Abstract: This paper describes an application of industrial robots that gain ground mainly in the aerospace industry. It is a TTT manipulator whose task is to automatically position the end-effector, in this case a complex sensor system and a eddy-current probe in the position set by the software application for testing by non-destructive ultrasound control of tickets and bars of titanium, both round and square, or any other transparent ultrasound metal (obviously in a certain range of sizes). For surface control, the effector also includes a Eddy current (Eddy current control system). The installation performs ultrasonic control by the echo boost method in total immersion using as a water coupling medium. This method provides the best coupling for automated control systems. This plant was specially produced for ZIROM S.A. A unique producer of titanium ingots in Romania by the reputed German company Karl Deutch (leader in this field), the founder of the company being also one of the inventors of the non-destructive ultrasonic control method, the part of Eddy current being produced by the German company Prüftechnik. This paper aims to explore the state of the art of non-destructive automatic ultrasonic control techniques according to the possible methods to be adopted, by the applications that demand such methods, by reviewing a series of installations more or less similar to those of Zirom s.a. It is thus found that there are a multitude of pine technical solutions that can be done with an ultrasonic automatic control and precision. In this context, the last chapter of the paper that attempts to probe the possible evolution of the future of US control in this field is of great importance because in the current pace of innovations in all fields, but especially in IT and electronics, the future holds many surprises.

Keywords: Industrial Robots, Automation, TTT Manipulator, Eddy-Current, Complex Sensor System, Software Application, Testing by Non-Destructive, Ultrasound Control, Bars of Titanium, Transparent Ultrasound Metal, Range of Sizes, Surface Control, Echo Boost Method, Total Immersion, Water Coupling Medium, Electronics
The modern industry, the practice of designing and building machinery is increasingly based on the results of scientific and applied research.

Each industrial achievement has backed theoretical and experimental computer-assisted research, which solves increasingly complex problems with advanced computing programs using increasingly specialized software (Aversa et al., 2016a; 2016b; 2016c; 2016d; 2017a; 2017b; 2017c; 2017d).

The robotization of technological processes determines and influences the emergence of new industries, applications under special environmental conditions, the approach of new types of technological operations, manipulation of objects in the alien space, teleoperators in the top disciplines like medicine, robots covering a whole field greater service provision in our modern, computerized society.

In this context, the present paper attempts to make a scientific and technical contribution by describing an application of industrial robots that gain ground mainly in the aerospace industry.

It is a TTT manipulator whose task is to automatically position the end-effector, in this case a complex sensor system and a eddy-current probe in the position set by the software application for testing by non-destructive ultrasonic control of tickets and bars of titanium, both round and square, or any other transparent ultrasound metal (obviously in a certain range of sizes).

For surface control, the effector also includes an Eddy current (Eddy current control system).

The installation performs ultrasonic control by the echo boost method in total immersion using as a water coupling medium.

This method provides the best coupling for automated control systems.

This plant was specially produced for ZIROM S.A. A unique producer of titanium ingots in Romania by the reputed German company Karl Deutch (leader in this field), the founder of the company being also one of the inventors of the non-destructive ultrasonic control method, the part of Eddy current being produced by the German company Prüftechnik.

This paper aims to explore the state of the art of non-destructive automatic ultrasonic control techniques according to the possible methods to be adopted, by the applications that demand such methods, by reviewing a series of installations more or less similar to those of Zirom s.a.

It is thus found that there are a multitude of pine technical solutions that can be done with an ultrasonic automatic control and precision. In this context, the last chapter of the paper that attempts to probe the possible evolution of the future of US control in this field is of great importance because in the current pace of innovations in all fields, but especially in IT and electronics, the future holds many surprises (Mirsayar et al., 2017).

Materials and Methods

About the Method of Non-Destructive Control with Ultrasunete

The method is based on the phenomenon of producing ultrasonic waves in materials, called generic crystals, under the influence of an electric wire, by passing the wave into the material and receiving it by the same crystal or by another (called receptor).

Waves involved in ultrasonic control are:

- Longitudinal waves-where oscillation direction coincides with the transmission direction (Fig. 1)
- Transversal waves-Where the direction of transmission is perpendicular to the oscillation direction (Fig. 2)
- Waves of surface-acts on the surface of the materials (Fig. 3)
- Waves Lamb-are produced only in thin plates (Fig. 4)

The procedures used in US control are:

- By transmission
- Pulse-echo

The most common is the echo pulse presented schematically in the following picture where it can be observed and the working mode of a apparatus for determining defects - producing device receives and processes the received wave and the result of penetration of the material is seen on the oscilloscope of the apparatus for determining defects (Fig. 5).

