Use of Electronic Modules on Device for Tribological Research in the Field of Plastic Deformation of Slim Metal Sheets

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Contribution to the State of the Art

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Abstract: Electronic modules are important components of manufacturing and research equipment in the field of plastic deformation of sheet metal fabrication, as well as in other processes. Depending on the type and complexity of the production or research process, different electronic modules are also used. The indispensable electronic modules in production as well as experimental (research) systems are: encoders, signal processing, A/D and D/A converters, required software of all levels, all the way to large packages for numerical process simulation. This scientific paper presents an original computerized device for testing tribological influences in plastic deformation of slim (thin) sheet metal forming (fabrication), whose control base consists of electronic modules. Some results are also shown as dependencies, obtained by testing on this developed device.

Keywords: slim (thin) metal sheet, tribology, plastic deformation, electronic modules.

Introduction

The technology of slim (thin) metal-sheet processing by plastic deformation in large-scale production has great advantages over other processing technologies. This is why slim (thin) metal sheets are a material of strategic importance in the metal world industry. The use of thin sheets as a deformation technology is most prevalent in the automotive industry.

The processing of slim (thin) sheets by plastic deformation is often the subject of study and specialization (production of sheets with better mechanical and tribological properties, development and production of new lubricants, development of numerical simulation techniques, development and used of control systems, etc.) in all well developed industrialized countries /1/. Computerized manufacturing and experimental slim (thin) sheet metal forming systems are a combination of mechanical, hydraulic, pneumatic and electrical modules. Without the proper electronic modules, neither control nor regulation of production or systems is possible as device for experimental research /2/.

Developed device

In this scientific work, a computerized device with programing control is implemented, which should provide appropriate tasks for changing the height of drawbead and metal-sheet holding force, as well as measuring the state of strees of traction /3/4/. The concept of the complete system is shown in the block diagram - Figure 1.

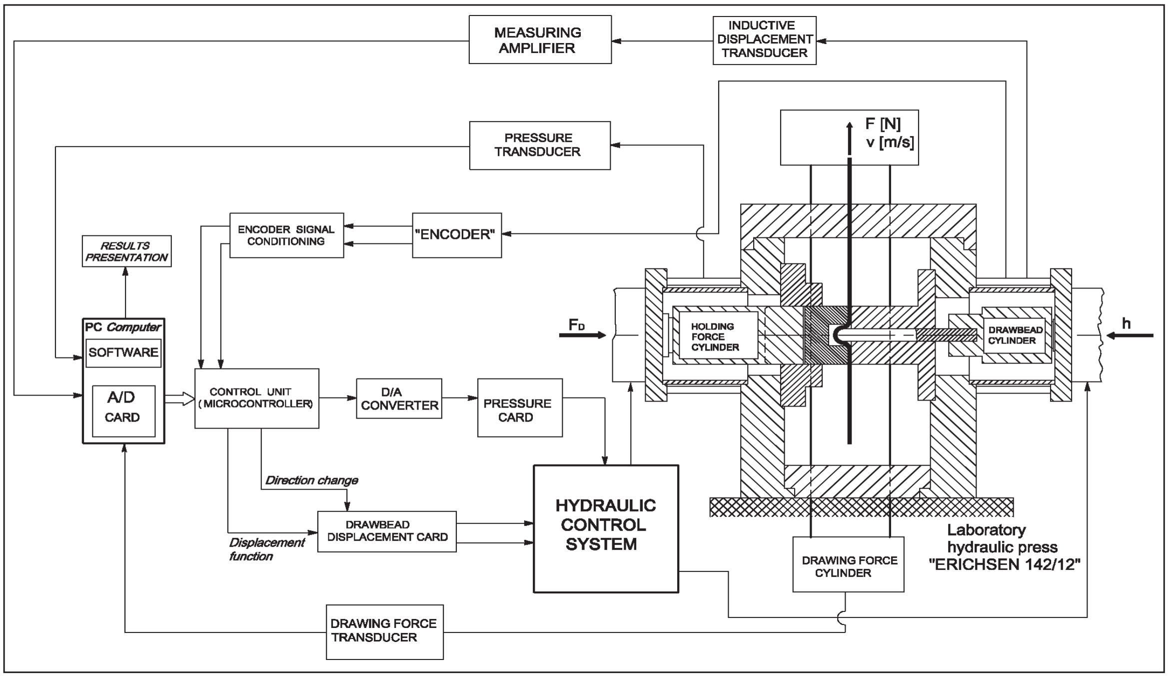


Figure 1. Scheme of a measuring and control system for testing the effect of the tensile curve and the holding force on the pulling force

