condition was caused by using stainless screws of class A2, for which the elongation strength limit is Rm = 700 MPa but the yield point is Re = 450 MPa.

Fig. 7. A view after unsealing the filter 1 – housing, 2 – flow plate, 3 – sealing

The screws were exchanged for stronger ones (class 12.9), whose Rm = 1200 MPa and Re = 1080 MPa and screwed home with the moment appropriate for them. During the following test (of leaktightness and of strength) no leakage of filtrated liquid was noticed, what is presented in a form of graphs in Fig. 8 and 9.

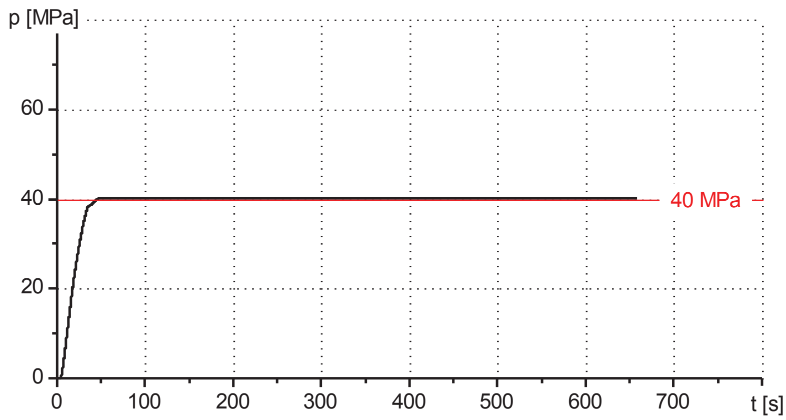

Fig. 8. Test of leaktightness – nominal pressure

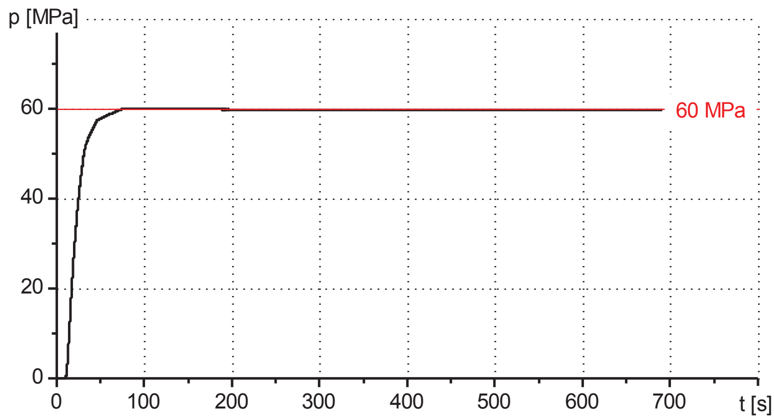

Fig. 9. Strength test – nominal pressure x1.5

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3. Summary

Three thematic groups work in the Division of Machines and Equipment at the KOMAG Institute of Mining Technology. One of them deals with hydraulic issues. It realizes projects oriented onto widely understood power hydraulics. Concepts, projects and technical documentations of machines and equipment to which belong, among others, reversion filters discussed before, are elaborated. These filters, designed for a filtration of water and of water-in-oil emulsion, are widely used in many branches of industry, including the hard coal mining industry. Exactly there, they are used in technological systems connected with the production. They purify water from mechanical pollutants. Among others this water is used in cooling systems of electric motors and high power gear – boxes, spraying systems or as regards emulsion – power roof support units.

Big experience enables to conduct research work connected with hydraulic supply systems and to offer assistance during assembly operations and start-up of machines and equipment constructed on the base of the authors' technical documentation. A close collaboration with the KOMAG laboratories, having test rigs enabling to conduct a broad tests' spectrum of systems, subassemblies and assemblies of power hydraulics for machines in series production and experimental prototypes, facilitates an implementation of safe machines and equipment.

The tests of one of the products, made according to the KOMAG technical documentation, are presented in the article. The conducted tests confirmed a correctness of the design. Drops of pressure during a regeneration of the filter cartridges were minor, which certifies a right selection of filtration surfaces. Only during the test of leaktightness an outflow of the sealing was noticed which was caused by an application of improper screws fixing the flow plate to the housing block. An exchange of screws, for stronger ones mechanically, eliminated the problem and a repeated test of leaktightness did not cause any liquid outflow from the equipment. The strength test, which was conducted by loading the filter with the pressure equal to 1.5 x nominal pressure was also successful which certifies the fact that the filter is efficient and can be exploited safety.

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