The principle of control with echo impulse is also clearly presented in the following picture where the two echoes of the bottom and the emission are distinguished, i.e., from the output of the probe from the touch probe and from the reflection of the wave on the bottom of the material (Fig. 6).

There is a smaller echo in the center of the diagram. This is the echo of the internal flaw and it is more of a concern to us. It is noted that there is also a direct link between the distance of the fault echo and the emission time-base from the diagram and the depth at which the defect in the piece material is found.

There is also a function between the defect size and the fault echo on the diagram.

A great importance is also the threshold-amplification, because overcoming it depends on the acceptance or rejection of the piece to be controlled. Just as important is the gate because for example we will have information about the defects of the piece only in the volume inside the gate.
Fig. 1. Longitudinal waves—where oscillation direction coincides with the transmission direction

Fig. 2. Transversal waves—Where the direction of transmission is perpendicular to the oscillation direction
Fig. 3. Waves of surface - acts on the surface of the materials

Fig. 4. Waves Lamb - are produced only in thin plates
Fig. 5. An echo pulse

Fig. 6. The control with echo impulse
About the Method of Non Destructive Control with Ultrasounds in Immersion

Air is the bad conductor of ultrasound. Therefore, the best ultrasonic coupling medium with the control piece is water. Normally, the control can only be done with a track piece. Figure 7 shows two applications of the immersion method for various axes as well as the control of the railway tracks. Both installations were produced by Karl Deutch.

In principle, ultrasound is reflected by any surface and any internal defect. In most cases the same transducer emits and receives ultrasounds. Ultrasonic pulses are converted into electrical signals displayed on the screen. The amplitude of the reflected signal is somewhat proportional to the magnitude of the fault. Sonic track time gives us information on the location of the fault. The front and bottom surfaces give great echoes. The control area is framed into an electronic gate within which only failures will be evaluated. A threshold is set which determines whether the defect found is critical. The size of this threshold is usually determined using either the echo amplitude of a known reflector, such as the bottom echo, or the echo resulting from an artificial defect (Cao et al., 2013; Dong et al., 2013; De Melo et al., 2012; Garcia et al., 2007; Garcia-Murillo et al., 2013; He et al., 2013; Lee, 2013; Lin et al., 2013; Liu et al., 2013; Padula and Perdereau, 2013; Perumal and Jawahar, 2013; Petrescu and Petrescu, 1995a; 1995b; 1997a; 1997b; 1997c; 2000a; 2000b; 2002a; 2002b; 2003; 2005a; 2005b; 2005c; 2005d; 2005e; 2016a; 2016b; 2016c; 2016d; 2016e; Petrescu and Calautit, 2016a; 2016b; Reddy et al., 2012; Tabaković et al., 2013; Tang et al., 2013; Tong et al., 2013; Wang et al., 2013; Wen et al., 2012; Antonescu and Petrescu, 1985; 1989; Antonescu et al., 1985a; 1985b; 1986; 1987; 1998; 1994; 1997; 2000a; 2000b; 2001; Mirsayar et al., 2017).

Total Immersion Control

Air is the bad conductor of ultrasound. Therefore, the best ultrasonic coupling medium with the part to be controlled is water. Normally control can only be done with track piece (Fig. 7).

Partial Immersion Control

Automatic ultrasonic control can often be performed in the case of a partial immersion of the parts to be controlled. Only a small portion of the piece is immersed. The round pieces are spinning until the entire surface of the piece is explored (Fig. 8).

HRP Control System

Partial immersion control and high speed control. Rods or bars have axial movement through the immersion chamber (Fig. 9).

Interstitial Coupling with Water

Another method of ultrasonic coupling with controlled parts uses supports for transducer guides. The ultrasound spreads to the control piece through a full of water (Fig. 10).
Directional Water Jet Coupling

For this type of coupling the volume of mechanical components is higher. The transducer support provided with the water jet guidance system is guided to the surface of the work piece by means of soles or rollers. This method reduces wear and shortens calibration times (Fig. 11).

STPS - Bar Control System

Characteristic for this system is the high speed of control correlated with a special mechanical robustness. Nine transducers provide a wide control coverage. Defects are detected in the central area and immediately
below the surface. Round or hexagonal profiles can be controlled with the same settings. You can also control square or flat profiles (Fig. 13).

**KNPS-Control System for Billets**

Large deviations from the repeatability of the parts to be controlled require a great flexibility in the positioning of the US transducers. The supports of these transducers are guided, on the surfaces of the parts, with soles or rollers. As with the STPS system, water jet coupling is used (Fig. 14).

