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## VIRTUAL MODELING OF ASSEMBLY AND WORKING ELEMENTS OF HORIZONTAL HYDRAULIC PRESS

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**Abstract:** This paper presents its own results of the modeling of the basic structure of a horizontal hydraulic press 6000 kN and an operating table that has a capacity of 100 kN using INVENTOR software package. The software package has enabled the modeling, simulation, kinematic animation and structural analysis of the parts and assemblies of the press prior to its manufacture (i.e. production of parts). For the needs of the EFT Mine and Thermal Power Plant Stanari, the geometrical, functional, physical, aesthetic and other properties of the press have been defined and tested by using vector graphics. The application of virtual reality in design and production is of great importance when making decisions for more efficient and effective production, which can be achieved by the modeling and visualization of the production and technological processes.

**Keywords:** horizontal press, modeling, virtual reality

### 1. INTRODUCTION

Historically, the design and prototype development of a new product were the bottleneck to win competition. Nowadays, to put a competitive product on the market requires much shorter development and design time while increasing quality in the phase of product design and manufacturing technologies, and maintaining an appropriate price in accordance with the competition. This was particularly evident when technological systems have introduced new manufacturing equipment, or enlarged the complexity of a product. The development of manufacturing systems and computer technology have been of crucial importance for the rapid development of new generation metrology systems based on the elements of flexible automation. For this reason, the problems of design and manufacturing are solving in parallel today. This method of product development is only possible if the production technologies are supported by computers. By the application of CAD/CAM/CAE (CATIA, Pro/Engineer, SolidWorks, Inventor, etc.) software it is possible to quickly obtain a geometric model of a part or assembly (of a product), which gives a physical form in space as a mechanical part and assembly, an abstract form in the form of drawings for manufacturing and an information form in the database. These tools enable the analysis of functionality, the analysis of stress-deformation state, testing, etc. Software packages enable the parts and assemblies to be modeled, which are then analyzed in various ways and tested prior to their creation.

The new requirements of the market in terms of price and quality impose the need for applying a more efficient way in designing products and tools, which includes the use of new CAx-technologies, modeling and FE simulation. The numerical simulations with the use of modern product design techniques (CAD/CAM/CAE) enable shortening the time for the development of a product. Obviously, 3D solutions bring the advantages to engineers and designers, thanks to their full associativity. This means that any change made in the module is automatically reflected in all applications derived from it, with no need for any data transfer. The study and analysis of the process, its visualization through virtual models is a verified method for increasing the efficiency of design and quality of the final product. In the past, this process was expensive and took away a lot of time because it required exclusive prototypes and special analyses.

### 2. PROBLEM DESCRIPTION

As a part of maintaining the equipment that works in the open-cast pit and on the separation of coal in the EFT Mine and Thermal Power Plant Stanari, there is often a need for a partial or complete disassembly and assembly of components and subassemblies of mining facilities. These assemblies and subassemblies have large dimensions and weight, they operate in dynamic conditions and harsh environments and that is the reason why great forces of separation or pressing appear during assembling and disassembling. The maximum dimensions of the parts and assemblies under pressing interventions are: length of 5200 mm, diameter of 1400 mm, and weight of 100 kN. The required press motion is 300 mm and maximum force is 6000 kN. To perform these operations, the most

acceptable solution is a horizontal hydraulic press with a hydraulic lift table to hold the components and parts in the axis of pressing or separation. For this purpose, the virtual press with given characteristics had been modeled first, and then produced in Engineering Industry Prijedor, Bosnia and Herzegovina.

### 3. VIRTUAL MODELING OF PRESS ASSEMBLY

#### 3.1. Virtual product development

The development of the press as a product went from the initial idea for a new product to launching the product into production. Today, computer hardware, communications and software are playing a great role in the process of product development. Their use provides several advantages of which particularly important are reduced costs until launching the product on the market and quality improvement. The product development supported by computer plays a key role in the product development and is more than just a tool in this process. Integrated approach to CAx tools and their use are essential in the product development, solving unique requirements during various development stages as well as the entire system development, including industrial design, technical design and manufacture (Figure 1).

In computer terminology, product development includes actions such as:

- » presentation and modeling,
- » processing and management of data and information,
- » documentation,
- » analyses and results,
- » calculation and simulation,
- » search,
- » optimization,
- » diagnosis,
- » knowledge processing and management,
- » synthesis or concept generation.

