Implementation of additive technologies in the system of maintenance and repair of printing machines

E Yu Orlova¹, M A Riahtsev¹, L G Varepo², O V Trapeznikova²

¹Moscow Polytechnic University, 38, B. Semenovskaya str., Moscow, 107023, Russia
²Omsk State Technical University, 11, Mira ave., Omsk, 644050, Russia

E-mail: orrlova@bk.ru, larisavarepo@yandex.ru

Abstract. Results of testing the additive technology and recommendations for its implementation into the structure of maintenance and repair of printing plants are given, as an example of manufacturing simple parts in a service point. Additive technology method was used for manufacture and testing of coatings of feeder table sheet feeding rolls and web conductors, the housing of the stroboscope for monitoring the check marks on the impression print in the process of printing, sealing packings to the automatic cleaning system of offset machines printing unit. A preliminary analysis of print materials, presented in the Russian market, that can be used in print works for manufacturing spare parts of printing machines, was carried out.

1. Introduction
The use of additional technologies in the manufacture of spare parts and fittings became widely-used and have been used for a rather long time in such industries as marine [1] and military machinery [2], mineral industry [3], automobile manufacturing and railroad transport maintenance. But additive technologies are gradually finding their place in the printing equipment maintenance system. Printing equipment has its specificity, which is represented both by machinery classification depending on the technology of pre-printing, printing, and post-printing processes and by scatter and use of mostly imported equipment throughout the Russian Federation. The last factor plays a significant role in the development of the use of additive technologies for spare parts manufacturing in conditions of pandemic and unpredictability of terms of border opening and closure in countries that supply and manufacture spare parts. In these conditions, the possibility of manufacturing slow-speed spare parts, high-demand spare parts with long-term usage cycle [4], and simple parts [5] at the place of printing machinery maintenance and operation may be actual now more than ever.

It is known that 3D printing has the following advantages when used in the maintenance and repair system:
– reduction of unscheduled downtime, reduction of time for waiting for a spare part;
– release of areas for storage, and the plant financial assets [3];
– ability to store files in cloud spaces and their uploading by request;
– waste and energy consumption minimization in the manufacture of parts;
– possibility of manufacturing spare parts for obsolescent equipment.

However, the use of this technology has disadvantages, namely:
– just a small part from 2.83 % of machinery details is technically and cost-effective for 3D printing [6,7], therefore, analysis [8] and strict classification of machine parts suitable for manufacture with regard of minimal requirements to tolerances and surface final machining, [9] are required;
– discretization and creation of the spare parts library for 3D printing components search are required;

1901 (2021) 012015 IOP Publishing doi:10.1088/1742-6596/1901/1/012015

MSTU 2021
– limitation of available 3D printing materials;
– issue of 3D printing materials environmental safety;
– issues of commercial importance of the 3D purchase and maintenance.

2. Problem statement
The problem statement consists in testing the implementation of additive printing technology at a printing plant by way of example of simple parts mounted on printing machinery, selection of bearing materials, and parts of printing machinery, that can be manufactured through 3D printing in the long run.

3. Problem solution
For testing the 3D printing technology implementation, KBA Rapida 105 offset machine sheet feeding system feeder table rolls were used as samples. They consist of an aluminum sleeve with a rubberized coating and are pressed on a bearing. Rolls were dismantled from the machine and analyzed for the nature of wear. Roll coating damages had signs of wearing away. The old rubberized layer was removed from the roll sleeve by the turning method. The model STL file was created for print. The example is given on attached 3D drawings in Figures 1–4. The model was built in SolidWorks 2015 CAD package. Work with Cura 14.07 slicer application and Gcode model preparation were carried out, with regard to the selection of plastic, layer height, print speed, and the part arrangement on a worktable. Further, the part was printed with the subsequent processing, and the cover fixation on the sleeve.

Polyurethane-based bearing material for 3D printing by PrintProduct, grade TiTi Flex Soft, was used for roll shell manufacture. Specifications stated: hardness - 70HSA; density - 1,18 g/cm³, elasticity modulus – 4 MPa; strength – 30 MPa; relative tensile elongation 650%; breaking strength 70 N/mm; temperature interval: –60 °C...+150 °C [10]. Cover printing parameters were selected as follows: nozzle size 0,4 mm; layer height: 0,1 mm; fill density: 100%; printing temperature: 239 °C; print speed: 50 mm/s. The selection of low print speed is conditioned by the absence of experience of printing with materials given, and by cases of catching the filament bar in the feed mechanism on higher speed due to its flexibility. Further, this issue was resolved by the mechanism modernization.

Figure 1. SolidWorks2015 application window for roll coating design.
Figure 2. Cura 14.07 print process application window. Gcode model preparation, with regard to selecting plastic, layer height, print speed, and the part arrangement on the worktable.