**RPS/RPT-Pipe Control**

Pipe control requires many directions of incidence. Pipes typically rotate. Longitudinal defects are detected by transmitting ultrasounds in circumferential directions. The transverse defects are detected by the proper inclination of the transducers relative to the pipe axis. The large number of transducer mounts required the design of a compact control system. Controls for the control of pipes or cylinders differ very little (Fig. 15).

**HRP Pipe and Bar Control System**

A high control speed can be achieved if the parts to be controlled do not rotate. Neither the control tanks rotate. The immersion control boxes contain the transducer bearing boxes. The entire control area is covered by transducers with curved surfaces (Fig. 16).

**SCHN Rail Control System**

Almost all rail profile is covered with US freely positionable transducers. Water jet coupling leads to short adjustment times and low mechanical wear (Fig. 17).

**Welding Control System**

Welded pipes can also be controlled automatically. Small diameter pipes are ERW type. Large diameter pipes of the SAW type can be welded longitudinally or spirally. Use solenoid and/or water jet coupling (Fig. 18).
Composing a Normal Transducer of Longitudinal Waves

In principle, a fingerprint transducer (Fig. 19) consists of an oscillator (a crystal of a special material that has the property as the variation of the electric current that crosses it changes its size by emitting ultrasonic waves and vice versa under the effect of the sonic pressure modifying its size emitting a current electric - piezoelectric effect).

In Fig. 20 one can see an ECHOGRAPH - ultrasonic electronics.

Modern digital electronics can command a multi-channel control system.

The current version of the electronic digital system ECHOGRAPH offers a wide variety of freely programmable parameters.
It is important for the beneficiaries to use up to four control gates. Each control gate can evaluate the echoes after three different thresholds. The weakest signals may be amplified by more than 100 dB.

High repetition frequency and frequency bandwidth are two common things for this system. In addition, he uses a noise suppression algorithm (Cao et al., 2013; Dong et al., 2013; De Melo et al., 2012; Garcia et al., 2007; Garcia-Murillo et al., 2013; He et al., 2013; Lee, 2013; Lin et al., 2013; Liu et al., 2013; Padula and Perdereau, 2013; Perumal and Jawahir, 2013; Petrescu and Petrescu, 1995a; 1995b; 1997a; 1997b; 1997c; 2000a; 2000b; 2002a; 2002b; 2003; 2005a; 2005b; 2005c; 2005d; 2005e; 2016a; 2016b; 2016c; 2013; 2012a; 2012b; 2011; Petrescu et al., 2016; 2009; Reddy et al., 2012; Tabaković et al., 2013; Tang et al., 2013; Tong et al., 2013; Wang et al., 2013; Wen et al., 2012; Antonescu and Petrescu, 1985; 1989; Antonescu et al., 1985a; 1985b; 1986; 1987; 1988; 1994; 1997; 2000a; 2000b; 2001; Mirsayar et al., 2017).

The Non-Destructive Control Method with Swirling Currents

Electromagnetic Method

The control coil (primary winding; Fig. 21) generates an alternating magnetic field that induces an electric current, the so-called "eddy current," in the control-piece. The presence of a defect on the surface of the piece produces a 'disturbance' in the electric circuit detected by the coil and transmitted to the oscilloscope where it can be evaluated according to the threshold.

Pipe, bar and wire producers, in order to meet the continuous demands of the beneficiaries to increase the quality of their products, require and use quality assurance systems that can meet these requirements. In order to stay at the top of these conditions, metallurgy manufacturers use fully automated non-destructive control methods, which, based on reliable resolutions, certify the quality of the controlled products.

The overriding concern of manufacturers is to optimize the production process to reduce stops and scrapes during manufacture. Eddy current control is one of the most important control methods for the semi-finished industry. Regardless of the control speed, cool or hot materials can be fully integrated into the control line. Immediate reporting on product quality, ensures immediate recognition of worsening production and remedial action. Eddy current control installs quickly, is easy to serve and provides information that you can rely on at any time. Circumferential control and segmented coil welding and magnetization unit.

Results

It displays the defect during calibration with a square standard (Fig. 22).

At the end of the test, the installation computer issues a noticeable B (B-scan) control bulletin for round and square bars in which the defect acceptance thresholds (line to the limit of the two colors) are visible, as well as their position along the length and in depth reported by each touch probe (Fig. 23).

A robotic system usually consists of a mechanical manipulator, a final effector, a microprocessor based on a controller, a computer and other devices. Six-axis robots have traditionally been used on production lines to move the end effector between two points where the path was not very important. Generally, the end effector was moved manually until the robot taught it. Then repeat the movement in that position and orientation whenever the application requested it. More recently, the technical capabilities of the present (couples, motors, software) have made the robots more flexible and smarter and can perform more complex tasks.

