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COORDINATE MEASURING MACHINE. STUDENT DEMONSTRATOR

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***Abstract**: The student demonstrators allow complete system investigation, often providing students with hands-on experience. This paper presents a coordinate measuring machine student demonstrator, both theoretical and practical approaches, pointing out the importance of re-using mechanical and electrical components from obsolete printers.*
***Key words:** demonstrator, coordinate measuring machine, translation module, stepper motor.*

1. INTRODUCTION

For the engineering students, which are active learners, a substantial effort for a proper balance between theory and applications is necessary. As it is known, the limits of traditional lectures have been demonstrated and alternatives have been proposed, including active learning based on student demonstrators. In this paper, the development of a coordinate measuring machine student demonstrator is presented.

1.1. Coordinate measuring machines

The advent of numerically controlled machine tools increased the demand for some means to support this equipment. There has been a growing need to have an apparatus that can do faster first piece inspection.

The coordinate measuring machines (CMM) have an important role in the mechanization of the inspection process. They measure the physical geometric characteristics of an object using a coordinate system, in order to determine the position of a point or a geometric element in space. The measurements are done by a probe attached to the moving axis of the machine. The probe uses a process in which the variable measurements are compared quantitatively with a size or reference of the same type. As a reference point the measure that represents the unit or parts of it, is used [2].

When analysing a measurements results, certain conclusions can be drawn:

- The quality of the measured object, for example if the piece is consistent or inconsistent;
- The processing parameters, for example if the proper process is used, the state of the machine;
- The ability of the supplier to manufacture products with the required characteristics.

1.2. The role of student demonstrators

For our students in Precision Engineering and Mechatronics, over the years, the demonstrators have showed that the practical applications help to improve their creativity and communication skills. Active problem analysis, encourage students to learn about brainstorming, problem solving and group dynamics, [9]. The developed demonstrators give students a chance to see projects at work and assist them in the improvement of engineering studies. Often, these demonstrators are made of re-used components of other machines and equipment.

2. RE-USING MECHANICAL AND ELECTRICAL COMPONENTS

Spectacular advances in technology have led to a dramatic increase in our dependence on the use of electronics. As the innovative products multiply and the use of them increases, the lifetime of the electronic equipment has declined. Limited storage space for waste and the need to adopt a new approach to material consumption has led to a greater attention being paid to the problem of electric and electronic waste. The main benefits of re-using components are:

- Diverts materials from disposal: re-using and recycling components saves voluminous equipment from landfills and incinerators.
- Conserves natural resources and reduces pollution: electronic products are made from valuable resources, including precious metals, plastics, glass and various metal materials. All require energy for their manufacture.

Many electronic products contain elements that could be profitably refurbished with little effort, even more in education where students can use demonstrators in order to improve practical skills, [9].

3. TRANSLATION MODULES AND CMM STUDENT DEMONSTRATOR

Using translation modules from obsolete printers (Fig. 1), different assembled structures can be created, as a coordinate measuring system.

Fig.1. Reconsidered / redesigned translation module, [1]

The stepper motor sets a timing belt in motion, thus moving the sled. This module is one of five that have been used in the practical implementation of the coordinate measuring system.

The CAD model of the studied CMM demonstrator is presented in Fig. 2. The element (5) moves vertically on the supporting elements (3) and (4), on elements (1) and (2) are mounted the vertical columns (3) and (4) which move horizontally therefore giving the structure the possibility the move on three axes. The open structure of this arrangement provides optimum accessibility for large objects.

Fig. 2. The CAD model of the CMM demonstrator (1, 2, 3, 4, 5- translation modules)

Generally, a CMM is a system structured in three distinct parts: the moving structure for each of the three coordinate axes; the electronic equipment and the control system. The developed prototype is given in Fig. 3.

