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# Production of Slotted Polymer Filter Tubes by Deformational Cutting

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**Abstract**—A method of producing adjustable slotted filter tubes is proposed; the operational characteristics of the tubes are determined as a function of the slot width.

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Coarse and intermediate filters are widely used in manufacturing, in the chemical, food, and medical industries, and in the oil and gas industry. Slotted filter elements are attractive here on account of their low hydraulic drag and the possibility of effective counterflow purification. The use of filters with precise adjustment of the depth of filtration is promising.

The filter elements are made from polymers—such as polyethylene, polypropylene, and fluoroplastic—since they last well, are inert in most of the media being filtered, and are relatively inexpensive.

The possibility of producing slots of width 10 μm or more in polymer pipe by deformational cutting has been experimentally demonstrated [1, 2]. This approach is waste-free and permits the use of standard metal-cutting equipment. Deformational cutting permits the manufacture of polymer slotted filter tubes, including tubes with slots of adjustable width.

The production of slotted filter tubes is based on deformational cutting of the tube wall, so that the cuts form rows of slots (Fig. 1). Slot cutting by a rotary tool is most promising, in conditions where the speeds of the tool and the blank (tube) and the tool supply along the tube are matched (Fig. 2). The speed ratio of the tool and the blank determines the number of rows of slots. This method is well suited to a lathe equipped with a device for rotating one or more tools (Fig. 3).

With a certain speed ratio of the tool and the blank, the rows of slots will be helical (Fig. 4); the inclination of the rows to the tube axis is directly proportional to the difference between the speeds. A tube with such a slot configuration may be axially deformed, analogously to a spring. The inclination $\omega$ of the rows to the tube axis depends on the speed of the blank $n_{tu}$, the speed $n_t$ of the tool assembly, the tool supply $S_{bl}$ per turn of the blank, and the external tube diameter $D$ [2]

$\omega = \arctan\left(\pi D\left(1 - \frac{n_t}{i n_{tu}}\right)/S_{bl}\right)$, where $i = n_t/n_{tu}$ is the number of rows of slots and is rounded to the nearest integer.

The rigidity of the filter element is inversely proportional to $\omega$. Axial extension of the filter element increases the width of the slots, which permits regulation of the size of the filtered particles. In addition, at maximum extension—that is, maximum slot width—counterflow in the filter element is possible. The change in slot width is directly proportional to the extension of the filter element and inversely proportional to the number of slots in the given section. Hence, the slot width $b$ may be calculated as $b = b_0 +$

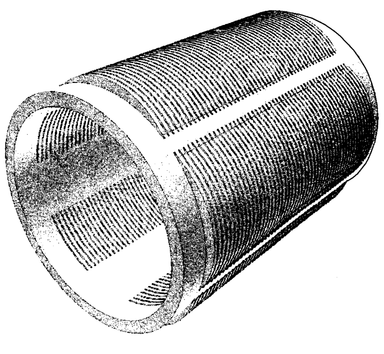

**Fig. 1.** Slotted filter tube made from a standard blank.

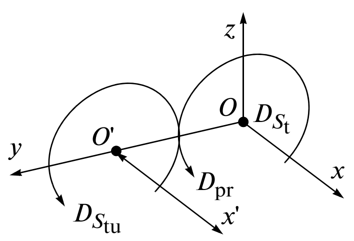


**Fig. 2.** Kinematic diagram of slot production on the filter element: $D_{pr}$, primary rotary motion of tool; $D_{S_{tu}}$, rotary supply motion of blank; $D_{S_t}$, linear supply motion of tool.

