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REPLICA OF CRNOJEVIC PRINTING PRESS - THE FIRST PRINTING MACHINE IN THE BALKANS

Radoslav Tomović[1, a], Aleksandar Tomović[1,b] and Samir Dizdar[2 ,c]
[1]University of Montenegro, Faculty of Mechanical Engineering, Montenegro
[2] BerDiz Consulting AB, Andra Långgatan 48, 41327 Gothenburg, Sweden
[a]radoslav@ucg.ac.me, [b]aleksandart@ucg.ac.me, [c]samir.dizdar@berdiz.se

Abstract The paper presents a replica of the Crnojevic printing press machine – the first printing machine in the Balkans, designed and produced by a working team from the Faculty of Mechanical Engineering in Podgorica for the needs of the Ministry of Economic Development and Culture of Montenegro. The Crnojevic printing house is the first state printing house in the world and the first printing house in the language of the South Slavic peoples and in Cyrillic script.

Keywords: Replica, printing press, Crnojevic, Oktoih, Cyrillic.

1. INTRODUCTION

Culture and history are integral parts of Montenegro's identity. Montenegrins value and take pride in their culture and history even more than in their natural beauty. The most significant milestone in the history of Montenegrin culture is, without a doubt, the start of printing. By the end of the fifteenth century, Montenegro, thanks to the Montenegrin Crnojevic dynasty—namely Ivan, the founder of Cetinje, and his son Djuradj—obtained a printing press, the first in the Balkans, only a few decades after Gutenberg's press, specifically only 40 years after the first printed book in the world. Two years later, the first printed book in Serbian, "Oktoih prvoglasnik," was produced by the Crnojevic Printing House in 1494. In that same year, two more books, "Oktoih petoglasnik" and "Psaltir sa posljedovanjem," were printed at the Crnojević Printing House.

The Crnojevic Printing House is the first South Slavic Cyrillic and the first state printing house in the world, representing a unique phenomenon of European significance in the medieval history of Montenegro. It was founded in 1492 by Djuradj Crnojevic, the eldest son of Ivan Crnojevic, the founder of Cetinje, thus permanently placing Montenegro on the cultural map of the enlightened nations of medieval Europe.

On the other hand, if we look closely, it can be concluded that the Crnojevic printing press machine is one of the first and oldest machines used in the Balkans, which in itself is a true curiosity. Although not manufactured in Montenegro, it was certainly assembled and used there, making the Crnojevic Printing House, in a way, a pioneer of technology and serial production in this region.

On the occasion of a significant anniversary—530 years since the appearance of the first printed book in Serbian, "Oktoih prvoglasnik"—the Montenegrin Ministry of Economic Development and Tourism requested that the Faculty of Mechanical Engineering in Podgorica design, construct, and later produce a replica of the first printing press machine in the Balkans, the Crnojevic Printing Press machine.

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According to the technical requirements, the printing press machine project should provide a detailed description of the primary design and construction of the press, including its components, their shape and arrangement, and the authentic materials from which the parts should be made. It should also describe the assembly process of the machine's components, as well as a description of the mechanism of pressure creating of the plate over the plate, the method of making and fitting movable clichés and the methodology of imprinting with the letterpress technique — respectively explaining the machine's functioning and operating principles.

After its construction and assembly, the printing press was installed in Njegos Museum – Biljarda in Cetinje and is available for visitors to view. This paper briefly presents the basic results of this project's development.

2. GUTENBERG'S INVENTION OF PRINTING WITH MOVEABLE LETTERS TECHNIQUE

Of all the inventions and patents that humanity has conceived and created, none has influenced the development of civilization as profoundly as Gutenberg's printing press and his invention of serial book printing (Figure 1.a).

Figure 1. a) ***Gutenberg's printing press machine b) Johannes Gutenberg*** **(1394-1468).**

Johannes Gutenberg (Figure 1.b) was a German inventor and craftsman who developed the technique of movable letters-type printing—a revolutionary method of text reproduction that enabled the mass production of books. Before Gutenberg's invention, books were mainly reproduced by copying (through scriptorium schools), a lengthy and arduous process. As a result, books were extremely expensive, considered small treasures, and owned only by the wealthiest individuals, rulers, and certain monasteries. Gutenberg's innovation allowed for faster and cheaper book production, significantly increasing the availability of written materials. This first wave of mass book printing opened the door to widespread education and information sharing, leading to a rise in literacy and the formation of public opinion. Shortly after Gutenberg, printing houses spread across Europe, making books more accessible to a wider population. This sparked a printing revolution in Europe, marking a turning point of the second millennium and the beginning of the modern era in human history. That played a crucial role in the development of the Renaissance, Reformation, Enlightenment, and

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scientific expansion, laying the foundation for a knowledge-based modern economy and the spread of learning among the general public.