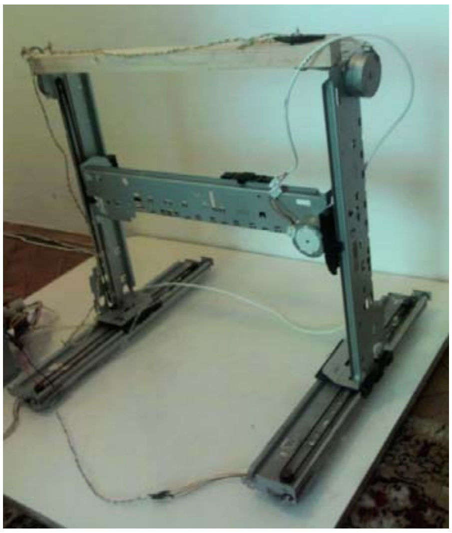

Fig. 3. The hardware of the developed prototype

3.1 Finite element analysis

The finite element analysis was conducted using SolidWorks Simulation Xpress and the results are based on linear static analysis and the material is assumed isotropic. Linear static analysis assumes that the material behaviour is linear complying with Hooke's law,[11]. The material used for the structure is Aluminium 1060 Alloy, having a mass of 1.25 kg. A normal force is applied of 50 N and the mesh density is 1.5 mm.

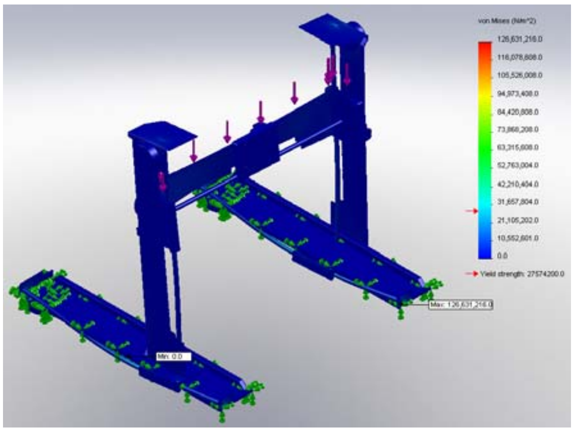

Fig.4. Simulation stress study

Table 1

Simulation stress results

Type	Min.	Location.	Max.	Location
Von Mises Stress	4.8e-010 N/m^2	(117.87 mm, -1.25 mm, 407.49 mm)	1.2e+008 N/m^2	(301.6 mm, 4.0 mm, 59.49 mm)

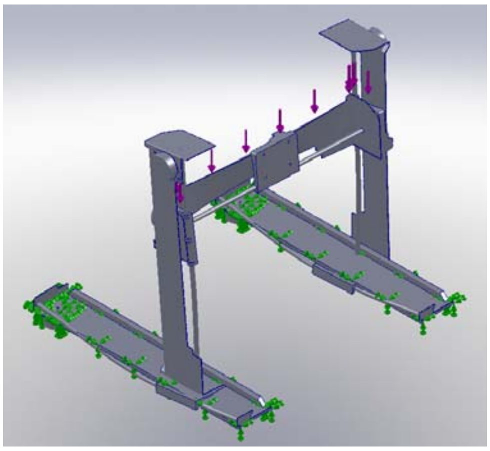

Fig. 5. Simulation deformation study

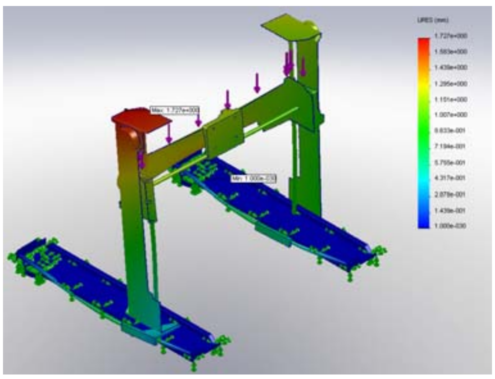

Fig.6. Simulation displacement study

Table 2

Simulation displacement result

Type	Min	Location.	Max	Location
Resultant Displacement	0 mm	(-43.0 mm, -8.16e-014 mm, 412.49 mm)	1.72 mm	(94.1 mm, 352.863 mm, 351.76 mm)

