International Journal of Industrial Engineering and Management (IJIEM), Vol. 7 No 3, 2016, pp. 125-128
Available online at www.iim.ftn.uns.ac.rs/ijiem_journal.php
ISSN 2217-2661

UDK: 658.512.2:669.017/.018

3D Technology in Production of Sealed Containers for Chemical Industry Devices

Nicolay P. Miducov
Senior Lecturer, Saint Petersburg State University of Industrial Technology and Design,
Ivan Chernykh Street, 4, 198095, Saint Petersburg, Russia, mnp83@mail.ru

Maria A. Fadeeva
Student, Saint Petersburg State University of Industrial Technology and Design,
Ivan Chernykh Street, 4, 198095, Saint Petersburg, Russia

Alexey A. Tikhonov
Professor, Saint Petersburg State University, 7-9 Universitetskaya nab., Saint Petersburg, 199034, Russia,
Professor, ITMO University, 49 Kronverksky Ave., Saint Petersburg, 197101, Russia, a.tikhonov@spbu.ru

Pavel V. Kaurov
Senior Lecturer, Saint Petersburg State University of Industrial Technology and Design,
Ivan Chernykh Street, 4, 198095, Saint Petersburg, Russia, pucmo@mail.ru

Victor S. Kurov
Professor, Saint Petersburg State University of Industrial Technology and Design,
Ivan Chernykh Street, 4, 198095, Saint Petersburg, Russia

Pavel A. Gashin
Student, Saint Petersburg State University of Industrial Technology and Design, Ivan Chernykh Street, 4, 198095, Saint Petersburg, Russia

Received (03.12.2015.); Revised (17.06.2016.); Accepted (30.07.2016.)

Abstract

Chemical industry today needs new high-tech and cheap sealed containers for devices. The material on the usage of 3D technology in production of device's drum is presented in this article. Samples of device's containers for chemical industry were fabricated by means of 3D printer with different parameters of the 3D printing (thickness of the drum and layer's height). The leak tightness of device's containers was tested under the air pressure. The optimum regimes for 3D printing of sealed containers for devices correspond to minimum possible thickness of sealed containers. The obtained results can be used in low cost production of chemical devices with complex body shape.

Key words: *containers for devices, leak tightness, 3D-technology, chemical industry*

1. INTRODUCTION

Chemical industry today needs new high-tech and cheap sealed containers for devices. These of the devices in contact with the liquid environment (in most cases water), are made of stainless steel. Complexity of containers' shapes, non-standard pipelines, confusors and diffusers makes them expensive, increases time of their production [1]. The important requirement at the same time is the leak tightness at a small thickness of a body's wall. Today 3D - printing is the most widespread and available type of production of non-standard details of irregular shape [2-4]. However the 3D technology isn't ideal and there is a number of problems. Plastic printing is based on the technology of material coating in the form of layers. The main problem at the same time is temperature deformation [5]. As a result of detail height increasing the temperature of the lower layers is more than the temperature of the layers located at considerable height from the warmed-up table. It means that the deformations occur in container's walls because of the temperature gradient which causes the layer separation and leakage of the tank course. Besides this, each layer can have imperfections which also affect the leak tightness of container.

Therefore the finding of the optimum mode for 3D printing in fabrication of highly leakproof thin-walled details is the main goal of our research.

To achieve this purpose the following problems were solved: preparation of the printing equipment

(3D-printer, compressor, service equipment); designing of 3D models of a thin-walled part; fabrication of the parts with various printing parameters; testing of obtained samples for leak tightness; the analysis of the obtained data.

2. EXPERIMENTS AND MATERIALS

The experimental part of our research included the following main positions: designing of a model of the body using the computer AutoCAD program; assembling and preparation of installation for carrying out the experiment; the coding of the model of the body by means of the Cura program which has various printing characteristics; fabrication of samples; testing of the samples for leak tightness.

The Wanhao Duplicator i3 3D-printer was used for the production of samples (area of the printing is 200x200x180 mm, thickness of a printing layer is 0.1-0.4 mm, diameter of a nozzle is 0.4 mm, the maximum speed of the printing is 100 mm/sec, working temperatures of an extruder are 190-260°C, platforms are 60-115 ºC, the supported types of files are ".stl" and ".gcode").

