



The 4th International Conference
"Computational Mechanics
and Virtual Engineering"
COMEC 2011
20-22 OCTOBER 2011, Brasov, Romania

THE DEVELOPMENT AND THE SIMULATION OF THE VIRTUAL PROTOTYPE OF A DEVICE FOR PENETROMETERS ACTING

Florin I. Loghin¹, Florean I. Rus², Ionuț V. Căpățîna³,

¹ Transylvania University, Braşov, Romania, loghin_florin_lucian@yahoo.com

² Transylvania University, Braşov, Romania, florus@unitbv.ro

³ Transylvania University, Braşov, Romania, ionutcapatana@yahoo.com

Abstract: The paper shows the way of elaboration and of simulation of virtual prototype of a device acting the penetrometers with constant speed, in order to verify the functionality of assemblies and also to achieve some optimizations. In order to elaborate the prototype there were used both components of some specialized firms which have 3D models available on-line and also new components whose models were made directly in INVENTOR software. The device consists of a drive system which carries out the vertical move of the penetrometer and a system which allows the folding the axle trailer where the device is located. By using the new technology implemented by INVENTOR software, there were made some resistance calculations of some components and assemblies, to verify their behavior in real operating conditions, without designing physical prototypes.

Keywords: virtual prototype of a device acting the penetrometers, analysis module with finite element, prototype simulation

1. INTRODUCTION

Penetrometers are frequently used to determine soil density, state of compactness, assessing foundation bearing capacity or for tractors and agricultural machinery wheels and of resistance opposed to the mechanical processing of soil.

Basically a penetrometer consists of a cone attached to a rod assembly that is inserted into the ground through the vertical force applied by the operator. Soil resistance to penetration in calibrated conical body penetration is measured by a force transducer (mechanical or electronic) and then is converted into pressure units (kPa or MPa) according to the base area and cone penetration resistance is. This index is used to assess the degree of soil compaction and penetrometer reading on the dial indicator [3].

When using cone penetrometers, for a more precise measurement of soil penetration resistance is required to take into consideration two basic conditions: the penetration speed of the cone into soil must be constant and the exact positioning of penetrometer rod on vertical side. In general modern penetrometers equipped with measuring devices of the the penetration speed during measurements, making possible to maintain the speed constant. But in order to make measurements with hand-operated penetrometer on ground it was found difficult to maintain the penetration speed constant by the human operator [3].

The paper presents the achievement way and of simulation of a virtual prototype of a device that provides a constant rate of penetration of cone into the soil. This device (figure 1) consists of an electric motor step by step 1, which involves a rotating motion, through a gear belt drive 3, two ball screws 4 which realize the vertical motion, with the constant speed of the penetrometer 7. The two screws with balls are mounted on a metallic frame 11 through some SKF bearings 9.

The penetrometer type Penetrologger is mounted on the device through a clamping system in 6 designed to be able to enable the rapid assembly and disassemble it. This was necessary taking into considerations that may arise situations where the penetrometer measurements Penetrologger type can not be done with the automatic device and it is necessary to perform measurements manually. In order to determine the precise depth of penetration and for penetration speed control, the Penetrologger penetrometer requires the use of a reference plate for which it was made to a removable attachment 10. In order to control the position of the acting device there were placed two inductive position sensors 8, used as origin points to detect the motion on the z axis of the penetrometer.

2. DESIGN AND SIMULATION OF THE VIRTUAL PROTOTYPE

For the achievement of the virtual prototyping of the device it was use the Inventor 2011 software, designed for the

modeling, simulation and optimization of the mechanical systems. The modeling and simulation method of the virtual prototype by using the *Inventor software 2011*, assumed the completing of the following three main steps: virtual modeling device, prototype simulation (run analysis); the processing of the results of the simulation and the making of the necessary improvements [1, 4].