Figure 3. Modeling of a roll drawing in SolidWorks2015 software package

Figure 4. Modeling of a coated roll as an assembly unit in SolidWorks2015 software package

Another additive technology implementation project was organized in a part of an improvement suggestion for developing a device for monitoring the special mark on impression prints directly on the printing machine. The stroboscope housing was developed and printed on a 3D printer. The housing consists of the base and the lid, Figures 5–7. Has a slot for boards and wiring, seats for LED installation, lid fixation holes, and a central hole for fixation on a printing machine bracket. The same software packages as described above in this article were used for 3D model implementation. PETG material. Housing print parameters: nozzle size 0.4 mm; layer height: 0.2 mm; fill density: 50%; printing temperature: 250 °C; print speed: 100 mm/s.
For the manufacture of sealing pads for offset machine printing section automatic washing system, modeled in SolidWorks 2015 CAD software, TiTi Flex Soft plastic was used. Print parameters: nozzle size 0.4 mm; layer height: 0.1 mm; fill density: 100%; printing temperature: 240 °C; print speed: 120 mm/s. The product print result is given in Figure 10.

4. Results discussion
For the possibility of printing specimen products, manufacturers' data were analyzed, and bearing materials, that may further be used for 3D printing of spare parts on printing plants, were selected; these materials are given in Table 1. Finished products are shown in Figures 8, 9, and 10.
Table 1. Materials for 3D printing of printing equipment parts.

| Material grade | Manufacturers' specifications | Recommended spare parts for manufacturing by 3D printing |
|----------------|------------------------------|----------------------------------------------------------|
| TiTi Flex Soft [10] | Shore hardness number — 70HSA; density — 1.18 g/cm³; elasticity modulus — 4 MPa; strength — 30 MPa; relative tensile elongation 650%; breaking strength 70 N/mm; temperature interval: – 60 °C….+150 °C | feeders, covers of paper conducting rolls, elements of flexible line of sheet blow feeding to the paper feed hopper |
| U3 TPU FLEX CFF 29D [11] | Extensional modulus 103 MPa Tensile strength 15.8 MPa Tensile strength —16.5 MPa Shore hardness number 29 D Electric resistance 1500 Ohm Tensile elongation, 32.5 % Tensile elongation 31.7 % | |
| U3 FLEX CONDUCTIVE [12] | Volume resistance: 1.14·10³ Surface resistance 9.50·10³ Young's modulus (ISO 527 – 1.2) 77.9 MPa Force at break (ISO 527 – 1.2) 15.3 MPa Elongation to break (ISO 527 – 1.2) 2.6% Shore hardness number 42 D Extensional modulus, 69.3 MPa | as antistatic material in the production of paper conducting elements, electric equipment cases with electric earthing |
| U3 ABS CONDUCTIVE [13] | Extensional modulus, 1652 MPa Tensile strength 28.3 MPa Tensile strength 28.7 MPa Shore hardness number, 73D Deformation temperature, 103 °C Impact resilience, 11.74 kJ/m² Tensile elongation, 2.54% Tensile elongation, 2.43 % | |
| U3 ABS DISSIPATIVE [14] | Impact resilience, 17.1 kJ/m² Deformation temperature, 100 °C | housing with charge continuous flow |
| TiTi Flex Spring Polyurethane [15] | Shore hardness number 55 D Density 1.18 g/cm³ Elasticity modulus – 3 MPa; Strength – 29 MPa; Relative elongation after break – 550%; | Sleeves, pads, sleeve gaskets, rugged housings, patch pieces, coating of sheet feeding rolls and web conductors, manufacture of flexible wear-resistant products |
Tensile strength – 70 N/mm; Wear resistance – 35 mm³

| Material                  | Property                        | Value                                      |
|---------------------------|---------------------------------|--------------------------------------------|
| TiTi Flex Hard [16]       | Shore hardness number           | 70 D                                       |
| Polyurethane              | Density –                       | 1.23 g/cm³                                 |
| HIPS [17]                 | Extrusion temperature           | 230 °C – 240 °C;                           |
| High-impact polystyrene;  | Bending strength                | 33 MPa                                     |
| Thermoplastic polymer     | Flex modulus                    | 2280 MPa                                   |
|                           | Breaking strength               | 62 MPa                                     |
|                           | Relative tensile elongation     | 65%                                        |
|                           | Thermal contraction             | 0.8%                                       |
|                           | Material density                | approx. 1.05 g/cm³                         |
|                           | Thermal contraction             | 0.8%                                       |
|                           | Recommended table temperature   | approx. 90 °C                              |
| Nylon Strong [18]         | Extensional modulus             | 1135 MPa                                   |
| PA12-based compound with  | Density,                        | 1.07 g/cm³                                 |
| carbon fiber filling over  | Tensile strength, 30 MPa        |                                            |
| 10% U3 NYLON SUPER CARBON M3 | Tensile strength, 27.4 MPa    |                                            |
|                           | Impact resilience               | 13.22 kJ/m²                                |
|                           | Shore hardness number, 74 D     |                                            |
|                           | Tensile elongation              | 9.4%                                       |
|                           | Tensile elongation              | 7.7%                                       |
|                           | manufacture of wear-resistant parts, resistant to corrosive media; plugs for chamber-color blade sections, air suction holders, side brasses of inking mechanisms ink bowls, paint separators for rainbow printing, gears, fixing elements, sleeves |

Sleeves, pads, sleeve gaskets, rugged housings, patch pieces, coating of sheet feeding rolls and web conductors, manufacture of flexible wear-resistant products

Packaging elements, fittings

Figure 8. KBA Rapida 105 offset machine sheet feeding system feeder table rolls.