The operation of the shown system consists of pulling the metal strips sheet over a tensile drawbead defined height (h), as well as a given holding force (FD), determined by the pulling speed (v) and the pulling force (F). The actuators are double acting hydraulic cylinders. Cylinders, with the support of mechanicaly constructed elements and electrical modules, should provide the specified dependence of the holding force and the pressure (force) of the grip holder as well as the measurement of the pulling force (Figure 2). A laboratory hydraulic press, which has its own hydraulic module, was used to provide traction force.

As the realization of the shown dependences of the pressure of the holder and the height of the drawbead, as well as the measurement of the pulling force, is ensured, it is shown in the measuring and control scheme (Figure 1). In the memory of the control unit, a program for all the curve of pressure and drawbead changes was recorded according to the experiment plan. The program is written in C-language. A LIMAS program is installed on the computer, which registers, processes and displays all values of the pulling force, the pressure of the grip holder and the displacement of the tension drawbead. The metal-sheet pull speed is adjusts using

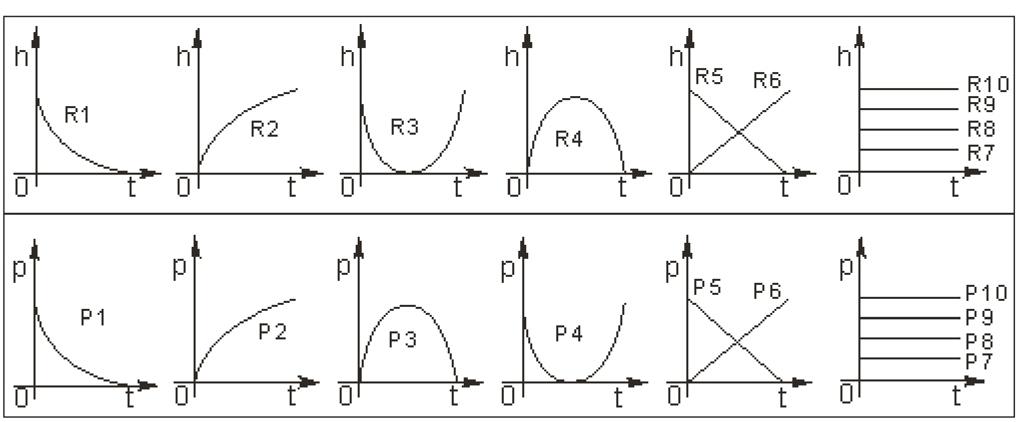
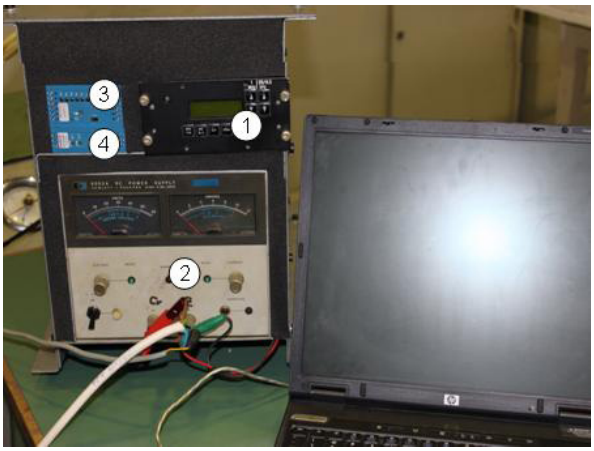


Figure 2. Curve changes in drawbead height and grip holder pressure

potentiometer, which is in line with the 60mm pull length for three minutes.

