CONSIDERATIONS REGARDING OF MECHATRONICS SYSTEMS FOR POSITIONING IN NON-DESTRUCTIVE TESTING

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Obtinerea rezultatelor satisfacatoare in operatiile de testare nedistructiva in timp scurt depinde de parametrii sistemului de comanda. Printre acestea se poate mentiona precizia de pozitionare corecta pentru p[iesele care vor fi sudate. In aceasta lucrare sint detaliate informatii despre aceasta problema. Se insista asupra sistemelor mobile cu structuri NDT din punct de vedere mecatronic.

Obtaining reliable results in operations which involve non-destructive testing, in a short time and protected from the effects of disturbing factors, depends on different parameters of control systems. Among these should be mentioned: the correct positioning of the emitter of radiation and the waves , against the weld and / or parts-piece surface, the position control of these parts, so that to be respected the terms of "feeling" and "collision" of the weld and surface, the conditions imposed by the NDT equipment manufacturing company, replacing attributions of human operators in NDT in order to protect them against irradiation etc. In this paper are detailed factual information about these issues. It is insisting on mobile systems designed in view of mechatronics, introduced in the NDT structures.

Keywords: Mechatronics, NDT, Penetrating radiation

1. Introduction

In establishing the design parameters and conception of NDT techniques in general and positioning systems of radiation emitter and from where in particular, the knowledge of defining details related to the weld joints and the technologies of materials developing are determinant

The positioning of the "feeler" /measuring device is a difficult problem and necessary. The constructive variants for positioning systems presented in the paper have constructive particularities which are taking account the principle of construction of means of nondestructive testing, about its metrological

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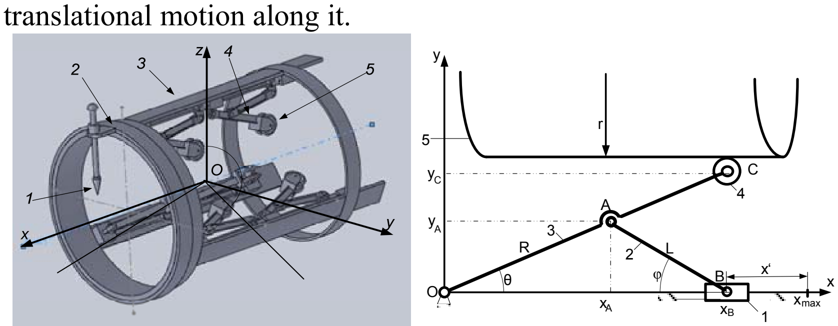
characteristics, and the geometry of measuring source (eg, welding cordons on the pipes, welding cordons on the elbows, structures of cast parts, etc..).

2. Mechatronics systems for positioning with arm-sliding mechanism

Moving mechanical systems designed in view of mechatronics will have to provide opportunities for control of radiation emitter positions and orientations, respectively rays that so that to be possible to obtain optimal images and to protect against irradiation of human operators. The positions that emitters will occupy in NDT are varied: orientation is along the tube or on direction of a cylindrical spiral .Variants presented in this work are done in SolidWorks design environment.

Fig. 1 is presented a first version of a positioning system. This system has in structure the crank rod mechanism in structural versión beam-slide. It provides emitter "end effector" a movement for positioning along a longitudinal weld.

An important characteristic and benefit of this system is to be able to make measurements on pipes of different diameters, this is possible because the mechanism of approaching the wheels F on pipe until the contact necessary to realize translational motion along it.



a) b)

Fig.1. Positioning system, version I; a) view, 1-end effector, 2-rotation ring, 3-corp, 4- rolling subassembly, 5- wheel, b) structural scheme.

Is attached for the mechanism a system xOy as shown in Fig. 1b. Considering the constructive parameters is necesary to calculate the value of yF in function of displacement x along the axis Ox. Depending on this value, will be estabilished the diameter pipe on which the weld cordon is placed. In the context of the same algorithm is determining the value of the race of the approaching subassembly of radiation on the pipe, forcing the distance once adjusted, to maintain the same and the emitter do not touch measurement source (pipe). The values of construction parameters of the system are : R, L, l_1, r.

