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CONSIDERATIONS ON MODELING AND SIMULATION OF MECHATRONIC POSITIONING SYSTEMS

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Abstract: *The mobile mechanical systems, designed in a mechatronics vision, will need to assure possibilities to control the positions and orientations of radiation emitters or waves, so that it is possible to obtain optimal images and protection of human operators against irradiation. The positions that the emitters will occupy in the NDA control are varied: orientations either throughout the pipe's generators, or on the direction of a cylindrical propeller, when the welding is carried out in a spiral. The variants presented in this paper are developed in SolidWorks design environment.*
Key words: *Nondestructive testing, inspection, autonomous agents, actuators.*

1. INTRODUCTION

Due to more frequent use of NDT methods, especially the welding seams on pipes found after X-ray production processes, professionals are trying to develop positioning systems. These positioning systems are designed to properly position the radiation sources to obtain proper radiographic imagines and protect human operators.

2. RING FRAME POSITIONING SYSTEMS

Figure 1 suggests a positioning system model for welding seams nondestructive means of control. This is an annular segment support frame type and it is designed to ensure the constant retaining of the X-ray emitter to the welding seams present in the pipe manufacturing technology.

3. MODELING AND SIMULATION OF THE DEVELOPED SYSTEM

The modeling and simulation of the system is done using Matlab Simulink environment. The developed model will include all components that define the dynamic behavior of the structure (mechanical structure, drive and transmission systems, control algorithms, etc).

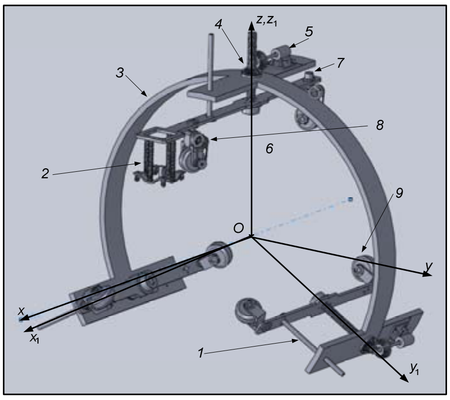


Fig. 1. Ring frame positioning system: 1-guidance; 2-the supporting subassembly of the "feeler"; 3-ring frame; 4-radial positioning and driving mechanism; 5-drive system; 6-............; 7-pivot motor; 8-rolling-drive wheel system; 9-rolling wheel system

The model obtained through importing will include Simulink blocks representing the elements and the kinematic couplings that define the structure of the inspection robot. Figure 2 presents the obtained model.

To define the interaction between the six wheels of the robot and the inspected pipe, the *Joint Custom* block was used where the possible movements between the two bodies have been defined.

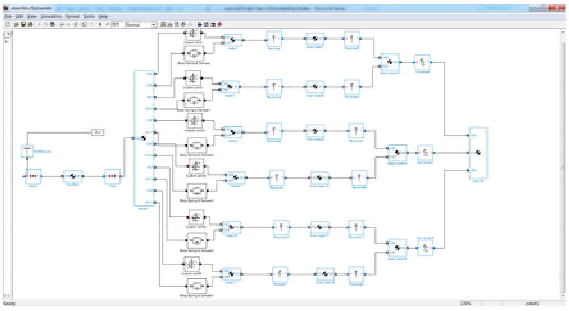


Fig. 2. Mechanical structure model

Also the friction between the pipe and wheel was defined, using *Body Spring and Dumper* block.

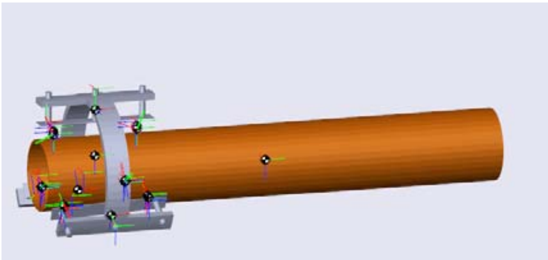


Fig. 3. Vizualisation of the system's behaviour

Simulink environment also allows the visualization of the system's behavior in a virtual environment (figure 3), the user being able to observe the way the system works.