3. BASIC INFORMATION ABOUT THE PROJECT ASSIGNMENT

The project's aim is to provide a comprehensive project for the printing press machine, utilizing available historical sources, literature, and studies, to ensure the creation of a replica of the first printing press machine in the Balkans. The project team is tasked with reconstructing the technical aspects of this historical machine through the analysis of available historical sources, literature, and artistic works from the Renaissance and early modern centuries. During this time, printing was not merely a technical activity; it was an art form in the truest sense of the word. This serves as the inspiration for designing a replica that is not only functional but also visually appealing. In this process, the project team had to consider various aspects—from the materials to be used to the printing techniques to be applied.

A significant challenge in implementing the project was the absence of historical sources detailing how the Crnojevic printing press machine looked. It is known only that it was made of wood and modeled after Gutenberg's original press machine. Consequently, the project designer is expected to take into account the available information regarding Gutenberg's printing press in Mainz, whose invention spurred the formation of similarly styled printing presses in other European centers. Additionally, historical facts should be considered to understand how the Crnojevic printing press differed from its predecessors. Notably, the Crnojevic printing press was unique for its use of movable metal (lead) Cyrillic letters of original typography, in two-color printing, combined with woodcuts that graphically shaped decorative initials, flags, and illustrations.

The project designer is also expected to execute this project in all aspects in accordance with the existing regulations of Montenegro. During the design process, it is essential to consider the applicable regulations, rules, and standards for this type of project, as well as the conceptual solutions outlined in the feasibility study prepared by the Ministry of Economic Development for the project's implementation. For defining specific project elements for which technical standards are not prescribed in Montenegrin regulations or the conditions specified in the project task, it is recommended to use technical requirements and standards from foreign regulations, with prior approval from the Client.

As a result of the project, it is necessary to produce complete constructional and technical documentation, which should include all the essential elements for the fabrication of the printing press machine.

4. TECHNICAL SOLUTION AND CONSTRUCTIONAL-TECHNICAL DOCUMENTATION

The complete appearance, shape, dimensions, and arrangement of the components of the replica of Djuradj Crnojevic printing press machine are defined in the constructional and technical documentation. Figure 2 shows the 3D drawing and rendered illustration of the replica.

The construction of the replica of Djuradj Crnojevic printing press machine features a massive frame structure made of oak, weighing approximately 780 kg. The base of the frame consists of two solid

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vertical pillars (1), which connect two bases: the lower base (2) and the upper base (3). The lower base also serves as the machine's support, while the upper base contains a box for storing maintenance tools and spare parts. Between the pillars, there are two additional beam supports that further strengthen the structure. The first beam support is the support beam (4), which receives the working force and transmits it to the pillars and the base. The second support is a threaded beam (5), which carries the threaded spindle (6). Additionally, there is a guide beam (7) positioned between the pillars, ensuring the translational movement of the stamp (8) without simultaneous rotation. The stamp is used to transfer pressure onto the working plates of the drawer with movable clichés (9).