A preliminary geometric synthesis involves establishing of a relation between the control parameter x' and the position of the branch C by its coordinates (x, y).

Parameter x 'will control the position of slide 1 and for different values attributed its, through rod 2 and rocker 3 the rotation joint D and roll 4 will come into contact with the pipe 5. Therefore through the slide 1 and the parameter x' is ensuring a permanent control of the positioning system with the measuring source (welded pipe). Result from here that the system can be used to control the welding on pipes with different diameters.

$$y_A = R \bullet \sin\theta,\ x_A = R \bullet \cos\theta \tag{1}$$

The position parameter x 'of the ram 1 is expressed by the formula:

$$x' = R - R \bullet \cos\theta + L - L \bullet \cos\varphi \tag{2}$$

or

$$x' = R + L - (R \bullet \cos\theta + L \bullet \cos\varphi) \tag{3}$$

Note : $R \bullet \cos\theta + L \bullet \cos\varphi = x_B$

The formula (3) becomes

$$x' = R + L - x_B \tag{4}$$

We can also write the formula :

$$\Rightarrow \quad R^2 = x_A^2 + y_A^2,\ L^2 = y_A^2 + (x_B - x_A)^2 \tag{5}$$

From (5) is obtaining successively :

$$R^2 - x_A^2 = L^2 - (x_B - x_A)^2 \tag{6}$$

or

$$R^2 - L^2 + x_B^2 - 2 \bullet x_A \bullet x_B = 0 \tag{7}$$

Synthesizing the above relationships where unknown are $\theta, \varphi, x_A, x_B,$ is obtaining the pseudo system

$$\begin{cases} x_A = R \bullet \cos\theta \\ x_B = x_A + L \bullet \cos\varphi \\ x' = R + L - x_B \\ R^2 - L^2 + x_B^2 - 2 \bullet x_A \bullet x_B = 0 \end{cases} \tag{8}$$

Solving the system depending on these unknowns, results:

$$x_B = R + L - x' \tag{9}$$

which in its turn allows solving the unknown x_A, respectively:

$$R^2 - L^2 + (R + L - x')^2 - 2 \bullet x_A \bullet (R + L - x') = 0 \tag{10}$$

$$x_A = \frac{R^2 - L^2 + (R + L - x')^2}{2 \bullet (R + L - x')} \tag{11}$$

By replacing the expression of abscissa x_A and x_B in the other relations is structured by several intermediate forms, the relations for cosθ and cosφ, respectively :

$$\cos\varphi = \frac{(R + L - x')^2 - R^2 + L^2}{2 \bullet L \bullet (R + L - x')} \tag{12}$$

$$\cos\theta = \frac{x_A}{R} = \frac{(R + L - x')^2 + R^2 - L^2}{2 \bullet R \bullet (R + L - x')} \tag{13}$$

Then is expressing the ordonate y_A and then the ordonate y_C in function of displacement on Ox of the ram 1, respectively the parameter x'. We have in succession:

$$y_A = R \bullet \sin\theta = R \bullet \sqrt{1 - \cos^2\theta} \tag{14}$$

From figure 4b can be written relations :

$$y_C = OC \bullet \sin\theta = OC \bullet \sqrt{1 - \cos^2\theta} \tag{15}$$

$$OC = R + AC \tag{16}$$

Relation (4) can be written as:

$$R = x' + x_B - L \tag{17}$$

From the last relations one can obtain the relation between x' and y_C:

$$y_C = (x' + x_B - L) \bullet \sqrt{1 - \cos^2\theta} \tag{18}$$

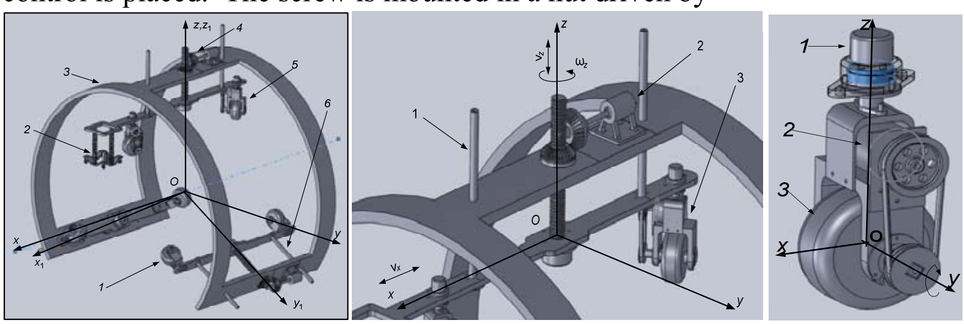
Depending how is the value of parameter"y_C", there is determining the position of translational movement of the support system for the radiation or ultrasound emitter of the nondestructive device structure.