The system is driven by using two step by step motors. The development of the actuator's dynamic model is done using Simscape library components. In figure 4 is presented the Simulink model obtained for an engine. *StepperMotor* Simulink block can be observed defining the dynamic parameters of the engine and *StepperMotorDriver* block that defines the behavior of the driver used for the engines.

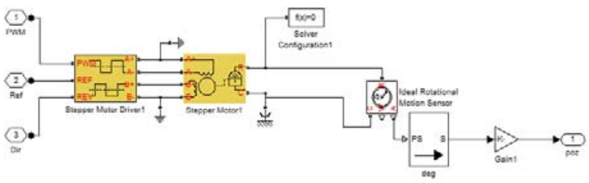


Fig. 4. Actuator model

In figure 5 is presented the Simulink model developed to simulate the dynamic behavior of the inspection robot. The robot's control is done in an open loop, the user inserting as reference the length of the pipe to be inspected and the controller determines the number of steps required to be performed and the order of the two engines to perform the desired movement.

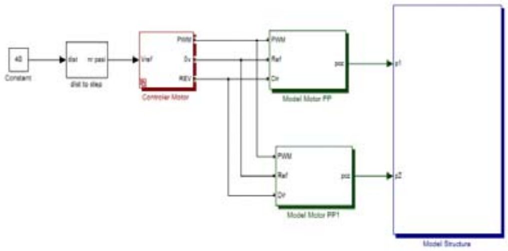
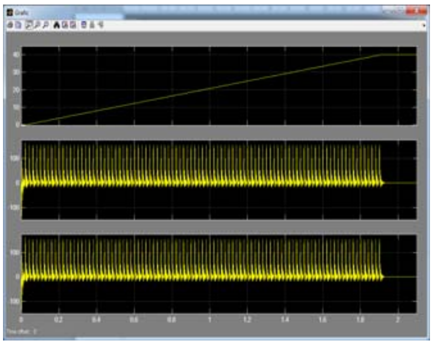
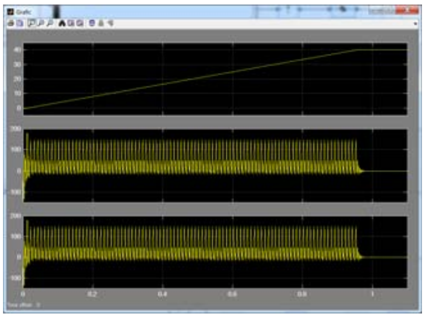


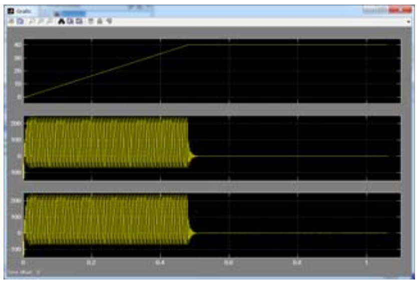
Fig. 5. Inspetion system model



a.



b.



c.

Fig. 6. a-System response – step frequency 50[Hz]; b-System response – step frequency 100[Hz]; c-System response – step frequency 200[Hz]

The following are the results obtained in the simulation. There were a set of three simulations in which changes frequency steps of two engines. The above graphs are shown variations in position, speed and acceleration of the structure.