The use of Ultrasonic Testing (UT) robots offers great flexibility for US inspections, with fast control and efficiency, especially for controlling large geometry complexity pieces. However, it was necessary to develop appropriate software to integrate the robots with the latest generation control tools. Trajectory planning (trajectory or path generation) for NDT control, is a very specific task. Commercial software for off-line robot programming stems from the need to flexibly handle manipulators to perform various traditional machining operations (turning, welding, drilling, etc.). As a result, many commercial software applications for off-line programming of robots are expensive tools that incorporate a lot of CAD/CAM functions with unnecessary purposes and features. Despite the abundance of features, a software trace-generating program of commercial software should usually be subject to change before all the necessary NDT inspection requirements are met. A number of problems are often present in the original trajectory being generated by software functions specifically generated for processing and production operations, rather than for ND tasks.

There are significant complications when it takes two or more robotic arms to be synchronized in order to perform a certain NDT inspection. Ultrasonic Transmission Technology (UTT), for example, uses two transducers: One transmitter and one receiver. The receiver being placed on the opposite side of the component and faced by the transmission probe. Currently, many commercial software (such as Del Cam and Master Cam) do not support robots working in tandem. Fast Surf allows partial synchronization of
robotic movements (for example, at the beginning or end of complex trajectory points) using I digital/O signals, but synchronization is not complete over the full path required for the UTT technique. Ultrasounds have the advantage of good penetration of materials and the fact that they are not a polluting method. Robots have the advantage of very good flexibility, so they can use both the advantage of robots and ultrasound control for applications of this type in aviation and beyond (Fig. 24).

![Fig. 22. Scanning a defect during calibration with a square standard](image1)

![Fig. 23. At the end of the test, the installation computer issues a noticeable B (B-scan) control bulletin](image2)
Discussion

The development and diversification of machines and mechanisms with applications in all fields requires new scientific researches for the systematization and improvement of existing mechanical systems by creating new mechanisms adapted to modern requirements, which involve increasingly complex topological structures.

Although not applicable in any situation, there may be advantages in using industrial robots in ultrasound systems, instead of traditional Cartesian scanners based on Robot Gantry type. Robots have excellent stiffness and repeatability—they are also available for short delivery and at an economical cost because they are widely used.

In the past, there have been limitations in the use of industrial robots in the field of ultrasonic testing due to low positioning feedback and the generation of disturbing "noise" by the servo drive systems of the engines. Currently, these limitations have been exceeded with a unique single control system of movement.

Conclusion

This paper describes an application of industrial robots that gain ground mainly in the aerospace industry. It is a TTT manipulator whose task is to automatically position the end-effector, in this case a complex sensor system and a eddy-current probe in the position set by the software application for testing by non-destructive ultrasound control of tickets and bars of titanium, both round and square, or any other transparent ultrasound metal (obviously in a certain range of sizes). For surface control, the effector also includes an Eddy current (Eddy current control system). The installation performs ultrasonic control by the echo boost method in total immersion using as a water coupling medium. This method provides the best coupling for automated control systems. This plant was specially produced for ZIROM S.A. A unique producer of titanium ingots in Romania by the reputed German company Karl Deutch (leader in this field), the founder of the company being also one of the inventors of the non-destructive ultrasonic control method, the part of Eddy current being produced by the German company Prüftechnik. This paper
aims to explore the state of the art of non-destructive automatic ultrasonic control techniques according to the possible methods to be adopted, by the applications that demand such methods, by reviewing a series of installations more or less similar to those of Zirom s.a. It is thus found that there are a multitude of possible technical solutions that can be done with an ultrasonic automatic control and precision. In this context, the last chapter of the paper that attempts to probe the possible evolution of the future of US control in this field is of great importance because in the current pace of innovations in all fields, but especially in IT and electronics, the future holds many surprises.

There are significant complications when it takes two or more robotic arms to be synchronized in order to perform a certain NDT inspection. Ultrasonic Transmission Technology (UTT), for example, uses two transducers: One transmitter and one receiver; The receiver being placed on the opposite side of the component and faced by the transmission probe. Currently, many commercial software (such as Del Cam and Master Cam) do not support robots working in tandem. Fast Surf allows partial synchronization of robotic movements (for example, at the beginning or end of complex trajectory points) using I digital/O signals, but synchronization is not complete over the full path required for the UTT technique. Ultrasounds have the advantage of good penetration of materials and the fact that they are not a polluting method. Robots have the advantage of very good flexibility, so they can use both the advantage of robots and ultrasound control for applications of this type in aviation and beyond.