The form variation of ram x' in each of the six mechanisms arranged two by two equidistant is obtained using a screw-nut cinematic axis. Driveing motors and steps must be the same type to provide the same displacement on wheels for axis Ox attached to each mechanism.

3. Positioning systems with closed framework

Fig. 2.a presents with more details another option for a different positioning system. Although conceived and played in SolidW the important structural parts of the system are explicitly detailed and nominated.

The system is formed from a support framework 3 made of two semi rings with lengths proper to a 270^o centre angle The two semi rings are linked together by three plates on which are mounted the rolling systems subassemblies. On the intermediary board, besides the rolling system, the positioning system of the radiation or ultrasound emitter is also mounted. On this intermediary board the rolling system serves for training purposes. Noted in Fig. 2.a. with (5). On the other parts, which have extreme positions only the rolling system is mounted. Each system is made of two pivoting wheels (1) mounted on a support board. Two guiding rods (6) and a screw that has a driving role reinforce the support board. These functions are necessary in the radial positioning operation of the system toward the pipe axis on which the welding line subjected to a non-invasive control is placed. The screw is mounted in a nut driven by



a. b. c.

Fig. 2.

a. Positioning system, II variant, 1 - free pivoting wheel, 2- final effecter, 3 - robot body, 4- Placement system of the robot, 5 - Orientation and training parts of the motor wheels, 6 – guidance

b. The settlement unit positioning system, 1-guide, 2-engine, 3-wheelmotors

c. Details of the wheel motors, 1 - Guidance motor,2 Driving motor,3-wheel

the gear wheel rotates a bevel gear. The pinion is driven by a stepper motor.Such an action (4) we find on each of the three panels corresponding to the three pairs of gears on the three boards that connect to the rails of the body positioning system.

The second assembly (2) is designed to be operated and controlled independently from the rest of the role of positioning.

Fig. 2.b. is detailed driving subassembly trained as described above. In this figure the guide rods are denoted by 1, 2 and with 3 the running wheel-drive system.Constructive version of Fig. 2.a. serves as a means of positioning radiographic nondestructive testing of welds and joints that occur in manufacturing various types of pipes.Its purpose is to verify the existence of different types of defects that can occur in the composition of materials joining.The system is self-enabled mobile agent to perform a translation movement along the pipe, a rotating motion around it and a combination of the

two movements. Being possible this combination , it enables the spiral welded pipes.The axis that joins the contact points of wheel-bore on each set of two wheels is always parallel to the axis of cylindrical pipe or implied by the coresponding generators to the imaginary cylinder attached tube. Travel subassemblies are positioned equidistant from the pipe surface and feeler positioning system provides a constant distance from the weld seam controlled.The drive nut subassembly running or running-training has a more complex form. This framework is based on the robot body by two thrust bearings to provide rotational movement with minimal friction.

The radial translational movement is continuous. Any locking are avoided by means oftwo guide rods fixed to support the running wheel. Gates of the three boards areindependent from each other even if they only asegura running or running and training.Taking these degrees of freedom ensured there is opportunity for them toautoorienteze after positions and movements that require the two driving wheels -Detailed driving on the Intermediate plate in Figure 2.b.

Fig. 2.c. presents a detail on how to run - the drive system shown in Fig. 2.b. the same role. Driving wheel - drive is mounted on a shaft which has camps in an asymmetrical fork. In an extension of the shaft, fork out (in a mounting bracket) is fixed a wheel belt. On the axis fork, at the top of its sidewalls is mounted a stepper motor drive. The motor shaft is fixed corresponding belt wheel. The rotation of the wheel moving the robot is thus achieved through the mechanism of the belt drive motor shaft at the wheel. To ensure the orientation of the wheel can be seen in another top fixing system. Engine is placed over a piece of masking an engine role after guiding the wheel motors when the weld seam is helical.