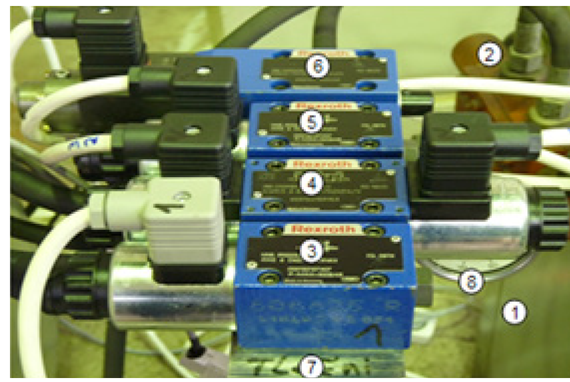
Functional dependencies of the height of tension drawbead (R) are achieved by sending information to the control unit for the selected dependency via PC. (Figure 3).



1-control unit; **2**-power source; **3**-drawbead control card; **4**-pressure control card

Figure 3. *Control unit with power supply*

According to the program, the control unit sends control signals to the control card (Figure 4), which generates these signals as required by the electromagnetic proportional valves that power the actuating hydraulic cylinder for the positioning of the drawbead (Figure 5). Then the LIMAS program is activated as well as the pulling metal sheet.



1. hydraulic power unit; **2.** thre-position manual distributor; **3.** solenoid valve for change the direction of the drawbead cylinder; **4.** proportional solenoid valve for drawbead cylinder for the holder; **5.** solenoid valve for change the direction of the cylinder for the holder; **6.** proportional elektromagnetic manifold for cylinder holder; **7.** juction plate

Figure 5. *Hydraulic module*

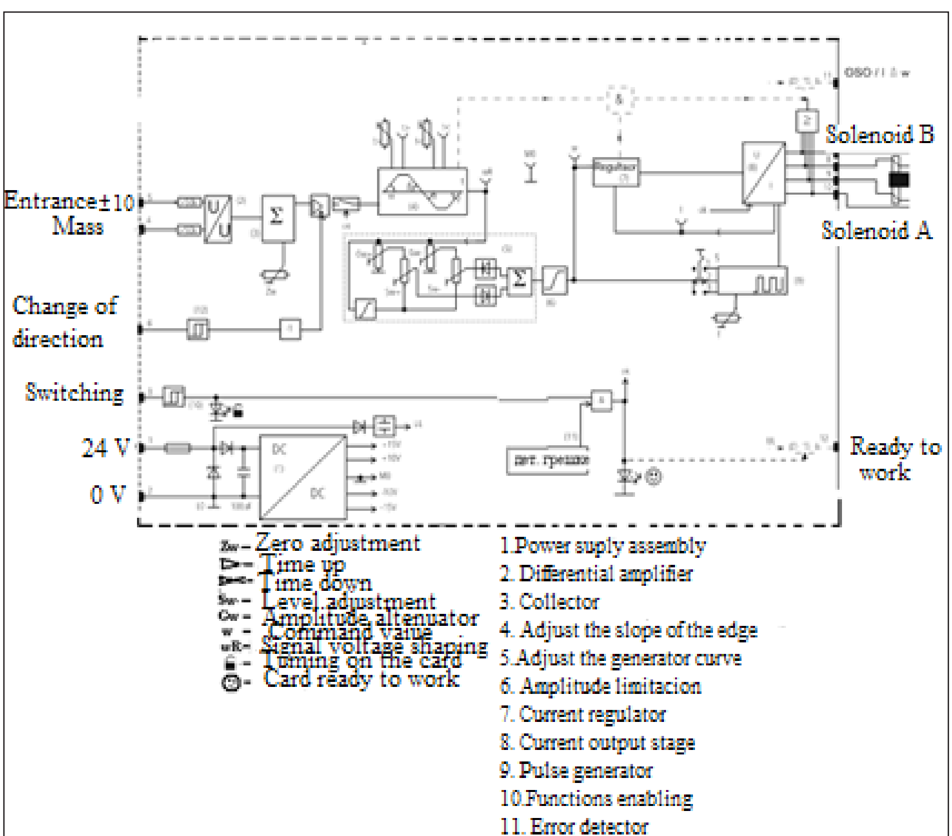
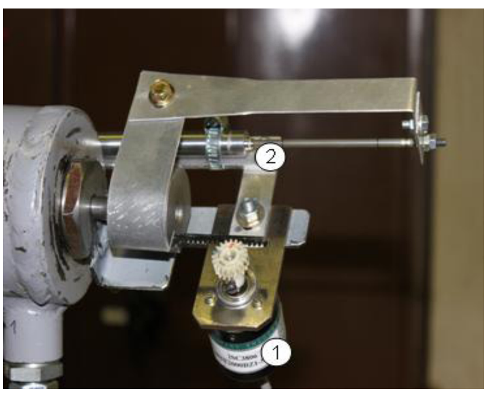