For the leak testing of samples the UK 40-2M compressor was used (nominal working pressure is 2 kgf/sm^2, productivity under nominal pressure is 40 liter/min, most reached pressure is 3.2 kgf/sm^2, the most reached vacuum is 70%).

The test samples were made of ABS plastic produced by FL33 company (the producing country is China, the diameter of a thread is 1.75 mm, melting point of 210-260 °C, solidification temperature of 130 °C).

The lacquer "Taft Mega Strong" with collagen entering into the composition and increasing adhesion was used for the best fixing of material on a working surface of the printer when drawing the first layers of plastic. For maintenance of constant temperature during the printing near the printer hermetically fixed cardboard box was used. Average temperature in the box was 42 ± 3 ºC.

The full scheme of experimental installation for the analysis of leak tightness of the samples is presented in Figure 1.

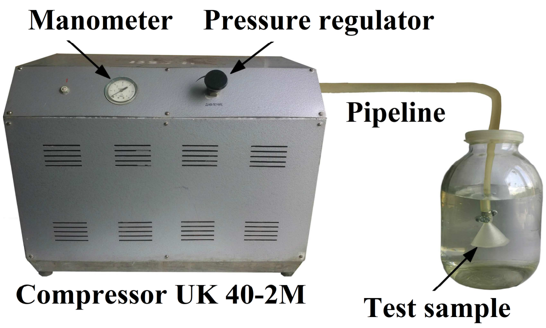

Figure 1. Scheme of experimental installation

3. RESULTS

The samples made by means of the 3D-printer from ABS plastic are presented in Figure 2.

Figure 2. Experimental samples

The geometric sizes of samples are presented in Figure 3. The main parameter of 3D - printing, influencing tightness of samples, is the printing layer height.

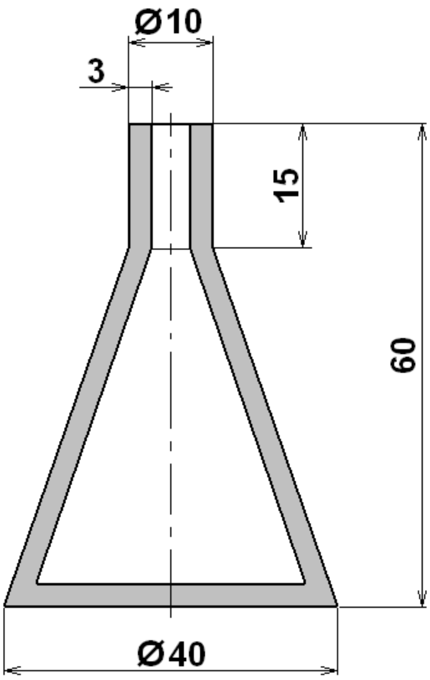

Figure 3. Geometric sizes of experimental samples

With the increase of this parameter the accuracy of production of the body decreases (the wall roughness raises) and tightness of a sample decreases also.

Experimental studies were conducted with height of a printing layer of 0,1-0,25 mm. Critical air pressure in a sample was defined visually, for this purpose the sample was plunged into the transparent container with water.

Critical pressure corresponded to emergence of air bubbles.

The results of the visual observation determining critical pressure with a different height of a printing layer are presented in Figure 4.

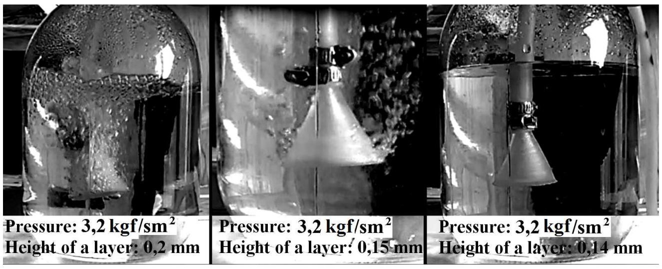

Figure 4. The results of visual observation (different heights of printing layers)

Thickness of a wall of samples is the main geometrical parameter determining the product cost. With the increase in thickness of it the consumption of material and, respectively, the cost increases. In this research, samples with a wall thickness range from 1 mm to 4 mm have been made. Figure 5 shows the results of the visual observation and determining the critical pressure at different thicknesses of a wall.

