

Application of Rapid Prototyping Technology for Modeling the Mechanisms of F. Reuleaux Collection

M. Vlasov and M. Samoylova

Abstract This article examines the possibility of the application of rapid prototyping technology for modeling the mechanisms of F. Reuleaux collection stored in Bauman Moscow State Technical University (BMSTU). Nowadays some models from the collection are successfully being used in the students' learning process in order to explain the structure, the kinematics and the dynamics of the mechanisms. However, other models from the collection over time have lost their efficiency so at the moment they are in need of the restoration. A study of F. Reuleaux model S8 (Q-4) was conducted by the analyzing of all its constituent units as well as computer 3D-modeling which allowed us to obtain a prototype of the mechanism with the use of the three-dimensional printing systems: Eden 250 and ZPrinter 650.

Keywords F. Reuleaux · Rapid prototyping · Kinematic schemes · Theory of mechanisms and machines · Restoration · 3D-modeling · Three-dimensional printing

1 Introduction

The department of “theory of mechanisms and machines” is one of the oldest not only in the Bauman Moscow State Technical University but also among the leading technical universities in Russia and abroad. Created by the outstanding scientists, its history goes back over 140 years. The department has a unique cabinet of mechanisms, founded by I.P. Balashev in 1845, which include more than 500 models that are widely used in the educational process. The collection includes more than fifty models of the mechanisms of Franz Reuleaux collection [1].

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Fig. 1 The models of the mechanisms from the collection of Bauman Moscow State Technical University

Theory of mechanisms and machines is the scientific discipline that studies the structure, kinematics and dynamics of mechanisms in connection with their analysis and synthesis. The objective of the structural analysis is the problem of determining the parameters of the structure of the—the number of units and the type of kinematic pairs, etc. The problem of structural synthesis is the synthesis of the mechanism with the desired properties.

The use of the mechanisms from F. Reuleaux collection in the learning process enables students to understand the structural synthesis and analysis of the mechanisms. Some of the mechanisms are presented at Fig. 1.

Nevertheless some models' operating property is gradually deteriorating due to the wear of parts, that is why they are in need of restoration that should be carried out based on the rules and regulations in the field of restoration of unique historical technical objects [2–4].

One of the models of the mechanisms from the Franz Reuleaux collection of Bauman University—model S8 (Q-4)—is shown in Fig. 2. Model S8 is based on dual slider mechanism, in which two prismatic guides are not at right angles.

This mechanism was used during the laboratory works of the discipline 'Theory of mechanisms and machines' by the students of the Bauman University, but currently it is in the process of restoration.

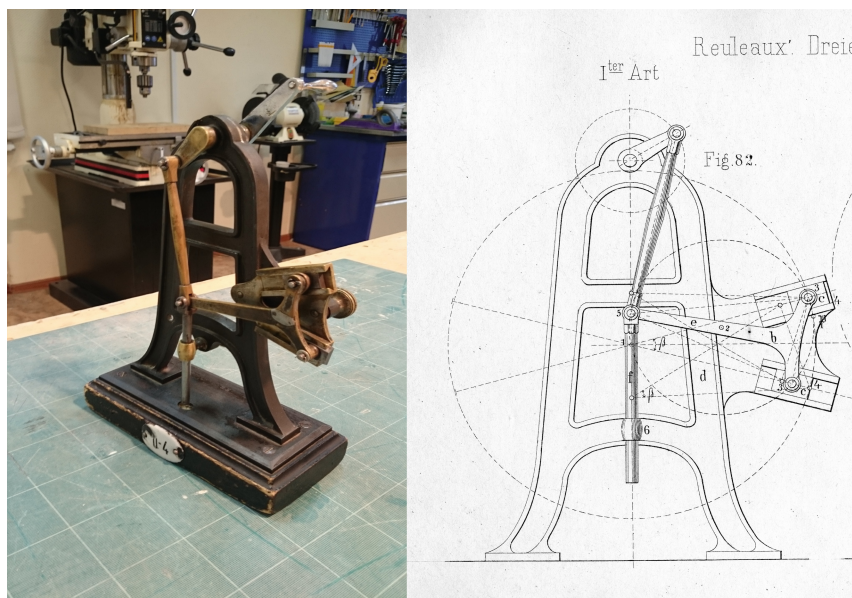


Fig. 2 Model S8 of the mechanisms from the Franz Reuleaux collection (Q-4)