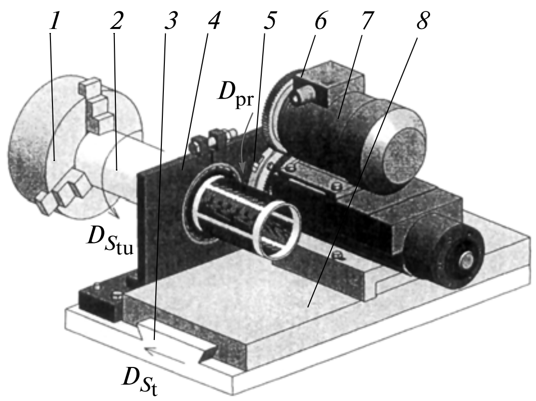


**Fig. 3.** Device for producing slots in a filter element with rotation of the tool and blank: (*1*) chuck; (*2*) blank; (*3*) lathe's longitudinal support; (*4*) mobile stay; (*5*) tool; (*6*) tool assembly; (*7*) tool drive; (*8*) transverse slides of lathe support.

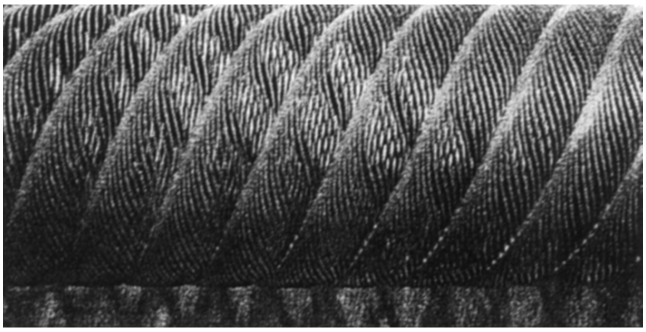

**Fig. 4.** Slotted filter tube in the extended state ($b$ = 1 mm).

$\Delta Lp/L$, where $b_0$ is the slot width with no extension; $\Delta L$ is the increase in length of the section on extension; $p$ is the spacing between the slots; $L$ is the length of the section.

Besides the degree of filtration, which depends on the slot width, an important characteristic of the filter element is its hydraulic drag, which must be taken into account in filter selection and in design of the hydraulic system. The hydraulic drag is expressed as the dependence of the pressure difference $\Delta p$ at the filter element on the liquid flow rate $Q$ [3]. As a rule, the hydraulic drag is determined experimentally.

In the department of hydraulics, hydraulic machinery, and automatic hydropneumatic systems at Bauman Moscow State Technical University, the hydraulic characteristics of slotted filter tubes produced by deformational cutting have been studied, with tap water as the working fluid. For example, the

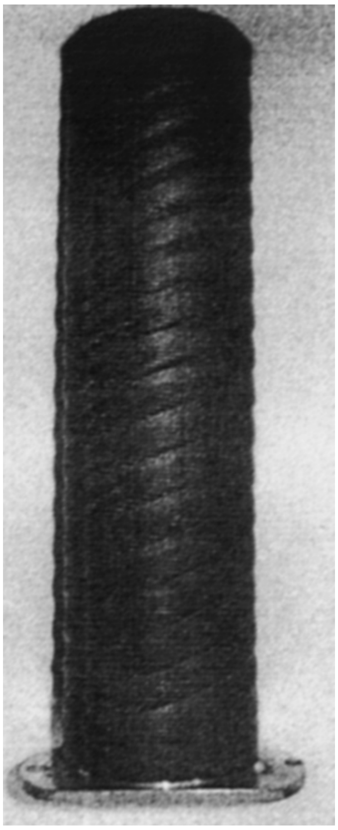

**Fig. 5.** Filter element.

technical characteristics of the filter element in Fig. 5 are as follows:

| | |
|---|---|
| External diameter, mm | 50 |
| Wall thickness, mm | 3 |
| Length of section with slots, mm | 165 |
| Slot spacing, mm | 1 |
| Number of slot rows | 6 |
| Slot width without extension, μm | 100 |
| Inclination of helical slot rows, deg | 69 |

The helical slot rows are directed to the right.

The filter element is mounted in a housing. A screw at the top of the housing permits extension of the slotted filter tube (Fig. 6). The extension is measured by a clock-type indicator.

The hydraulic system of the experimental apparatus is shown in Fig. 7. Water is supplied by centrifugal pump *1*, with regulation by valve *2*. The pressure difference at filter *4* is determined from the readings of manometers *3* and *5*; the water flow rate is determined by means of measuring tank *6*.