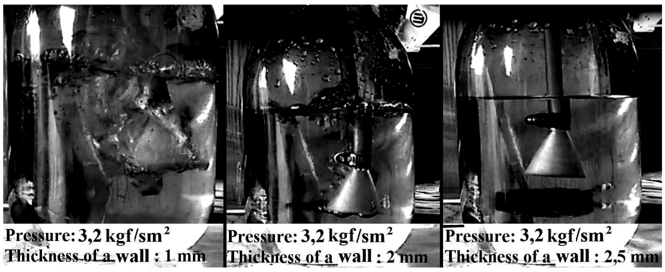

Figure 5. The results of the visual observation (different thicknesses of a wall)

By analyzing dependencies of main parameters it is possible to obtain optimum values of thickness of a wall of the device and height of a layer of the printing. From the diagram in Figure 6 it is visible that the critical point of decrease in air pressure (violation of tightness of the body of the device) corresponds to the height of a layer of 0.14 mm. Further reduction of height of a layer (less than 0.14 mm) doesn't increase tightness of a product, but increases production time. According to the made experiments for the samples with height of a layer of 0.1 mm and 0.14 mm, the time difference of production makes 1 hour 21 minutes.

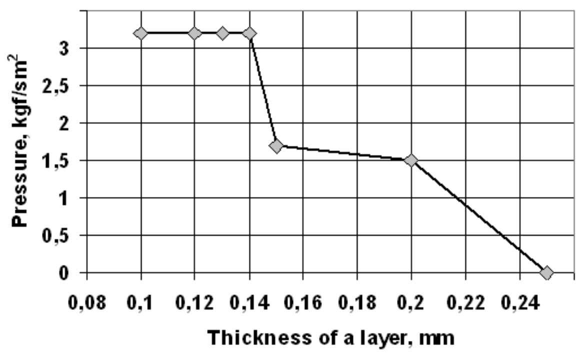

Figure 6. Layer's thickness dependence of the pressure

Dependence of time of production on height of a layer is presented in Figure 7. In the absence of strict requirements to a roughness of a surface it is irrational to reduce the layer height as at the same time the printing time, power costs of heating and work of an extruder and a desktop increase.

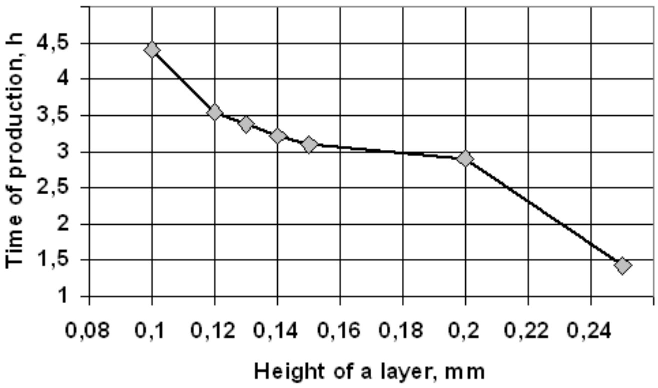

Figure 7. Layer's height dependence of production time

The analysis of data on variation of air pressure as a function of thickness of a wall of the body (Figure 8) allows defining a critical point in pressure decreasing (violation of tightness of the body of the device). It correspond the 2.5 mm thickness of a wall. Thickness of a wall influences time of the printing and material consumption.

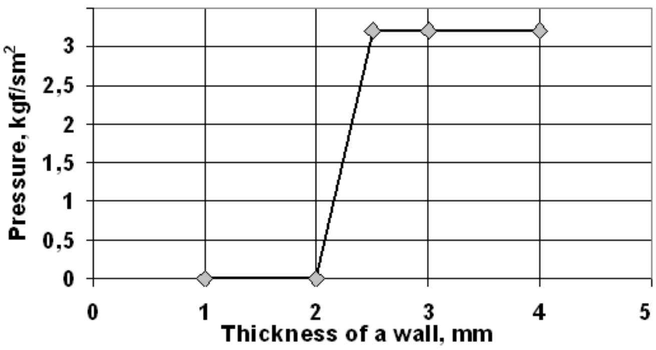

Figure 8. Wall thickness dependence of pressure

Figure 9 shows the diagram of dependence of a consumption of plastic on wall thickness.