4. THE PRACTICAL MADE VERSION BY THE MECHATRONICS POSITIONING SYSTEM USED IN PIPES NDT EXTERNAL CONTROL

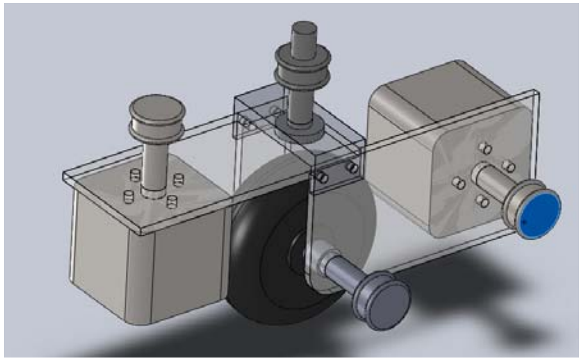
This paragraph presents Positioning System version made practical. This choice was made to demonstrate both command and control facilities that they require mechatronic positioning system and ergonomics can be easily used in a wide range of cases, the tubes are closed, the pipes that are outside or in some other places. It is also apparent that can easily reconfigure the system using a shift tube to support and guide the probe to the other can be controlled by reversing its surface.

Fig. 7. Mecatronic positioning system for pipes NDT

The positioning system proposed for non-destructive testing of welding seams from the pipes structure is based on a mechanical component, an electronical one and an informatical one. The autonomous mobile system has a ring shaped body, or a ring sector, with three synchronized engine subassemblies arranged at 120° from each other so as to provide adjustment for the work diameter of three wheel subassemblies. Of these, two subassemblies contain two swivel driven wheels arranged along the generating controlled pipe and the central wheel subassembly is composed by two wheels with two motors synchronized with each other to provide orientation and movement for the mobile system on the desired trajectory to be controlled non-destructively using penetrant radiations.

The robot's body was manufactured by cutting a 500 mm diameter pipe as shown in figure 7. This component will be the frame on which the three plates arranged at 120 degrees around the axis of symmetry of the ring will be assembled.

The driving wheels subassemblies (figure 8) can perform two rotations. A rotation transmitted to the wheel around its rotation axis to provide the transmission through the belt from a step by step engine, and a rotation of the driving wheel around its normal in the contact point of the wheel with the surface of the control pipe. This rotation provides orientation of the engine subassembly that influence the system's trajectory.



a.

b.

Fig. 8. Conceptual version of the driving wheel

An improvement in terms of construction was achieved in the practical manufacturing phase. It consists of modifying the structure of the driving wheels subassembly from the originally designed layout in the version of engine displaying as in figure 8. In figure 8.a is shown CAD subassembly designed in the SolidWorks environment.

The driving engine is KH42JM2B080A. It is installed on the specially constructed support so as to save the space above the wheel. The transmission is done through a belt between the motor shaft and wheel axle. For orientation there is another engine PM55L-048-HP69 type C2164-60045 which is fixedly installed on the wheels support body.

5. CONCLUSIONS

The structural elements acting as actuators, controls, checks and guidance are effective in terms of positioning accuracy if they are fitted in/placed in the vicinity of each other in a compact subassembly. The types of actuators that respond to the requirements of the positioning systems are the bipolar step by step type. For the driver of stept by step engines a program was developed to action and movement/control for positions of the designed technical system.

6. REFERENCES

[1] Craciun, S., Ardelean, I., Csibi, V.. *Considerations Regarding of Mechatronics Systems for Positioning in Non-Destructive Testing*, COMEFIM 10, Bucureşti, 2011
[2] Craciun, S., *Name of the article in italics "Contribuții privind îmbunătățirea sistemelor de poziționare utilizate în controlul nedistructiv"- Teză de doctorat,* Editura Tehnica, 2011
[3] www.ndtautomation.com
[4] www.ndt.ro
[5] www.sherpa-eng.com

Consideraţii privind modelarea şi simularea sistemelor mecatronice de poziționare

Rezumat: Sistemele mecanice mobile concepute în viziune mecatronică vor trebui să asigure posibilități de control a pozițiilor şi orientărilor emitoarelor de radiații, respectiv unde, astfel încât să fie posibil să se obțină şi imagini optime şi protejarea operatorilor umani împotriva iradierilor. Pozițiile pe care urmează să le ocupe emitoarele în controlul CND sunt variate: orientări fie de-a lungul generatoarelor țevii, fie pe direcția unei elici cilindrice, când sudura este realizată în formă de spirală. Variantele prezentate în lucrare sunt realizate în mediul de proiectare SolidWorks.

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