Figure 8 shows rolls that are being operated in print works and have already passed 25 mln impression prints. Surface resistance is within the range of 0.05 mm per diameter so far. This material proved to be rather reliable, wear-resistant, and prospective in application.

Figure 9 shows the lower part of the finished housing, performed by means of 3D print with in-built measurement device boards for monitoring the check mark on the impression print in the process of printing. The experience of this product manufacture demonstrated that additive technologies allow personalizing the plant needs and solving issues of controlling the quality of the printed goods in the
equipment operation point, with regard to features of installation, arrangement, and fixation of measurement devices on printing machines.

**Figure 9.** Housing base of the stroboscope for monitoring the check mark on the impression print in the process of printing.

**Figure 10.** Sealing pads for offset machine printing section washing system.

Titi flex soft pads for offset machine printing section washing system are given in Figure 10. These products were tested by seasoning in washing solutions for UV paints and ligroin for 24 h. Based on test results, they demonstrated resistance to swelling and permanent plastic hardness index. It gives an advantage over regular sealing pads made from NBR materials. As application experience has shown, NBR materials in the process of operation swelled out blocked liquid flow through snap-in connection nozzles. The NBR ring data were used due to the temporary absence of EPDM rings at the plant warehouse.

5. **Conclusion**

Upon the analysis of production process and 3D printing solutions, it follows that additive methods of manufacturing simple parts for printing machinery are rather prospective and reliable in operation. In the presence of the developed STL model, material choice, and performance accuracy, the parts are quickly interchangeable if a failure occurs. The experience of additive technologies implementation demonstrated that parts can be manufactured on contractors' facilities, or, with the preliminary classification and determination of the number of parts, 3D printing of which is cost-effective and technically reasonable, to buy necessary equipment.
References

[1] Kostidi E and Nikitakos N 2018 TransNav the International Journal on Marine Navigation and Safety of Sea Transportation **12**(3) pp 557–564
[2] den Boer J Lambrechts W and Krikke H R 2020 Journal of Cleaner Production **257** 120301
[3] Westerweel B, Basten R, den Boer J and Houtum G 2020 Production and Operations Management pp 1–18 doi:10.1111/poms.13298
[4] Das S 2017 Last-time-build strategies of spare parts with the advent of 3D printing technology URL: http://hdl.handle.net/1721.1/112062
[5] Ulbrich D *et al* 2018 *Journal of Research and Applications in Agricultural Engineering* **63** 75–78
[6] Khajavi S, Salmi M and Holmström J 2020 Additive Manufacturing as an Enabler of Digital Spare Parts in book: *Managing 3D Printing* pp 45–60 doi: 10.1007/978-3-030-23323-5_4
[7] Heinen J and Hoberg K 2019 *Journal of Operations Management* **65**(8) 826–810
[8] Varepo L G *et al* 2019 *Journal of Physics: Conference Series* **1210** 012155
[9] Song J-S and Zhang Y 2016 SSRN *Electronic Journal* URL: http://dx.doi.org/10.2139/ssrn.2884459
[10] New TiTi FLEX SOFT Technical specifications. Print. Features URL: https://3dtoday.ru/blogs/printproduct/new-titi-flex-soft-specifications-print-features
[11] U3 TPU Flex CFF 29D URL: https://u3print.com/plastik-dlya-3d-printera/u3-tpu-flex-cff-29d
[12] U3 Flex Conductive URL: https://u3print.com/plastik-dlya-3d-printera/u3-flex-conductive
[13] U3 ABS Conductive URL: https://u3print.com/plastik-dlya-3d-printera/u3-abs-conductive
[14] U3 ABS Dissipative URL: https://u3print.com/plastik-dlya-3d-printera/u3-abs-dissipative
[15] TiTi Flex Spring. Print material URL: https://gomake.ru/market/materialy-dlya-3d-pechati/flex/printproduct/titi-flex-spring-material-dlya-pechati-printproduct
[16] TiTi Flex Hard URL: https://top3dshop.ru/materiali/titi-flex-hard-black.html
[17] HIPS SolidFilament URL: https://top3dshop.ru/materiali/hips-1-75-solidfilament-white-1kg.html
[18] Nylon Strong URL: https://top3dshop.ru/materiali/nylon-strong-printproduct-175-05-natural.html