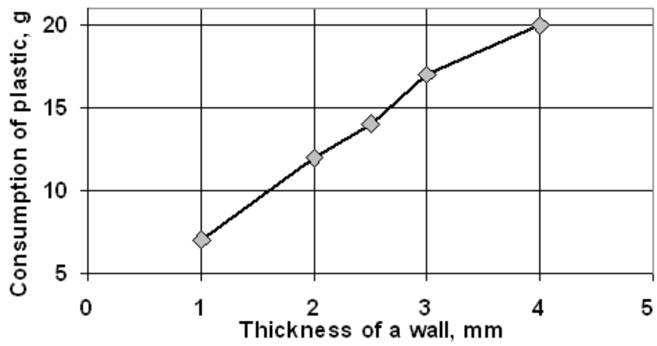

Figure 9. Wall thickness dependence of plastic consumption

4. CONCLUSION

1. Optimum height of a layer of the printing of the tightness devices' bodies from ABS–plastic equal to 0.14 mm is determined. It allows to keep pressure of 3.2 kgf/sm^2 and to make a product in minimum time. It is recommended to use the received value of thickness in the absence of additional requirements for a surface roughness.
2. Optimum thickness of a wall of 2.5 mm for the air pressure of 3.2 kgf/sm^2 is determined and it corresponds to the minimum expenses of plastic and time of the printing.
3. The results received during this research can be put into practice in real life. Their application will be reflected on economic benefit and decrease in energy consumption in chemical industry that are the main problems of chemical technology. Use of 3D - printing will also reduce time of production of bodies of devices and their service. Thus, the 3D - printing technology meets the requirements of development of chemical technology, optimizing conditions of production of devices and decreasing in product cost at the expense of it.

5. REFERENCES

[1] Lysych M., Shabanov M, Romanov B (2014), "Sphere of technologies, 3d printing " New high technologies, No. 12 - 2, pp. 165 – 169 (in Russian).

[2] Ishengoma, F. and Mtaho, A. (2014), "*3D Printing: Developing Countries Perspectives*", International Journal of Computer Applications, Vol. 104, No. 11, pp. 30 - 34.

[3] Fink S., Fuhrmann U., Lange C., Mueller R. and Zwecker V. (2016) "3d Printed Cryogenic High Voltage Devices", IEEE Transaction on applied superconductivity, Vol. 26, No. 3 April 2016

[4] Bernardini, F. and Rushmeier, H. (2002), "*The 3D Model Acquisition Pipeline*", Comput. Graph. Forum, Vol. 21, No. 2, pp. 149 - 172.

[5] Crane N., Lusk C., Nussbaum J. and Consuegra Reyes Y. (2013) "Deformation post processing of additive manufacturing components", in Solid Freeform Symposium, Austin, Texas, pp. 242

3D Tehnologija u proizvodnji zaptivenih posuda u hemijskoj industriji

Nicolay P. Miducov, Maria A. Fadeeva, Alexey A. Tikhonov, Pavel V. Kaurov, Victor S. Kurov, Pavel A. Gashin

Primljen (03.12.2015..); Recenziran (17.06.2016.); Prihvaćen (30.07.2016.)

Apstrakt

Današnja hemijska industrija zahteva visoko tehnološke i jeftine kontejnere. Posude koje se upotrebljavaju u hemijskoj industriji danas moraju biti i visokotehnološke i pristupačne sa cenom.
U ovom radu je prikazana upotreba 3D tehnologije u proizvodnji rezervoara posude. Uzorci posuda za hemijsku industriju su kreirani primenom 3D štampača sa različitim parametrima 3D štampanja (debljina rezervoara i visina sloja štampanja). Zaptivenost je testirana putem vazduha pod pritiskom. Optimalni režimi za 3D štampanje posude odgovaraju minimalnoj mogućoj debljini posude. Rezultati se mogu koristiti u proizvodnji posuda komplesnog oblika za hemijsku industriju, sa niskim troškovima.

Ključne reči: *Posude za hemijsku industriju, zaptivenost, 3D tehnologija, hemijska industrija*