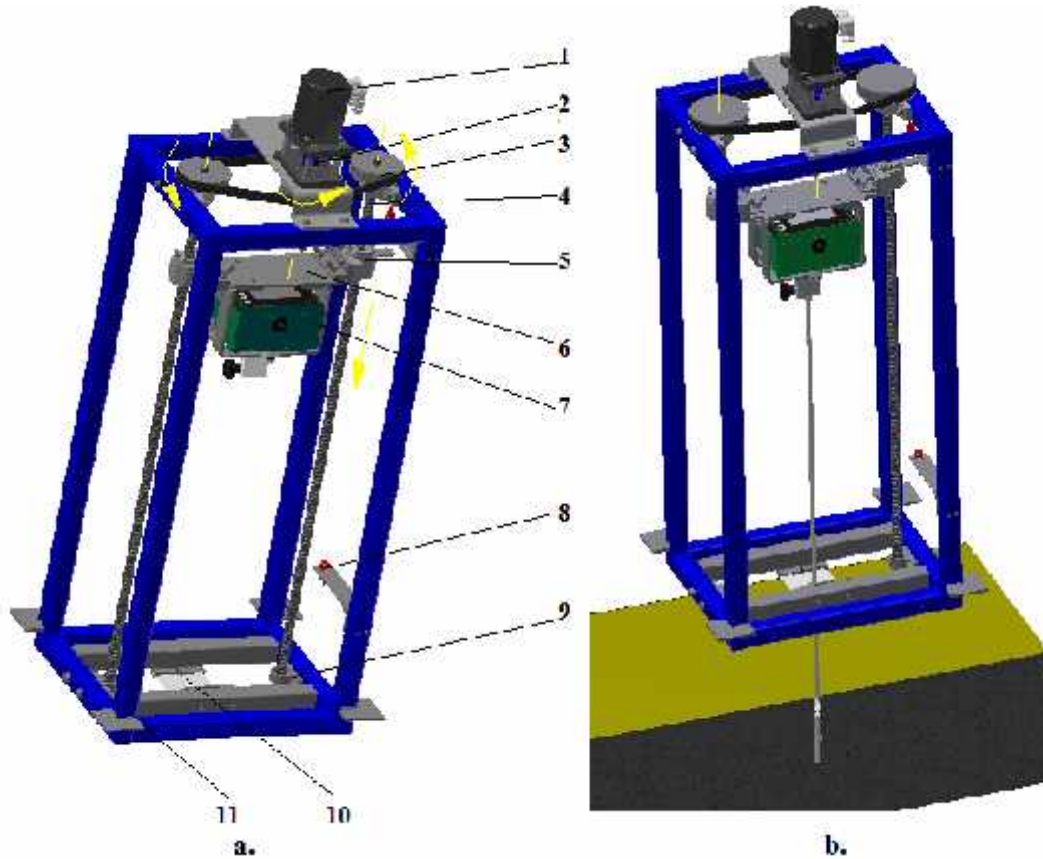


Figure 1. The virtual prototype of the device for the penetrometers acting with constant speed:
a. the kinematic model; b. the dynamic model;

1 – electric engine; 2 – coupling; 3 – belt transmission; 4 – screw with balls; 5 – nuts; 6 – clamping system of the penetrometer; 7 – penetrometer; 8 – position sensors; 9 – bearing units; 10 – clamping system of the reference plate; 11 – frame.

The design of (dynamic) virtual model device required the following steps to be followed:

a. The 3D representation of all the components of the device and the imposing of some restrictions on how the assembly was carried, restrictions that made possible the correct positioning of all components of the device, resulting the structural model of this. The design concept of the acting device was based on the use of some components made by specialized companies which 3D models are available on-line (electric motor, coupling, ball screws, nuts, bearing units, sensors, etc.) and also on new components whose new models were made by the *Inventor software*.

b. After generating the components and their placement within the ensemble, the next step was to achieve kinematic model, by applying restrictions of kinematic order models on movement order and the introduction of the entrance motion. The kinematic constraints are restrictions on which generates the movement of transmission elements thus canceling some mobility degree [2]. To ensure proper functioning of the device in kinematic terms, there were introduced into the system 5 kinematic restrictions. The first two kinematic restrictions refer to the two screw-type mechanisms - nut balls. Thus there were introduced into the model two restrictions Screw type, this type of restriction provides the transformation of the rotation motion of the two screws in the axial movement of nut. Also the software allows you to enter the following data: the sense of winding of the thread, thread pitch, the value of the winding angle, the coefficient of friction value, etc. [5]

The following three restrictions refers to generation of belt transmission components. For the transmission modeling it was used the Designs and Synchronous Belts of *Inventor software* that allows also the design calculations and the elaboration of the 3D models using the results of calculations that were made. The *Inventor software* through the module *Design Accelerator*, allowed a rapid design of the transmission belt using the following input data: the transmission ratio, the distance between the centers of wheels, original width of the wheels, etc. By introducing the specific energy parameters: power, speed, torque, etc., the module *Design Accelerator* calculates the required strength of the transmission in order to be designed. By generating three belt wheels there were automatically entered in three kinematic model type restrictions Rolling Joints (1, 2 and 3, figure 2) [5].