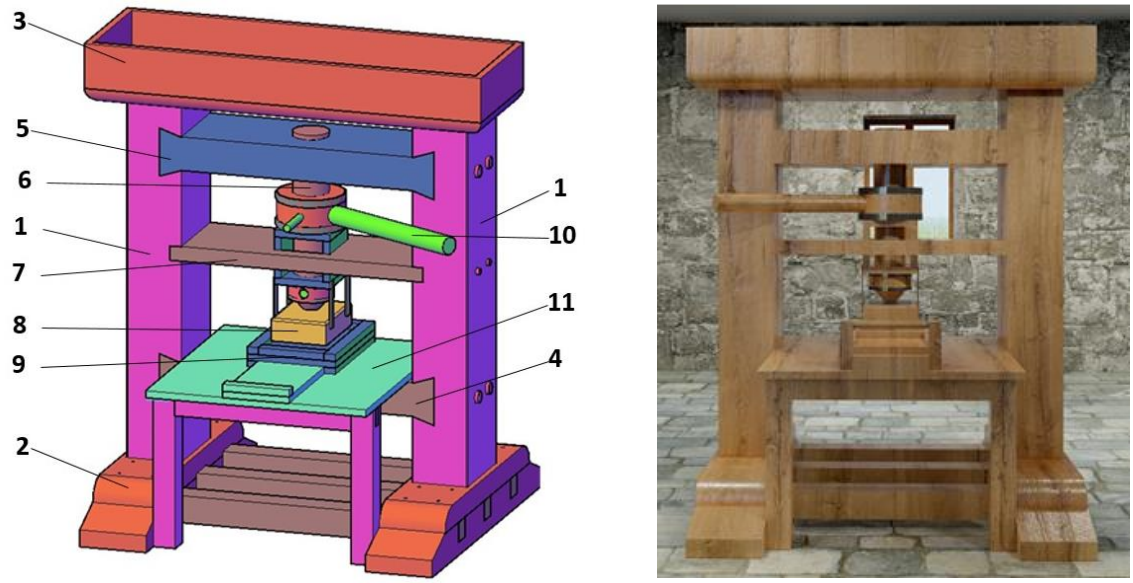

Figure 2. 3D i rendered illustration of the Crnojevic printing press replica.

The basis of the mechanism for generating pressure force is the threaded spindle (6). The pressure force is applied through the rotation of the handle (10) connected to the threaded spindle. The force is then transferred through the stamp to the working plates of the drawer with movable clichés, creating an impression on the paper.

Another important element of the construction is the drawer with movable clichés (9), which is capable of sliding along the guide of the worktable (11). The most critical positions of the drawer are the front and rear end positions. In the front position, the clichés are arranged in the drawer, and the paper for the impression is set. Pushing the drawer to the rear position brings the clichés directly under the stamp, ready for printing. After printing, the drawer is moved back to the front position, the paper is changed, and printing continues.

The main drawing in the constructional and technical documentation is the assembly drawing shown in Figure 3. This assembly drawing provides a view of the shape and arrangement of the elements that make up the construction of the printing press machine.

Figure 4 shows the completed printing press machine installed in Njegos Museum Biljarda in Cetinje, along with the first imprint produced by the press—the Coat of Arms of the Crnojevic dynasty.

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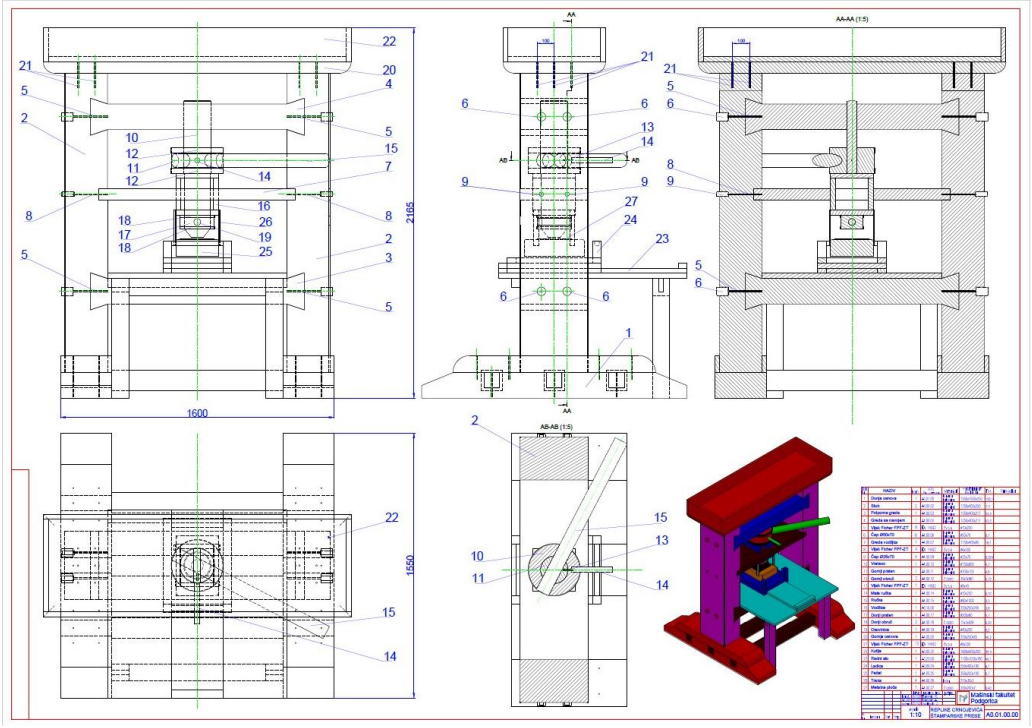

Figure 3. Assembly drawing of the Crnojevic printing press replica.

Figure 4. The printing press machine replica installed in the Njegos Museum in Cetinje.