Fig. 2.c. is seen in more detail wheel drive subassembly by component. The piece of plate on engine 1 has a flange on the bottom is assembled and on the other hand it takes the rotation of the drive motor 2 located on a mounting bracket on the component that supports both wheels and the end effector also through a flange. In this support there is a special geometry designed for so that a wheel bearing is inserted to ensure rotation around the surface normal at the point of wheel contact with the pipe. This Need to use of the bearing appeared knowing that by pressing the barrel must ensure the necessary adhesion between tire and tube.

These two driving wheels must be synchronized by controlling the engines every time to ensure the proper concentric position of the bearing the robot from the pipe control. This will be one of the main aspects that will require special control.

The other two sets of wheels are pivoting, without driving. Their axes are free and will be considered to auto-guide on the directions imposed by the driving wheels.

A matter of the usefulness of this system is that which concerns the possibility of positioning "feeler" on the portions of the pipes that has some type of bends or elbows joints. The system shown in Fig. 2.a. and detailed in Fig. 2.b. and Fig. 2.c. provides positioning especially difficult because the mounting position of the bearing the supporting system.

4. Positioning system with ring frame

Otherwise, the principle of movement keeps the same aspects that the previous version. Both the motion and orientation of the wheels as well as their closing to the pipe to achieve the necessary grip displacement remained unchanged. Instead the degree of maneuverability is improved. This will secure better conditions in the of positioning the feeler on areas of the pipe which shows elbows or bends .

In Fig. 3 is shown this version wich ensures the positioning of nondestructive systems on a wider range of pipe sizes. If the previous versions there is only one "source" to adjust the system for certain diameters of the pipes, respectively adjusting the running systems - moved by screw-nut drive assembly.

Otherwise, the structures of other parts are similar.

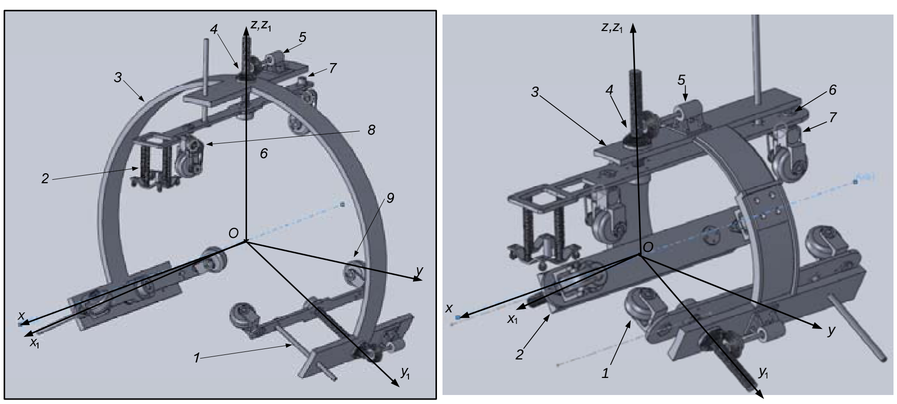


Fig.8. a) Ring frame positioning system, 1-handle, 2-subassembly supporting the "feeler" 3-ring framework, 4-drive mechanism and radial positioning, 5 - drive system, 7-pivoting motor, 8-wheel driving system, 9-running wheel system. b) Adjustable Ring Frame system, 1, 2 - wheel drive, 3-radial positioning positioning unit, 4 - radial positioning drive and positioning mechanism; 5 - radial positioning engine, 6-swivel motor, 7-running -driving system.

6. Conclusions

Structuring principles of moving mechanical systems offers possibilities for achieving high performance positioning systems

On the principle of ensuring the desmodromia for mobile mechanical system, positioning systems ensure compliance with optimal conditions for palpation the welded cordon.

Structuring principles of command and control components designed in mechatronics vision are provideing both the maintenance of mobile mechanical system as well linear and spiral trajectory. It is possible to coordinate accordingly the system position while on the rectilineal direction (linearly welded pipe) and positioning on portions of the pipe which shows curvature.

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