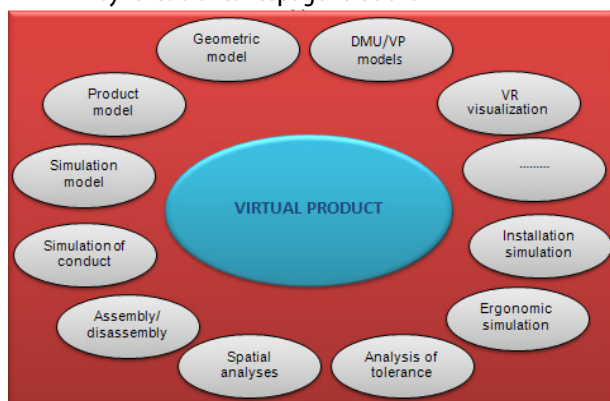


Figure 1. Virtual product [2]

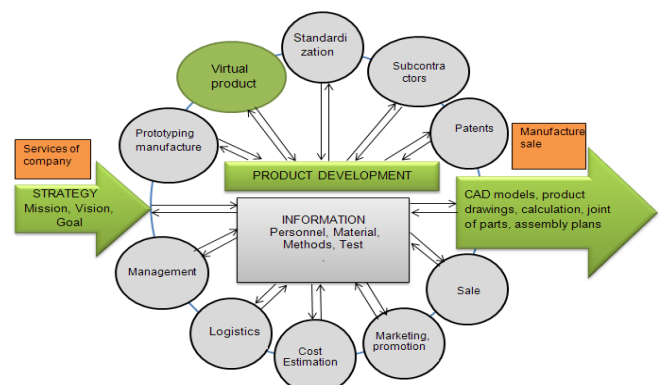


Figure 2. The information flow of the product development (a press)

The development of the product begins collecting and verifying information in the class of top designers and manufacturers of machinery and equipment. The information flow of the product development is given in Figure 2.

Using virtual reality, INVENTOR has enabled the realization of the digital press prototype. The virtual reality is used for the development of new products as an auxiliary tool in engineering and manufacturing processes, for the development of new prototypes and simulation. The virtual reality is a term that refers to computer simulated environments that can simulate the physical presence of the real and imaginary world. In that way, we obtained a visual appearance of the press simulated before putting into production. The digital prototype has significantly shortened the time to create the final product, reduced the number of errors and production cost. Also, the opportunity to apply 3D modeling of press parts in the assembly which supports DWG format has been used. This means that 2D drawings for the production can be easily made from the existing 3D model. In INVENTOR, a designer is given an opportunity to use professional automated modules for steel structures, sheet metal, plastic parts, injection plastic pressing, pipes, electric cables, simulation and dynamic animation.

To minimize the risk of the failures and fractures of parts, verification and work simulation was carried out using the finite element analysis (FEA) what had already been done on the digital prototype. On the digital model, it is possible to quickly remove structure defects of the parts that do not meet the requirements (allowable stresses and deformations, excessive wear). The theoretical background and methodology of virtual product modeling and product system modeling provide the basis for further spreading of the concept to other products and technologies in domestic industry. Based on the results of the stress and deformation of components and press assembly using INVENTOR program, and developing the prototype and pilot testing, it was concluded that developed and presented calculation systems of bearing and working press elements using FEM could be fully applied in practice.

Introducing variant forms of elements and assemblies and variant loads, values of stress and deformation states were reached relatively fast, and, on the basis of this, the optimal solutions were selected. Computer tools for product development is given in Figure 3.

To develop welded structures is a demanding job. There are a bunch of steel bars, plates, and welds distributed unevenly in space. A part of INVENTOR contains a comprehensive database of standard parts, a set of analyses and calculation of mechanical parts. The aforementioned software provides a variety of facilities and benefits such as the automatic selection of an appropriate screw assembly, together with washers and nuts, taking into account standard, length and diameter based on the holes that have been previously defined on the parts. The opportunity provided by INVENTOR is that all the holes of the assembly are filled automatically with appropriate screws, using artificial intelligence built into the program (Smart Fasteners Technology). As a part of the implementation, it has been created a library of parts which complies with the Procurement Department that works in a mutual information system. In this way, after the completion of the structure and the product, the output component provides a sufficient set of information for an accurate estimation of steel structure mass, which allows forming precise offers for clients. In the process of preparing documentation, INVENTOR automatically draws the position of all parts of welded structure and in the corresponding table it enters standard, mark, and length values of steel profiles that are used for cutting and preparation for welding. In addition to the geometry, the software provides unique functionality for the definition of welds. Each weld is defined in a 3D model, and later, in the technical documentation is briefly shown in the table of all welds with the estimation of total length, price and quantity of additional welding materials (electrodes and CO<sub>2</sub> wire). The time required for welding operations are automatically evaluated. The cross sections, based on the definition of weld from the 3D model, show the appropriate symbols achieving significant savings in time for the preparation of technical documentation.