Although not applicable in any situation, there may be advantages in using industrial robots in ultrasound systems, instead of traditional Cartesian scanners based on Robot Gantry type. Robots have excellent stiffness and repeatability-they are also available for short delivery and at an economical cost because they are widely used.

In the past, there have been limitations in the use of industrial robots in the field of ultrasonic testing due to low positioning feedback and the generation of disturbing “noise” by the servo drive systems of the engines. Currently, these limitations have been exceeded with a unique single control system of movement.

Acknowledgement

This text was acknowledged and appreciated by Dr. Veturia CHIROIU Honorific member of Technical Sciences Academy of Romania (ASTR) PhD supervisor in Mechanical Engineering.

Funding Information

Research contract: 1-Research contract: Contract number 36-5-4D/1986 from 24IV1985, beneficiary CNST RO (Romanian National Center for Science and Technology) Improving dynamic mechanisms. 2-Contract research integration. 19-91-3 from 29.03.1991; Beneficiary: MIS; TOPIC: Research on designing mechanisms with bars, cams and gears, with application in industrial robots. 3-Contract research. GR 69/10.05.2007: NURC in 2762; theme 8: Dynamic analysis of mechanisms and manipulators with bars and gears. 4-Labor contract, no. 35/22.01.2013, the UPB, "Stand for reading performance parameters of kinematics and dynamic mechanisms, using inductive and incremental encoders, to a Mitsubishi Mechatronic System" "PN-II-IN-CI-2012-1-0389". All these matters are copyrighted! Copyrights: 394-qodGnhhtej, from 17-02-2010 13:42:18; 463-vpstuCGsity, from 20-03-2010 12:45:30; 631-sqk6gqyutm, from 24-05-2010 16:15:22; 933-CrDztElqow, from 07-01-2011 13:37:52.

Author’s Contributions

All the authors contributed equally to prepare, develop and carry out this manuscript.

Ethics

This article is original and contains unpublished material. Authors declare that are not ethical issues and no conflict of interest that may arise after the publication of this manuscript.