5. CALCULATION OF THREADED SPINDLE PITCH

The maximum axial gait of the threaded spindle is set to h=15 mm (comprising 5 mm of distance between the spindle and the stamp, plus 10 mm of distance between the platen and the cliché). It is considered that a gap of 10 mm between the stamp and the cliché plates is sufficient for the drawer with the clichés to slide under the stamp without any operational hindrance. A square thread and a spindle diameter of 160 mm are adopted for the threaded spindle.

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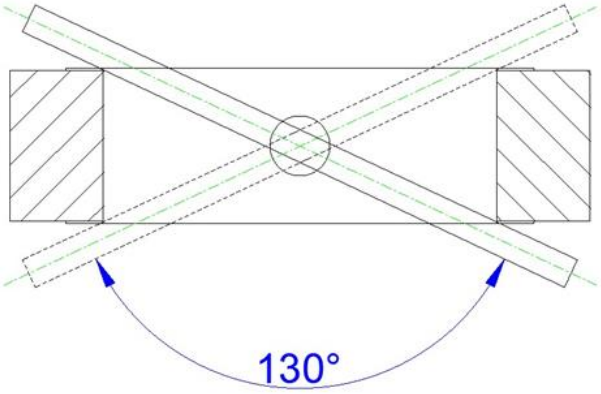

Figure 5. End positions of the handle for starting the threaded spindle.

Based on the end positions of the handle, the maximum angular displacement between the end positions is graphically determined to be $\alpha=130^{O}$, or approximately 2,269 rad (Figure 5).

It is established that a rotation of the handle by 130^{O} results in a maximum spindle gait of 15 mm. The pitch of the threaded spindle corresponds to the axial movement when the spindle is rotated a full turn. Based on this, the following equality can be established:

h:α=P:2π, thus, 15:2,269 = P:6,283.

From this, the minimum pitch of the thread (P) can be calculated as follows:

$$P = \frac{15 \cdot 6,283}{2,269} = 41,2 \text{ mm} \quad (1)$$

The pitch is adopted as P= 42 mm, corresponding to a square thread Sq 160 x 28.

According to this, the actual axial gait of the spindle can be expressed as follows accoriding to the (1):

$$h = \frac{P \cdot \alpha}{2\pi} = \frac{42 \cdot 2,269}{6,283} = 15,2 \text{ mm} \quad (2)$$

This results in a negligible difference compared to the adopted value.

6. CALCULATION OF THE HARDNESS AND DEFORMATION STATE OF THE ELEMENTS OF THE STRUCTURE

The calculation of the hardness and the deformation of the structure elements was performed using the finite element method on the ANSYS software platform. The results of the FEM analysis are shown in the images.

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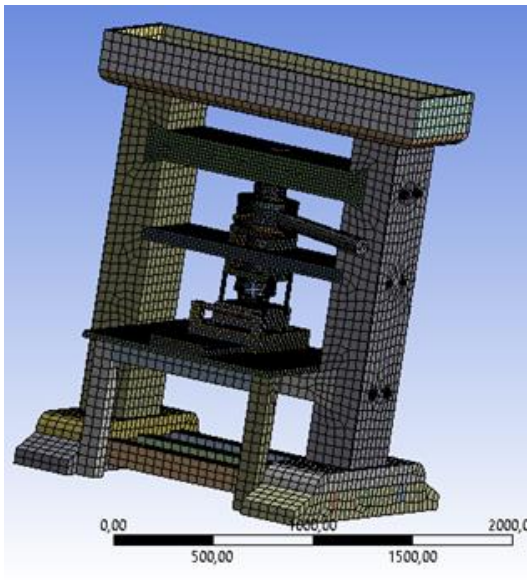

Figure 6. Mesh of the finite elements.