2 3D-Modelling

During the first step of the restoration process we examined the model S8 (Q-4) by analyzing all its constituent units (visual analysis, etc.). Figure 3 shows a model of this mechanism in the form prepared for the subsequent rapid prototyping. This mechanism consists of four significant parts: the two sliders, one link of the drawbar, which traces the curve, and the permanent link, which includes two guides.

During the study it has been found out that it is possible to create a new model of the mechanism S8 (Q-4) with the use of rapid prototyping technology of three-dimensional printing systems Eden 250 and Zprinter 650.

The rapid prototyping technology used to create, as a rule, working models to demonstrate the principle of their action, can be realized in the following ways: stereolithography, curing on a solid basis, coating of thermoplastics, spraying of thermoplastics, or laser sintering of powders [4, 5].

During the first stage of prototyping we constructed a computer three-dimensional model of the mechanism S8 (Q-4), which allowed us to analyze the structure of the virtual model and look for the possible mistakes as well as make the necessary adjustments and changes to the model before the next step of the prototyping process. Moreover, the three-dimensional virtual allowed us to pick up the necessary materials and technologies to create a prototype.

An example of the three-dimensional computer model of the mechanism F. Reuleaux is shown in Fig. 4.



Fig. 3 Components of the mechanism S8 (Q-4)

Fig. 4 Three-dimensional computer model of the mechanism of the F. Reuleux collection



3 3D-Printing

During the next stage of prototyping of the model of F. Reuleaux mechanism S8 (Q-4) we chosen the method of stereolithography realized with the help of three-dimensional printing system EDEN-250, shown in Fig. 5, and the method of the color printing technology using a 3-D printing system Zprinter 650 (Fig. 6). Stereolithography (STL—stereolithography), is one of the methods of rapid

Fig. 5 3D printing system EDEN 250 used for prototyping of the model S8 (Q-4)





Fig. 6 3D printing system Zprinter 650 used for prototyping of the model S8 (Q-4)

prototyping technology that differs from the other 3D-printing methods since it uses the photopolymers in a liquid state as the ‘building blocks’ instead of the powders [6].

The main advantage of the stereolithography is the high accuracy of printing. This technology allows the printer EDEN-250 to apply layers of a thickness of 15 microns, which is much thinner than the thickness of a human hair. The speed of printing is relatively high, taking into the account the high resolution of such devices: it takes a few hours to construct the model of the Franz Reuleaux mechanism, but in the end depends on the size of the model and the number of laser heads used by the device simultaneously [6].

The working technology of Zprinter 650 is called ColorJet Printing (CJP) which applies model material and the glue in the consecutive layers. CJP belongs to the one of the industrial 3D-printing methods that allows us to obtain full color models of the mechanisms or their parts that can be provide the additional help for the students in the learning process during a demonstration of mechanisms’ structure and the principle of their action. 3D-printer Zprinter 650 also provides high accuracy of the models. The smallest element produced by this system has a size of 0.1 mm.

4 Conclusion

Modern rapid prototyping technologies that are used to produce prototypes of the models of the mechanisms will extend the ‘life’ of historical collections, which include the models of F. Reuleaux mechanisms stored in Bauman Moscow State Technical University. The main advantage of using three-dimension printing

systems is the speed of getting a prototype as well as the accuracy of the produced models. Prototypes obtained by three-dimensional printing systems such as Eden 250 and Zprinter 650, will be a unique object for research and study for the students as well as an additional teaching tool for explaining the basics of the theory of mechanisms and machines.

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