References

Antonescu, P. and F. Petrescu, 1985. Metodă analitică de sinteză a mecanismului cu camă si tachet plat. Lucrările celui de-al IV-lea Simpozion International de Teoria și Practica Mecanismelor, (TPM’ 85), Bucuresti. Antonescu, P. and F. Petrescu, 1989. Contribuții la analiza cinetoelastodinamică a mecanismelor de distributie, Bucuresti. Antonescu, P., M. Opren and F. Petrescu, 1985a. Contribuții la sinteza mecanismului cu camă oscilantă și tachet plat oscillant. Lucrările celui de-al Patrulea Simpozion Internațional Privind Teoria și Practica Mecanismelor, (TPM’ 85), Bucuresti. Antonescu, P., M. Opren and F. Petrescu, 1985b. Contribuția la proiectarea profilului Kurz a camei rotative chez les mechanisms a distribution variable. Lucrările celui de-a V-a Conferință de Motoare, Automobile, Tractoare și Masini Agricole, I-Motoare si Automobile, (AMA’ 85), Brasov. Antonescu, P., M. Opren and F. Petrescu, 1986. Proiectarea profilului Kurz al camei rotative ce actionează tachetul plat oscilant cu dezaxare. Lucrările celui de- al III-lea Siopozion National de Proiectare Asistată de Calculatoare in Domeniul Mecanismelor si Organelor de Masini, (MOM’ 86), Brasov.
Antonescu, P., M. Oprean and F. Petrescu, 1987. Analiza
dinamica a mecanismelor de distributie cu came. Lucrările
celu de-al VII-lea Simpozion National de Roboti Industriali si Mecanisme Spatiale, (IMS '87), Bucuresti,
Antonescu, P., M. Oprean and F. Petrescu, 1988 Sinteza
analitica a profilului Kurz, la cama cu tachet plat
rotativ. Revista Constructia de Masini, Bucuresti.
Antonescu, P., F. Petrescu and O. Antonescu, 1994. Contributii la sinteza mecanismului cu camã rotativã
si tachet balansier cu vãrf. Brasov.
Antonescu, P., F. Petrescu and D. Antonescu, 1997.
Geometrical synthesis of the rotary cam and balance
tappet mechanism. Bucuresti.
Antonescu, P., F. Petrescu and O. Antonescu, 2000a.
Contributions to the synthesis of the rotary disc-cam
profile. Proceedings of the 8th International
Conference on the Theory of Machines and
Mechanisms, (TMM' 00), Liberec, Czech Republic,
pp: 39-44.
Antonescu, P., F. Petrescu and O. Antonescu, 2000b.
Synthesis of the rotary cam profile with balance
follower. Proceedings of the 8th Symposium on
Mechanisms and Mechanical Transmissions,
(MMT' 00), Timişoara, pp: 31-36.
Antonescu, P., F. Petrescu and O. Antonescu, 2001.
Contributions to the synthesis of mechanisms with
rotary disc-cam. Proceedings of the 8th IFToMM
International Symposium on Theory of Machines
and Mechanisms, (TMM’ 01), Bucharest,
ROMANIA, pp: 31-36.
Aversa, R., R.V. Petrescu, A. Apicella and
F.I.T. Petrescu, 2017a. Nano-diamond hybrid
materials for structural biomedical application. Am.
J. Biochem. Biotechnol., 13: 34-41.
DOI: 10.3844/ajbbsp.2017.34.41
Aversa, R., R.V. Petrescu, B. Akash, R.B. Bucinell and
J.M. Corchado et al., 2017b. Kinematics and forces
to a new model forging manipulator. Am. J. Applied
Sci., 14: 60-80. DOI: 10.3844/ajassp.2017.60.80
Aversa, R., R.V. Petrescu, A. Apicella, F.I.T. Petrescu and
J.K. Calautit et al., 2017c. Something about the
V engines design. Am. J. Applied Sci., 14: 34-52.
DOI: 10.3844/ajassp.2017.34.52
Aversa, R., D. Parcesepe, R.V. Petrescu, F. Berto and
G. Chen et al., 2017d. Processability of bulk
metallic glasses. Am. J. Applied Sci., 14: 294-301.
DOI: 10.3844/ajassp.2017.294.301
Aversa, R., F.I.T. Petrescu, R.V. Petrescu and
A. Apicella, 2016a. Biomimetic FEA bone modeling
for customized hybrid biological prostheses
development. Am. J. Applied Sci., 13: 1060-1067.
DOI: 10.3844/ajassp.2016.1060.1067
Aversa, R., D. Parcesepe, R.V. Petrescu, G. Chen and
F.I.T. Petrescu et al., 2016b. Glassy amorhous
metal injection molded induced morphological
defects. Am. J. Applied Sci., 13: 1476-1482.
DOI: 10.3844/ajassp.2016.1476.1482
Aversa, R., R.V. Petrescu, F.I.T. Petrescu and A. Apicella,
2016c. Smart-factory: Optimization and process
control of composite centrifuged pipes. Am. J.
Applied Sci., 13: 1330-1341.
DOI: 10.3844/ajassp.2016.1330.1341
Aversa, R., F. Tamburrino, R.V. Petrescu, F.I.T. Petrescu
and M. Artur et al., 2016d. Biomechanically
inspired shape memory effect machines driven by
muscle like acting NiTi alloys. Am. J. Applied Sci.,
13: 1264-1271.
DOI: 10.3844/ajassp.2016.1264.1271
Cao, W., H. Ding, Z. Bin and C. Ziming, 2013. New
structural representation and digital-analysis
platform for symmetrical parallel mechanisms. Int.
J. Adv. Robot. Sys. DOI: 10.5772/56380
Dong, H., N. Giakoumidis, N. Fugieroa and N. Mavridis,
2013. Approaching behaviour monitor and vibration
indication in developing a General Moving Object
Alarm System (GMOAS). Int. J. Adv. Robot. Sys.
DOI: 10.5772/56586
De Melo, L.F., R.A., S.F. Rosário and J.M., Rosário,
2012. Mobile robot navigation modelling, control
and applications. Int. Rev. Modelling Simulations,
5: 1059-1068.
Garcia, E., M.A. Jimenez, P.G. De Santos and M.
Armeda, 2007. The evolution of robotics
research. IEEE Robot. Autom. Magaz., 14: 90-103.
DOI: 10.1109/MRA.2007.339608
Garcia-Murillo, M., J. Gallardo-Alvarado and
E. Castillo-Castaneda, 2013. Finding the generalized
forces of a series-parallel manipulator. IJARS.
DOI: 10.5772/53824
He, B., Z. Wang, Q. Li, H. Xie and R. Shen, 2013. An
analytic method for the kinematics and dynamics of
a multiple-backbone continuum robot. IJARS.
DOI: 10.5772/54051
Lee, B.J., 2013. Geometrical derivation of differential
kinematics to calibrate model parameters of flexible
manipulator. Int. J. Adv. Robot. Sys.
DOI: 10.5772/55592
Lin, W., B. Li, X. Yang and D. Zhang, 2013. Modelling
and control of inverse dynamics for a 5-DOF
parallel kinematic polishing machine. Int. J. Adv.
Robot. Sys. DOI: 10.5772/54966
Liu, H., W. Zhou, X. Lai and S. Zhu, 2013. An efficient
inverse kinematic algorithm for a PUMA560-
structured robot manipulator. IJARS.
DOI: 10.5772/56403
Mirsayar, M.M., V.A. Joneidi, R.V. Petrescu, F.I.T. Petrescu and F. Berto, 2017. Extended MTSN criterion for fracture analysis of soda lime glass. Eng. Fracture Mech., 178: 50-59. DOI: 10.1016/j.engfracmech.2017.04.018