Figure 4. *Proportional valve control valve for moving the drawbead*

The process is flowing, the path encoders (Figure 6) register the position of the drawbead, measure and send signals to the computer, which through LIMAS processes displays them on the monitor. At the same time, the encoder (Figure 6 Pos. 1) registers the position of the drawbead at all times, and sends this information to the control unit that compares the measured and programmed setpoint (position) at that moment. If there is a difference, the control card sends correction pulses for the next step. Likewise, the inductive displacement encoder (Figure 1) registers the position of the drawbead during the process, and sends information via a measurement bridge (Figure 7) to a computer that draws the dependency achieved through the A/D converter and the LIMAS program.



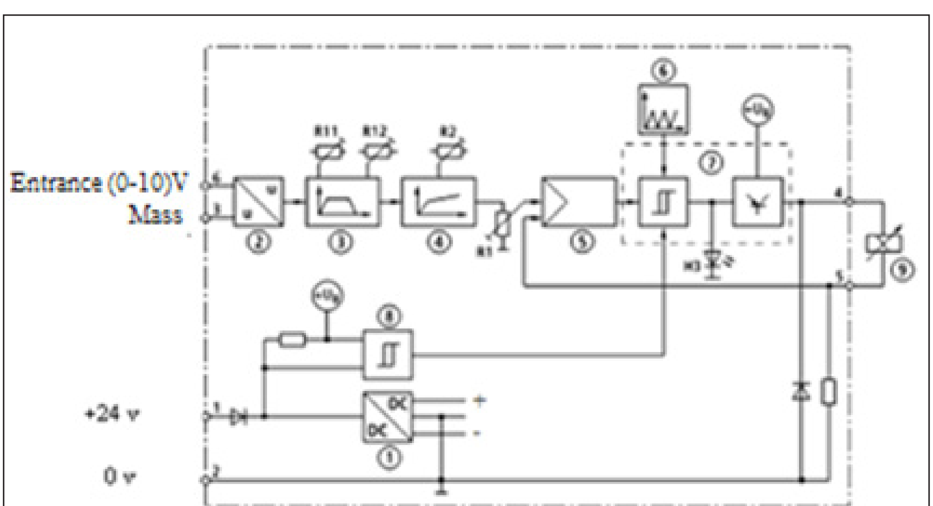
1-optical encoder; **2**-inductive path encoder

Figure 6. *Encoders for drawbead position measurement*

Figure 7. *Measuring bridge*

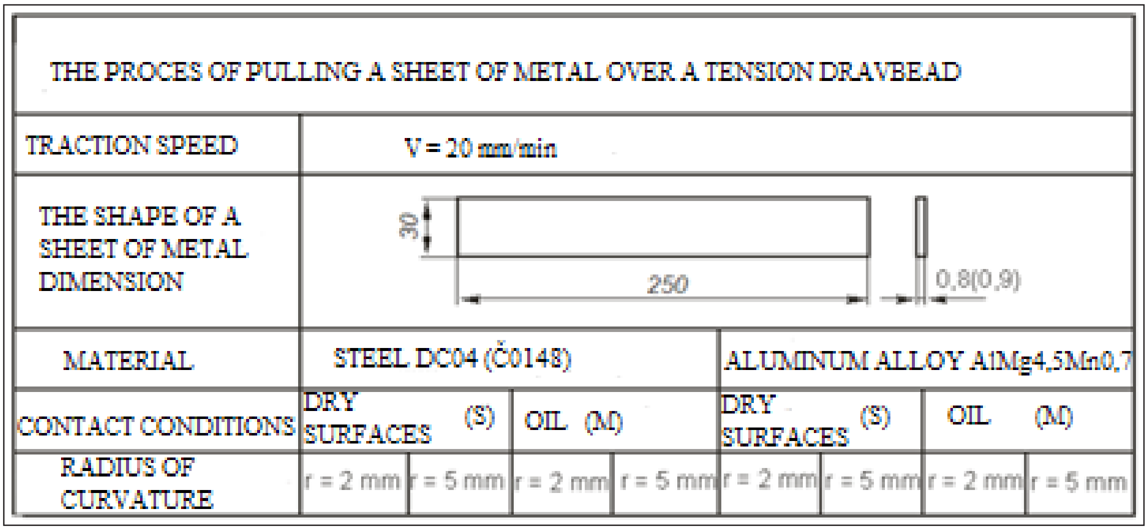
The functional dependencies of the pressure of the holder are provided and realized in the same way as with the drawbead so that the selected dependence is sent via PC to the control unit (Figure 3). According to the program, the control unit sends control signals to a control card (Figure 8), which generates these signals as required by the electromagnetic proportional valves that power the actuating hydraulic cylinder to exert a holding force. Then the LIMAS program is activated as well as the lane drag. During the process, the pressure transmitter measures the pressure and sends values to a computer that graphically displays the A/D (Figure 1) of the converter and the LIMAS program draws the realized dependency.