**3.2. Virtual press modeling**

The horizontal hydraulic press (Figure 4) is composed of two bearing sides, a movable and immovable support (Figure 5 and 6) and movable operating table (Figure 7). It works with a single double-operating hydraulic cylinder that provides a maximum force of 6,000 kN. The cylinder is attached with screws for a fixed press support. The structure of press foundation consists of press footings and a technical channel in which the press operating table moves. The joint of the steel structure to the footings is achieved via anchor bolts. The steel press structure is presented through technical documentation with all necessary details, elements, sections, and drawings for welding, as well as drawings for additional processing of drilling, milling etc. The digital prototype of press assembly has enabled the testing of all essential functions of designed mechanism, from the defined tolerances to the simulation of part movement (kinematics, dynamics) in mechanism assemblies. Figure 4 shows the assembly model of the horizontal hydraulic press.

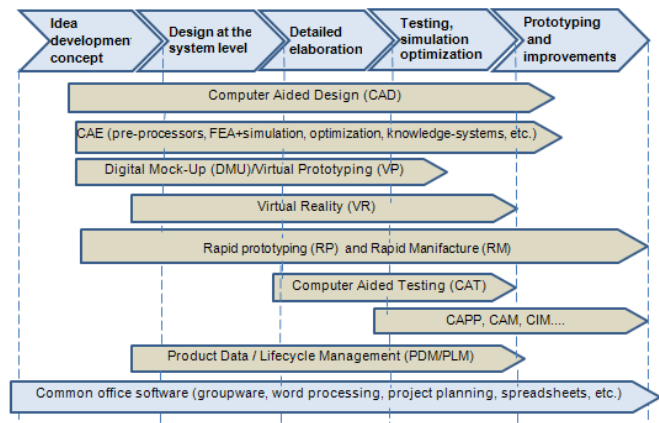


Figure 3. Computer tools for product development

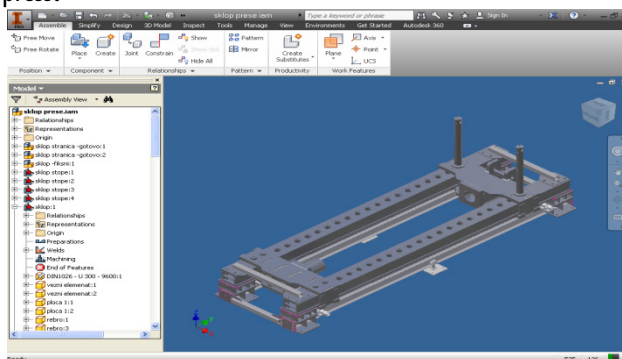


Figure 4. Assembly model of horizontal hydraulic press [1]

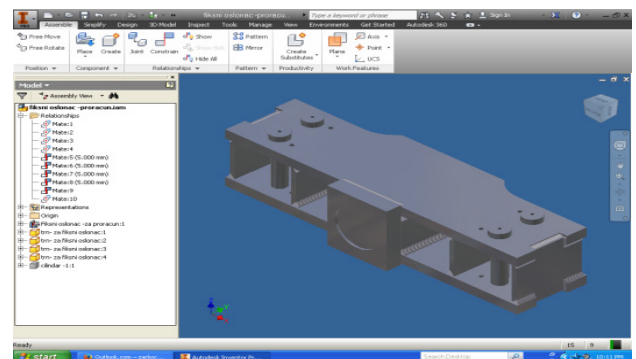
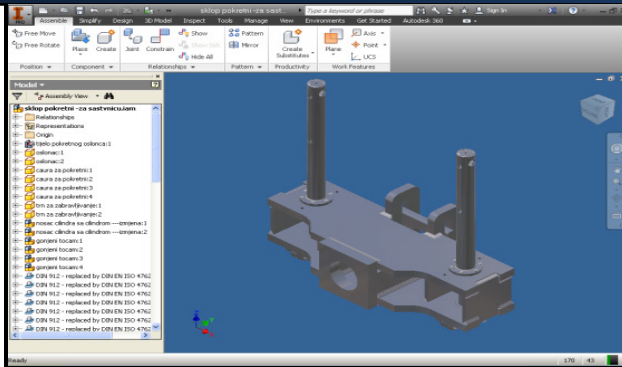
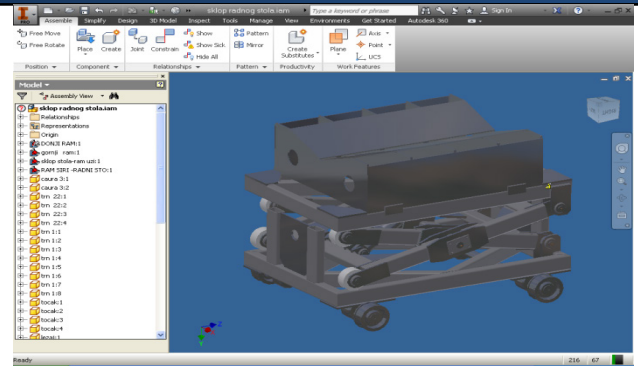


Figure 5. Fixed support model – the support of the main hydraulic cylinder [1]

The steel structure of the lift table with capacity of 100 kN is composed of the framework with table wheels moving on it, diagonal profiles (scissors) and operating table. The operating table is always in a horizontal position. The prism of "V" has been intended for setting ground shape mechanical elements. The longitudinal movement of the operating table and movable support of the press are mechanized.