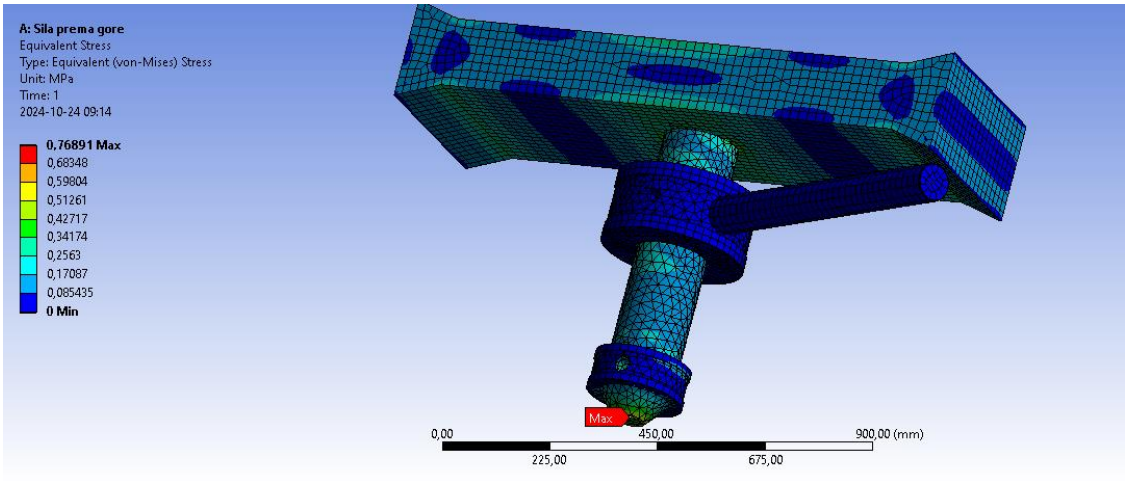

Figure 7. Stress state of threaded spindle and threaded beam.

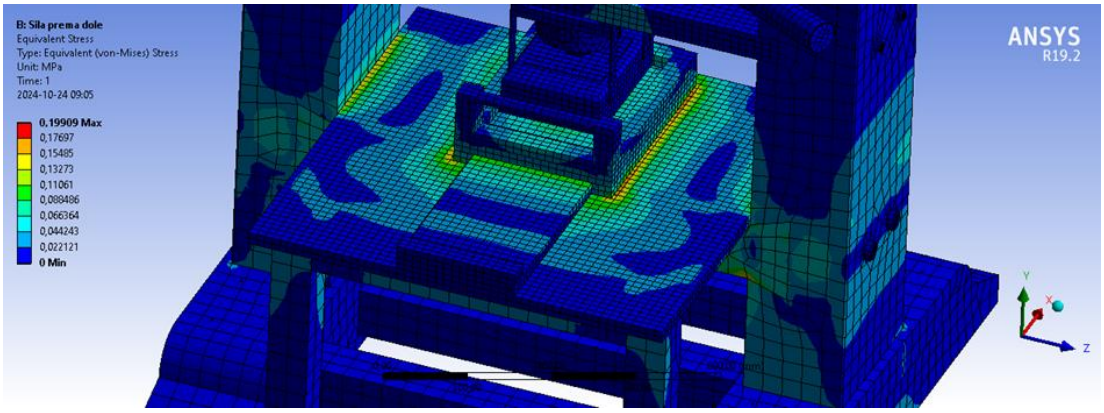

Figure 8. Stress state of the workbench.

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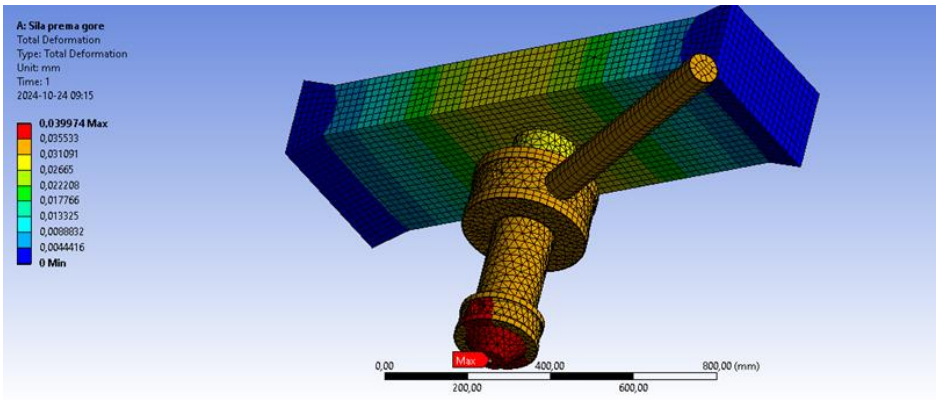

Figure 9. Maximum deformations of the threaded spindle and threaded beam.

7. CONCLUSION

The replica of the Crnojevic printing press machine visualizes an important aspect of our history and culture. The combination of historical heritage with modern technical knowledge creates a unique blend that can inspire and ensure that key ideas and innovations from the past are passed on to future generations. This replica will not only serve as a museum exhibit but also as a dynamic educational platform that will inspire art, technology, and culture enthusiasts to understand and appreciate the evolution of one of the most significant inventions in human history. In this way, the project continues to play a key role in preserving and promoting the rich cultural heritage of Montenegro, as well as in laying the foundation for future development and research in this field.

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