The basic results of testing the process of pulling the ribbon over the tensile drawbead essentially boil down to examining the nature of the relationship between the tractive force and the



1. Charging; **2**. Diffenential amplifier; **3**. Edge slope adjustment; **4**. Function generator; **5**. Curent regulator; **6**. Pulse generator; **7**. Output stage; **8**. Commutation degree; **9**. Proportional solenoid

Figure 8. *Schematic of the proportional valve control card for changing the pressure of the holder*



THE PROCES OF PULLING A SHEET OF METAL OVER A TENSION DRAVBEAD								
TRACTION SPEED	V = 20 mm/min							
THE SHAPE OF A SHEET OF METAL DIMENSION	30; 250; 0,8(0,9)							
MATERIAL	STEEL DC04 (Č0148)				ALUMINUM ALLOY AlMg4,5Mn0,7			
CONTACT CONDITIONS	DRY SURFACES (S)		OIL (M)		DRY SURFACES (S)		OIL (M)	
RADIUS OF CURVATURE	r = 2 mm	r = 5 mm	r = 2 mm	r = 5 mm	r = 2 mm	r = 5 mm	r = 2 mm	r = 5 mm

Figure 9. *Conditions for the experiment*

combination of various influences including: friction conditions (dry and lubricant used), drawbead geometry (two radius of curvature) and material type (Č0148 and AlMg4,5Mn0,7) which are shown in Figure 9. with flexible pressure functions and tension drawbead.

The results of these studies are given in the form of diagrams. As this developed device enabled the