From experimental results for a controllable filter and for the same housing without the filter element, subtraction of the approximate data yields the depen-

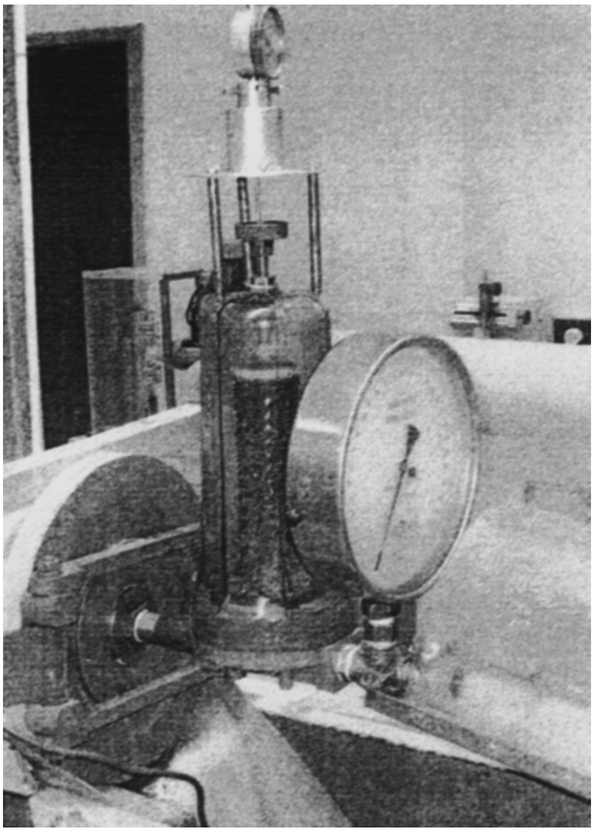

**Fig. 6.** Assembled adjustable filter.

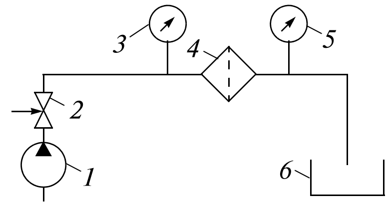


**Fig. 7.** Hydraulic diagram of experimental apparatus.

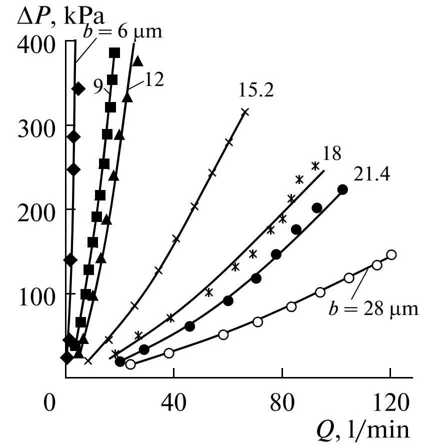


**Fig. 8.** Dependence of the pressure difference $\Delta p$ in the slotted filter tube on the water flow rate $Q$, for different slot widths.

dence of the pressure difference $\Delta p$ in the slotted filter tube on the water flow rate $Q$, for different slot widths $b$ (Fig. 8) $\Delta p(Q_i) = \Delta p_f(Q_i) - \Delta p_h(Q_i)$, where $\Delta p_f(Q_i)$ is the pressure difference in the assembled filter at flow rate $Q_i$; $\Delta p_h(Q) = 0.0213Q^{1.85}$ is the pressure difference in the housing without the filter element at the same flow rate.

Analysis shows that, when the slot width is less than 15 μm, the pressure difference at the assembled filter is significantly greater, even at low flow rate. Therefore, it is expedient to conduct fine filtration at a flow rate no higher than 20–30 l/min, with a 260-cm$^2$ filter surface. With increase in flow rate, the sharply increased pressure difference requires verification of filter strength. The strength of the filter element will depend on the structural parameters: the external diameter, wall thickness, length of the working section, slot spacing, and slot width.

Thus, our experiments confirm the practicality of filter tubes with adjustable slot width, at pressure differences up to 400 kPa.

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