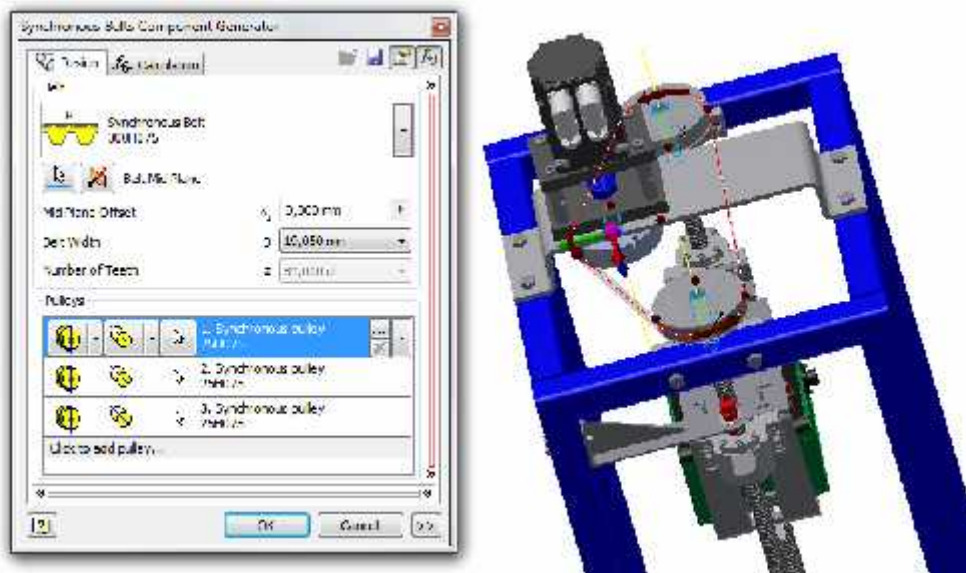


Figure 2. The rapid generation of the belt transmission

The next step was the introduction of input motion, which consists of applying a rotation movement of motor shaft power.

c. The elaboration of the dynamic model. The masico - inertial characteristics of the component elements (mass, the position of the mass center and the inertia moments) are automatically calculated by the application used, based on the geometrical features and material characteristics of which parts are made. The introduction into the model of the force gravity was done by establishing the direction of gravitational acceleration.

In order to simulate the functioning of the device in working conditions, it was introduced into the model a constant force whose value is 1000 N (this being the maximum force for which the cell force of the penetrometer type Penetrologger was sized). In order to introduce into the model this force it was necessary to introduce a prior board to replace the soil and the use of a constraint type Jack.

d. Simulation stage (run model) is done automatically by completing the application and consists of the following sequences:

- the assembly of the system through restrictions placed on the movement of the body-components;
- the identification and the elimination of redundant links (extra constraints) from the system.

3. RESULTS AND DISCUSSIONS

This modeling allowed the kinematic analysis of the driving mechanism of the two ball screws, using the geometric model and the existing motion restrictions in the pattern. As a result of the virtual prototype simulation, there was possible to make some improvements, of which the most important are: the establishment of the necessary length of the two ball screws, the correct positioning of inductive sensors, sizing of the penetrometer attachment support, etc.

