Creation of a universal housing for a liquid purification filter made of corrosion-resistant steels

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Abstract. Scientists from different countries are engaged in the development of new or improvement of existing water purification technologies. At the same time, not enough attention is paid to the development of equipment for water purification and technologies for their manufacture. The article presents a model of a universal filter housing for cleaning liquids from solid particles. Mechanical filters of cartridge or bag type can be used as filter elements. The main supporting element of the filter housing is a thin-walled cylindrical flask. The use of rotary rolling in the process of manufacturing a cylindrical flask makes it possible to reduce the negative effect of welded seams and increase the strength of the cylindrical shell. The results of experimental studies on assessing the effect of the relative deformation value along the wall thickness during rotary rolling of steel cylindrical shells on their strength and stability are presented.

1 Introduction

Providing the population and food industry enterprises with high-quality drinking water, as well as purification of domestic and industrial waste water are among the most important tasks of the world level [1-4]. Poor-quality drinking water can cause various human diseases [5, 6]. For water purification, depending on the type and concentration of pollutants, as well as the volume of its consumption, various technologies are used [1, 3, 4, 6-14].

The condition and ease of maintenance of the equipment and communications used have a great influence on the quality and cost of water treatment [2, 3, 7, 12, 14]. From this point of view, the most effective are modular cleaning systems, which are a system of sequentially installed filters [15-17].

Currently, cartridge trunk filters are widely used for household needs [16]. The demand for such filters is due to the versatility of the design, ease of maintenance, and relatively

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low cost. The disadvantage of such filters is their low productivity, which does not allow them to be used for water purification in the amount consumed by industry.

To remove solid and colloidal particles, mechanical cleaning filters of cartridge or bag type are used (Fig. 1). The main disadvantage of such filters is the need to use, depending on the type and design of the filtering element, various filter housings.

![Fig. 1. Examples of filter elements: a - cartridge type; b - bag type.](image)

2 Materials and methods

A model of the design of a filter for cleaning a liquid from solid particles using filter elements of a cartridge or bag type is shown in Fig. 2. The filter is a sealed vessel consisting of a body 1 with nozzles for supplying and removing liquid and a cover 2. Inside the body there is a filtering partition designed to divide the working cavity of the body into two chambers (a chamber with an initial liquid and a chamber with a purified one) and installation of a filter element. In contrast to existing models, the filter partition is made of two plates, upper 3 and lower 4, and does not have a rigid fixation with the filter housing, for example, by welding. The fixation of the filter partition is ensured by pressing the fixing gasket 5, made of an elastic material (for example, rubber), to the body 1. This fixing principle allows you to change the installation height of the filter partition depending on the length of the filter element.

Special grooves are provided in the plates of the filtering partition for hermetic fixing of the filtering element. In Fig. 2b an example of fastening a bag-type filtering element with a basket 6 is shown. To install a filtering element of a different type or of a different diameter, without changing the design of the filter housing, it is necessary to use a filtering partition having grooves corresponding to the type and size of the filtering element.

The main supporting element of the filter housing is a thin-walled cylindrical flask. Thin-walled cylinders of filter housings for water purification are predominantly made of corrosion-resistant steel, the cylindrical shape of which is given by rolling sheet blanks on a sheet bending machine, followed by longitudinal welding of abutting edges. The main requirement for welded filter housings under conditions of ensuring weld penetration through their entire thickness and the absence of defects in welded joints is their strength under the action of static and alternating pressure [14, 18, 19].
3 Results

Table 1 shows the results of experimental tests of thin-walled rolled cylindrical specimens to assess their strength under static internal pressure. Experimental cylindrical specimens were made of AISI 304 and AISI 321 steels with a tensile strength of 510 MPa and 520 MPa, respectively. Experimental samples with a diameter of 90 mm with an initial wall thickness of 1.0 mm were rolled to thicknesses of 0.9, 0.8, 0.7, and 0.6 mm.

Table 1. Influence of relative deformation during rolling on the strength of thin-walled cylindrical specimens.

<table>
<thead>
<tr>
<th>No.</th>
<th>Wall thickness, mm</th>
<th>Relative deformation ε along the wall thickness during rolling</th>
<th>Internal static pressure of destruction P, kPa</th>
<th>Calculated von Mises stress, MPa, arising in the wall of a cylindrical specimen during fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>AISI 304</td>
<td>AISI 321</td>
</tr>
<tr>
<td>1</td>
<td>1.0</td>
<td>0.0</td>
<td>12624</td>
<td>12753</td>
</tr>
<tr>
<td>2</td>
<td>0.9</td>
<td>0.1</td>
<td>21662</td>
<td>23417</td>
</tr>
<tr>
<td>3</td>
<td>0.8</td>
<td>0.2</td>
<td>19912</td>
<td>21513</td>
</tr>
<tr>
<td>4</td>
<td>0.7</td>
<td>0.3</td>
<td>18483</td>
<td>19902</td>
</tr>
<tr>
<td>5</td>
<td>0.6</td>
<td>0.4</td>
<td>16089</td>
<td>17444</td>
</tr>
</tbody>
</table>

The results of experimental studies to assess the effect of the outer diameter D and the wall thickness t on the critical value of the length L of the rolled part of the cylindrical shell, at which there is a loss of stability of the shell wall, characterized by the formation of
bulges or corrugations are shown in fig. 3. Experimental samples were made from AISI 304 steel with an initial wall thickness $t_0 = 1.0$ mm.

4 Discussion

The use of rotary rolling in the process of manufacturing a cylindrical flask makes it possible to reduce the negative effect of welded seams and increase the strength of the cylindrical shell. The quality of steel thin-walled axisymmetric vessels obtained using the rotary rolling operation depends on the combination of the geometric parameters of the rolled pipe and tool, the degree of pipe wall thinning and the mechanical characteristics of the cylindrical billet material [14, 20-22].

It can be seen from the results obtained that even at a relative deformation $\varepsilon=0.1$, a sharp hardening of the material is observed, caused by work hardening due to plastic deformation of the shell material, while the samples are able to withstand internal static pressure by about 70% more. With a further increase in $\varepsilon$, a slight increase in the strength of the material and a decrease in the value of the fracture pressure are observed, as well as with an increase in $\varepsilon$, the critical value of the length of stable shaping by rotary rolling of cylindrical shells decreases. It should be noted that at $\varepsilon<10\%$, complete elimination (smoothing) of undercuts on the fusion lines of welded seams is not ensured [14].

Fig.3. Graphical dependence of the critical value of the length $L$ (mm) of stable forming by rotary rolling of cylindrical shells made of AISI 304 steel on the outer diameter $D$ (mm) and wall thickness $t$ (mm) of the rolled part (with the initial wall thickness $t_0 = 1.0$ mm).

5 Conclusions

Thus, the recommended range of values of the relative deformation along the wall thickness during rolling should be taken within $10\% < \varepsilon \leq 25\%$. The choice of $\varepsilon$ from the specified range ensures the stability of the wall of the cylindrical part of the vessels of a wide range of sizes and makes it possible to manufacture filter housings for liquid purification with
high performance properties and reduced material consumption, by reducing the volume of material used for the cylindrical part of the housing to 25%.

![Mechanical treatment section of the water treatment plant LLC GoodChicken, Voronezh region, Russia.](image)

The developed filter design was used in the construction of a water treatment plant for LLC GoodChicken (Fig. 4).

### 6 Acknowledgements

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