Padula, F. and V. Perdereau, 2013. An on-line path planner for industrial manipulators. Int. J. Adv. Robot. Sys. DOI: 10.5772/55063

Perumaal, S. and N. Jawahar, 2013. Automated trajectory planner of industrial robot for pick-and-place task. IJARS. DOI: 10.5772/53940

Petrescu, F. and R. Petrescu, 1995a. Contributii la optimizarea legilor polinomiale de miscare a tachetului de la mecanismul de distributie al motoarelor cu ardere interna. Bucuresti.

Petrescu, F. and R. Petrescu, 1995b. Contributii la sinteza mecanismelor de distributie ale motoarelor cu ardere interna. Bucuresti.

Petrescu, F. and R. Petrescu, 1997a. Dinamica mecanismelor cu came (exemplificata pe mecanismul clasic de distributie). Bucuresti.

Petrescu, F. and R. Petrescu, 1997b. Contributii la sinteza mecanismelor de distributie ale motoarelor cu ardere interna cu metoda coordonatelor carteziene. Bucuresti.

Petrescu, F. and R. Petrescu, 1997c. Contributii la maximizarea legilor polinomiale pentru cursa activa a mecanismului de distributie de la motoarele cu ardere interna. Bucuresti.

Petrescu, F. and R. Petrescu, 2000a. Sinteza mecanismelor de distributie prin metoda coordonatelor polare (metoda triunghiurilor). Universitatea din Craiova, Craiova.

Petrescu, F. and R. Petrescu, 2000b. Designul (sinteza) mecanismelor cu came prin metoda coordonatelor polare (metoda triunghiurilor). Universitatea din Craiova, Craiova.

Petrescu, F. and R. Petrescu, 2002a. Legi de miscare pentru mecanismele cu came. Lucrările celor de-al VII-lea Simpozion Național cu Participare Internațională Proiectarea Asistată de Calculator, (PAC' 02), Brașov, pp: 321-326.

Petrescu, F. and R. Petrescu, 2002b. Elemente de dinamica mecanismelor cu came. Lucrările celor de-al VII-lea Simpozion Național cu Participare Internațională Proiectarea Asistată de Calculator, (PAC' 02), Brașov, pp: 327-332.

Petrescu, F. and R. Petrescu, 2003. Câteva elemente privind îmbunătățirea designului mecanismului motor. Lucrările celor de-al VIII-lea Simpozion Național, de Geometrie Descriptivă, Grafică Tehnică și Design, (GTD’ 03), Brașov, pp: 353-358.

Petrescu, F. and R. Petrescu, 2005a. The cam design for a better efficiency. Proceedings of the International Conference on Engineering Graphics and Design, (EGD’ 05), Bucharest, pp: 245-248.

Petrescu, F. and R. Petrescu, 2005b. Contributions at the dynamics of cams. Proceedings of the 9th IFToMM International Symposium on Theory of Machines and Mechanisms, (TMM’ 05), Bucharest, Romania, pp: 123-128.

Petrescu, F. and R. Petrescu, 2005c. Determining the dynamic efficiency of cams. Proceedings of the 9th IFToMM International Symposium on Theory of Machines and Mechanisms, (TMM’ 05), Bucharest, Romania, pp: 129-134.

Petrescu, F. and R. Petrescu, 2005d. An original internal combustion engine. Proceedings of the 9th IFToMM International Symposium on Theory of Machines and Mechanisms, (TMM’ 05), Bucharest, Romania, pp: 135-140.

Petrescu, F. and R. Petrescu, 2005e. Determining the mechanical efficiency of Otto engine’s mechanism. Proceedings of the 9th IFToMM International Symposium on Theory of Machines and Mechanisms, (TMM’ 05), Bucharest, Romania, pp: 141-146.

Petrescu, F.I. and R.V. Petrescu, 2013. Cinematics of the 3R Dyad. Engevista, 15: 118-124.

Petrescu, F.I. and R.V. Petrescu, 2012a. Kinematics of the planar quadrilateral mechanism. Engevista, 14: 345-348.