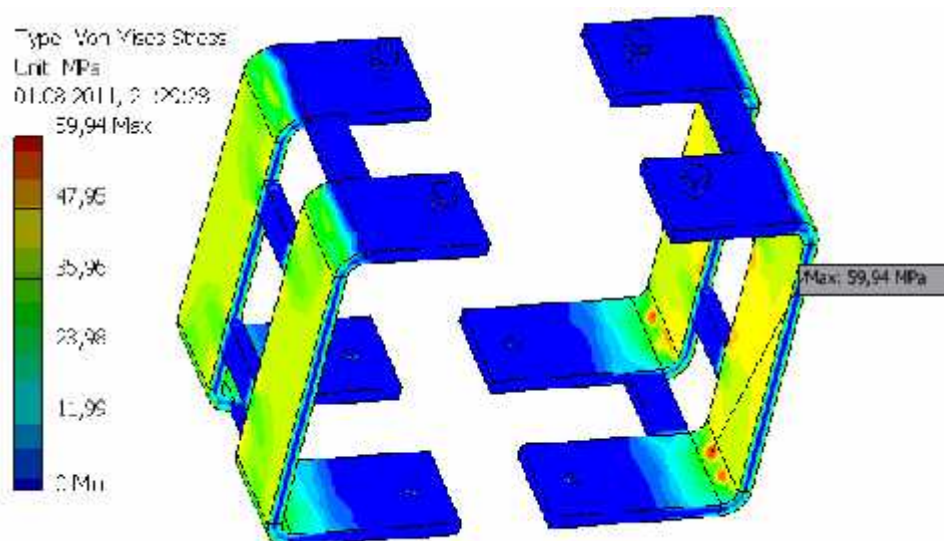


Figure 3. The tension state of the clamping support of the penetrometer

The inventor 2011 software has implemented a new technology for finite element analysis module, with which calculations can be made resistant parts and assemblies to verify their behavior in operating real conditions without being necessary to design physical prototypes. For example is presented the distribution of tension state in the clamping support of the penetrometer figure 3 and its rod figure 4.

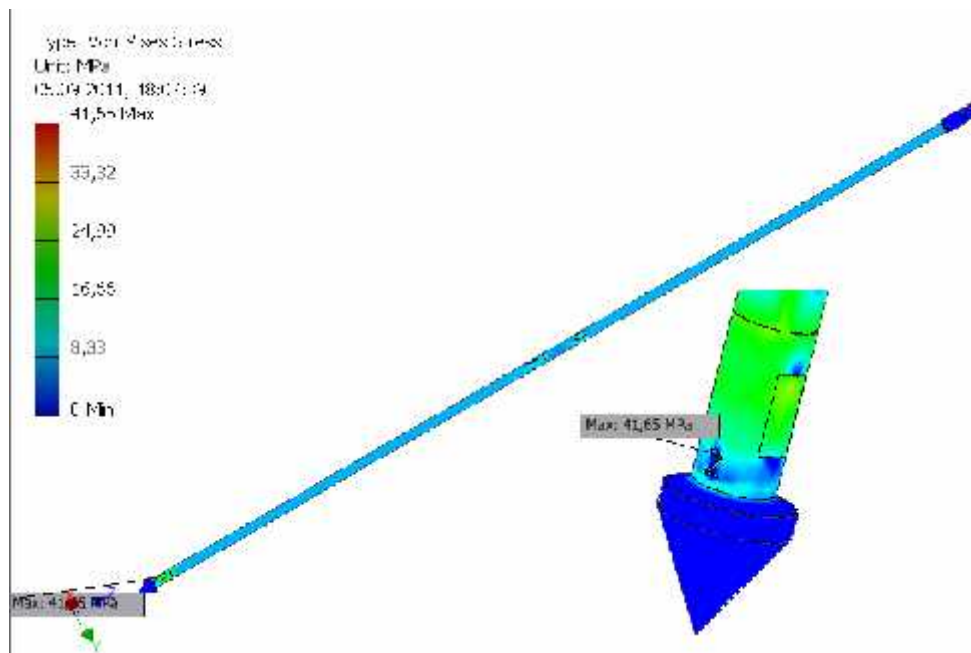


Figure 4. Tension of the rod penetrometer

3. CONCLUSION

The simulation of the virtual prototype allowed the assessment of device functionality from the early stages of design and provide the opportunity for multifunctional optimizations, from where we obtained a correlation between constructive and functional parameters of the device. In this case the simulation of the virtual prototype was materialized through the following: an analysis of the functional device, perform rapid calculations of resistance of various parts and subassemblies; graphical animation (simulation) of the prototype, in different planes of representation.

REFERENCES

- [1]. Barbu I., Luculescu M., Barbu D.M.: Virtual Prototyping Methods Applied in Mechanical Engineering, Proceedings of the 1st International Conference on Computational Mechanics and Virtual Engineering, Braşov/Romania, 2005.
- [2]. Loghin Fl., Contributions regarding the kinematics and the dynamics of transmissions with intermittent motion of universal seed drills, PhD Thesis, Transilvania University of Brasov/ Romania, 2010.
- [3]. Loghin Fl., Rus Fl.: Research on soil compaction by agricultural aggregates tyres with variable mass, Proceedings of the 3rd International Conference „Research People and Actual Tasks on Multidisciplinary Sciences”, Lozenec/Bulgaria, 2011.
- [4]. Loghin Fl., Popescu S., Rus Fl.: Dynamic modeling of working sections of grassland oversowing machine MSPD - 2.5, Proceedings of the International Conference “Engineering for rural development”, Jelgava/ Letonia, 2011.
- [5]. xxx. *Explore Dynamic Simulation*, Tutorial Learning Resource INVENTOR 2010.

Acknowledgement: This paper is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and by the Romanian Government under the project number ID59323.