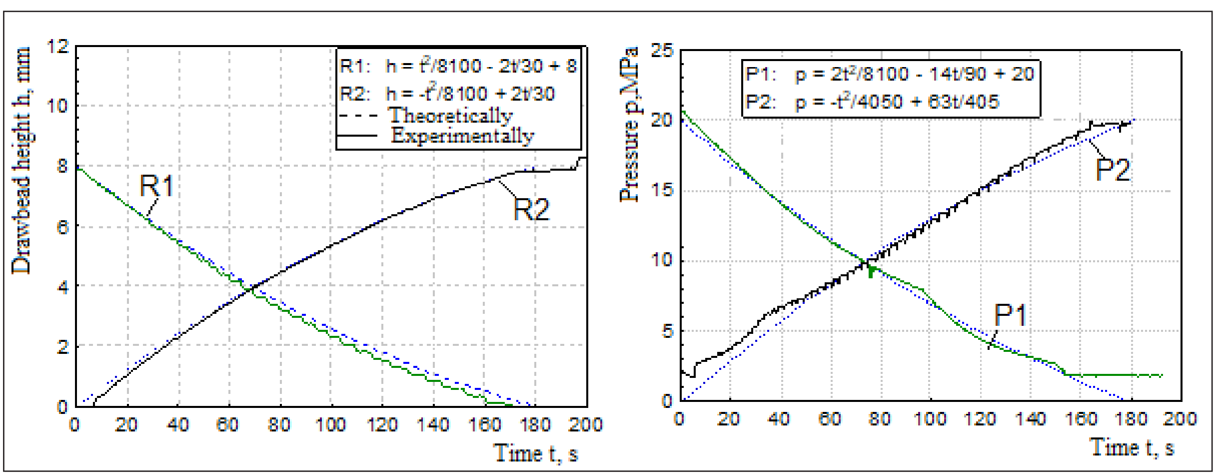


Figure 10. *Theoretical and realized dependencies*

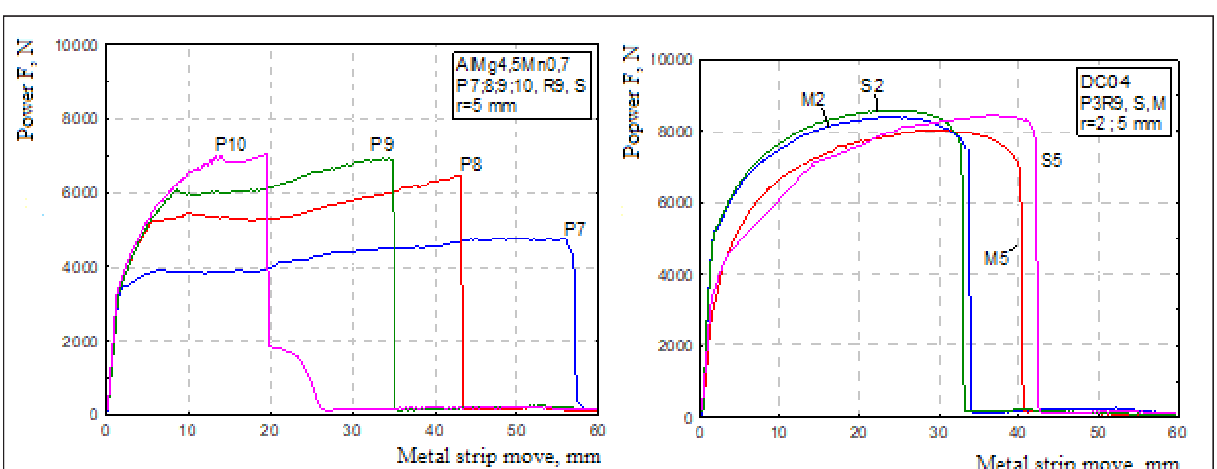


Figure 11. *Combinations of realized drag force dependencies*

foreseen tests (investigations) which consisted in performing, measuring and recording is best shown in the results. Only a few of these results in this scientific paper will be shown in the theoretical and realized dependencies of pressure and drawbead (Fig. 10), as well as realized dependencies of pulling force under different conditions (Figures 11 and 12).

CONCLUSION

The obtained results show that the developed device with sufficient accuracy achieves the required dependencies. With a combination of used electrical modules, which are neither complex nor expensive, a fairly simple device was developed on which complex tribological research in the field of thin sheet metal processing can be performed. In addition to the electro module, a proportional technique was used in the structure of the device to support the executive hydraulic cylinders, which is much simpler and less expensive than the servo technique.

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Tomislav Vujinović was born on May 10, 1958. in Ratkovo. He completed his undergraduate studies at the Faculty of Mechanical Engineering in Banjaluka, where he also received his master's degree. He successfully defended his doctoral dissertation at the Faculty of Mechanical Engineering in Kragujevac. Since 2012, he has been working as a professor at the Pan-European University Apeiron Banjaluka. He has published more than 40 scientific and professional papers in scientific and professional journals. He is the author of a university textbook and a member of the editorial board of the international journal Traffic and Transport Theory and Practice. Since 2018, he is the dean of the Faculty of Traffic Engineering.

Dragan Mihić born on November 29, 1959 in Jagodina. He finished primary and secondary school in Derventa in 1978. He enrolled at the Faculty of Mechanical Engineering in Banjaluka in 1978, where he graduated in 1982. At the Faculty of Mechanical Engineering in Mostar, he enrolled in postgraduate studies in 1988. In 1994, he enrolled at the University of Westminster in London. Since 1990, He have mostly worked in the UK as a consultant in the field of Informatics. As a software analyst and developer, he used a number of current IT technologies.

Esad Jakupović Ph.D. is an academic and member of the Academy of Sciences and Art of Republic of Srpska. Since 2005, he is employed at the Pan-European University Apeiron in Banjaluka as a full professor. In the period 2014-2018, he was the Rector of the Pan-European University Apeiron. His scientific work is primarily focused on mathematical modeling of technological processes, analysis of energy balances in biomass production, analysis of dielectric and absorption molecular crystals, and alternative energy sources. During his scientific career, he has published many books and scientific papers.

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