Petrescu, F.I. and R.V. Petrescu, 2012b. Mecatronica-Sisteme Seriale si Paralele. Create Space Publisher, USA, ISBN-10: 978-1-4750-6613-5, pp: 128.

Petrescu, F.I. and R.V. Petrescu, 2011. Mechanical Systems, Serial and Parallel-Course (in Romanian). LULU Publisher, London, UK, ISBN-10: 978-1-4466-0039-9; pp: 124.

Petrescu, F.I. and R.V. Petrescu, 2016a. Parallel moving mechanical systems kinematics. Engevista, 18: 455-491.

Petrescu, F.I. and R.V. Petrescu, 2016b. Direct and inverse kinematics to the Anthropomorphic Robots. Engevista, 18: 109-124.

Petrescu, F. and R. Petrescu, 2016c. An otto engine dynamic model. IJM&P, 7: 038-048.

Petrescu, F.I. and R.V. Petrescu, 2016d. Direct and inverse kinematics to the Anthropomorphic Robots. Engevista, 18: 109-124.

Petrescu, F. and R. Petrescu, 2016c. An otto engine dynamic model. IJM&P, 7: 038-048.

Petrescu, F.I. and R.V. Petrescu, 2016d. Dynamic cinematic to a structure 2R. GEINTEC, 6: 3392-3406.

Petrescu, F.I. and R.V. Petrescu, 2016e. Dynamic cinematic to a structure 2R. GEINTEC, 6: 3143-3154.

Petrescu, F.I., B. Grecu, A. Comanescu and R.V. Petrescu, 2009. Some mechanical design elements. Proceeding of the International Conference on Computational Mechanics and Virtual Engineering, (MEC’ 09), Brașov, pp: 520-525

Petrescu, R.V., R. Aversa, A. Apicella, M.M. Mirsayar and F.I.T. Petrescu, 2016a. About the gear efficiency to a simple planetary train. Am. J. Applied Sci., 13: 1428-1436. DOI: 10.3844/ajassp.2016.1428.1436

582
Petrescu, R.V., R. Aversa, A. Apicella, S. Li and G. Chen et al., 2016b. Something about electron dimension. Am. J. Applied Sci., 13: 1272-1276. DOI: 10.3844/ajassp.2016.1272.1276

Petrescu, F.I.T., A. Apicella, R. Aversa, RV. Petrescu and J.K. Calautit et al., 2016c. Something about the mechanical moment of inertia. Am. J. Applied Sci., 13: 1085-1090. DOI: 10.3844/ajassp.2016.1085.1090

Petrescu, R.V., R. Aversa, A. Apicella, F. Berto and S. Li et al., 2016d. Ecosphere protection through green energy. Am. J. Applied Sci., 13: 1027-1032. DOI: 10.3844/ajassp.2016.1027.1032

Petrescu, F.I.T., A. Apicella, R.V. Petrescu, S.P. Kozaitis and R.B. Bucinell et al., 2016e. Environmental protection through nuclear energy. Am. J. Applied Sci., 13: 941-946. DOI: 10.3844/ajassp.2016.941.946

Petrescu, F.I.T. and J.K. Calautit, 2016a. About nano fusion and dynamic fusion. Am. J. Applied Sci., 13: 261-266. DOI: 10.3844/ajassp.2016.261.266

Petrescu, F.I.T. and J.K. Calautit, 2016b. About the light dimensions. Am. J. Applied Sci., 13: 321-325. DOI: 10.3844/ajassp.2016.321.325

Reddy, P., K.V. Shihabudheen and J. Jacob, 2012. Precise non linear modeling of flexible link flexible joint manipulator. IReMoS, 5: 1368-1374.

Tabaković, S., M. Zeljković, R. Gatalo and A. Živković, 2013. Program suite for conceptual designing of parallel mechanism-based robots and machine tools. Int. J. Adv. Robot Sys. DOI: 10.5772/56633

Tang, X., D. Sun and Z. Shao, 2013. The structure and dimensional design of a reconfigurable PKM. IJARS. DOI: 10.5772/54696

Tong, G., J. Gu and W. Xie, 2013. Virtual entity-based rapid prototype for design and simulation of humanoid robots. Int. J. Adv. Robot. Sys. DOI: 10.5772/55936

Wang, K., M. Luo, T. Mei, J. Zhao and Y. Cao, 2013. Dynamics analysis of a three-DOF planar serial-parallel mechanism for active dynamic balancing with respect to a given trajectory. Int. J. Adv. Robotic Sys. DOI: 10.5772/54201

Wen, S., J. Zhu, X. Li, A. Rad and X. Chen, 2012. Endpoint contact force control with quantitative feedback theory for mobile robots. IJARS. DOI: 10.5772/53742