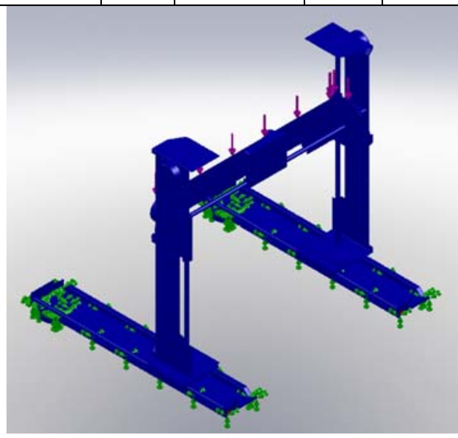

Fig.7. Simulation safety factor

The safety factor is used to describe the structural capacity of the system beyond the expected loads. The safety factor for this structure is 3, meaning that the structure can withstand a force tree times higher.

4. THE ACTUATION AND CONTROL SYSTEMS

The actuation system of CMM demonstrator is based on stepper motors. The position of the motor can be commanded to move or hold a step without a feedback sensor. Every revolution of the stepper motor is divided into a discrete number of steps, and the motor must be sent a separate pulse for each step.

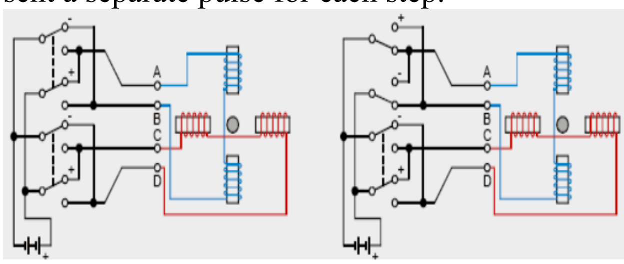

Fig. 8. The polarization diagrams. [4]

The motor coil assemblies operate at voltage levels ranging from +5 to +24 volts. The motor has a single rotor which is connected to a shaft at the centre of the assembly. There are multiple coils surrounding the rotor. A total of 100 steps are required for one complete revolution, each step increments by 3.6 deg., [4]. The main board has five stepper motors.

Controlling a stepper motors in AVR works by turning ON and OFF four I/O port lines generating a particular frequency. The drivers are needed in order to add the necessary power required for the system, [5].

To operate the system, stepper motors were used which enabled the translation of the axis coordinate system. The stepper motors are controlled by an electric board designed for this purpose. The motors are powered by integrated circuit drivers (L298). Processing data and information is performed using a ATMEGA8535 Microcontroller (Fig. 9).

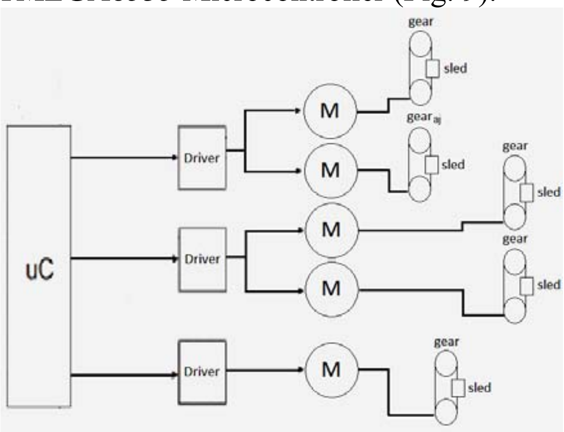

Fig.9. The block diagram of the control system

5. CONCLUSIONS

The developed demonstrator permits a wide spectrum of activities, in adequate and safety work conditions, in individual or group activities, for achieving the target competences. The re-use of electrical and mechanical components can help create useful projects. The designed structure accomplished with translation modules from printers can be configured in different modes such as a double column or a L type bridge structure.

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Demonstrator pentru sisteme de măsurare în coordonate

Sistemele de tip demonstrator permit studiul complet al diferitelor procese şi echipamente, oferind studenților experientă practică. Aceasta lucrare prezintă un demonstrator destinat studiului maşinilor de măsurat în coordonate. Este evidențiată importanța reutilizării componentelor mecanice şi electrice, recuperate din imprimantele scoase din uz.

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