**Figure 6.** Movable support with hydraulic pins for fixing [1]

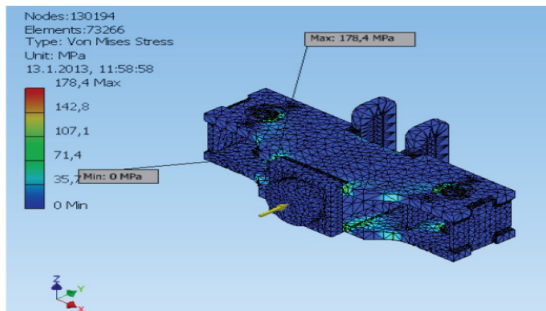


**Figure 7.** Lift table model [1]

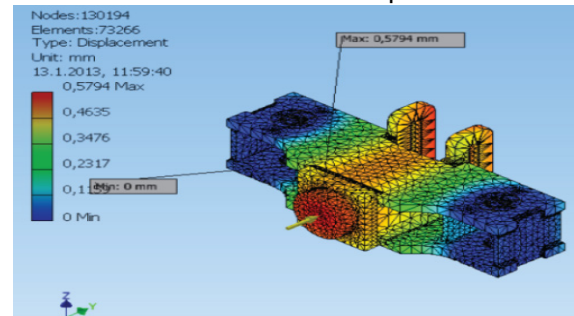
The hydraulic press and lift table are equipped with a hydraulic power unit driven by a frequently regulated electric drive.

#### 4. STRUCTURAL ANALYSIS

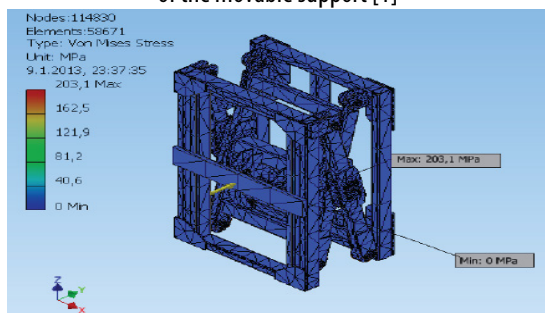
The main task of the structural analysis in the horizontal press design is the calculation, simulation and optimization of parts and complex assemblies satisfying the mechanical properties of the product. For the movable support, maximum stress is 136.4 MPa and deformation is 0.535 mm, while for the lift table, maximum stress is 203.1 MPa, and deformation is 3.453 mm. Based on the analysis results, it can be concluded that the distribution of stress and deformation is approximately symmetrical and they are within allowable values. After experimental testing the press and operating table with workload, it has confirmed the accuracy of the results, which leads to the conclusion that the model is adequate.



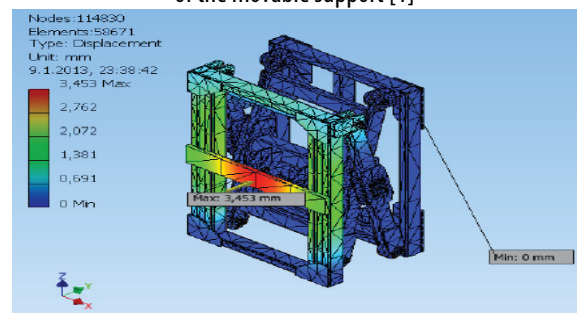
**Figure 8.** Distribution of the effective stress of the movable support [1]



**Figure 9.** Distribution of the effective deformation of the movable support [1]



**Figure 10.** Distribution of the effective stress of the operating table [1]



**Figure 11.** Distribution of the effective deformation of the operating table [1]

#### 5. CONCLUSIONS

The paper gives a brief overview of its own research in the field of design and manufacture, in which the technology of virtual reality in the area of mechanical manufacturing has been applied. The reliability and accuracy of the results obtained by applying modern techniques of virtual engineering indicate that the applied method is essential in developing new products because it greatly contributes to reducing the time when a new product will appear on the market. The main contribution of this paper is in illustrative representations applying the intelligent function of model form recognition, the technological process and technological documentation definition in the development and manufacture of new product. Further research will certainly go in the direction towards wider implementation of the illustrated techniques and tools of INVENTOR software package in real production.

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