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The 50th CIRP Conference on Manufacturing Systems

In Memoriam: Janez Peklenik, 1926 – 2016

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Abstract

Janez Peklenik was one of the outstanding scientists and engineers of the twentieth century, who left visible trails in manufacturing engineering research and education. He contributed to the advancement of manufacturing from soft empirical science into pure hard science. As a practitioner he was striving toward perfection and toward implementation of research ideas and results in real life. He was also a great scholar who was aware of the needs of industry on one side and of the problems that young students were confronted with on the other side, while trying to bridge over these two worlds.

Janez Peklenik was recognized far over the Slovenian borders. His numerous invited lectures all over the globe confirm this fact. He was also a very active and distinguished member of The International Academy for Production Engineering - CIRP and, in the year 1979/80, its president. Fifty years ago he, as a young scientist with a vision, proposed the idea of organizing The International Seminar on Manufacturing Systems as a platform for exchanging ideas and experiences especially among young researchers and engineers. This idea attracted his CIRP colleagues and friends, Bertil Colding from Sweden, Toshio Sata from Japan and Günter Spur from Germany, and they founded together the CIRP Conference on Manufacturing Systems, the CIRP conference series with the longest tradition.

The contribution brings forward a brief review of Janez Peklenik life milestones and major achievements.

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Keywords: Janez Peklenik; in memoriam; CIRP CMS conference; founder; review;

Fig. 1. Prof.Dr.-Ing.habil., Dr.h.c.mult. Janez Peklenik (personal archive).

In March 2016 we were shaken by the sad news of the death of academician and emeritus professor, Professor Janez Peklenik (Fig. 1), at the age of ninety.

On the occasion of The 50th CIRP Conference on Manufacturing Systems, which he co-founded fifty years ago, we would like to portray his course of life and work, as well as his contributions to the development of manufacturing as a science, and especially to the manufacturing systems and the CIRP Conferences on Manufacturing Systems.

Janez Peklenik was born in June 1926 in Tržič, a small town in Slovenia at the foothills of Alps. The creative domestic craft environment excited his interest in mechanical engineering and led him throughout his entire life.

He was a good pupil but the beginning of World War II in 1941 interrupted his education on Gymnasium in Ljubljana. He returned back to Kranj, where in September 1941 the German manufacturing company Luftfahrtgerätewerk took over one

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Slovenian factory and opened positions for apprentices. Janez Peklenik took the opportunity and started his training of machine tools operation and learning for a toolmaker. He was among the best apprentices and after two years of learning he was invited as a reward for one month to a factory in Berlin, where he discovered a lot of advanced approaches in manufacturing. He successfully finished his learning and became a qualified toolmaker. This was the first technical burden he had overcome. It gave him not only the hands-on experiences but also the important feeling and intuition of what can be achieved in manufacturing and how, which accompanied him all his life.

In the year 1944, in those turbulent times of the WW II, as a conscious Slovenian he joined the National Liberation Army at the age of eighteen. He always spoke of this period in his life with pride.

After the war he completed the Gymnasia secondary school in Kranj. Then he undertook studies at the Faculty of Technical Sciences at the University of Ljubljana and finished them with distinction in 1954. During his studies he showed a strong interest in research work and was two times awarded the highest University Award for students. Apart from that, he occasionally gained practical experience as a constructor in industry.

After graduation, he went to the Laboratory for Machine Tools (WZL) at the Technical University (RWTH) in Aachen, Germany, which was one of the leading institutions in the field of production engineering. Under the mentorship of Professor Opitz he researched the physical principles of grinding. He received his PhD from this topic in 1957 with distinction. Within the framework of his work he developed an original method for measuring the temperature of the abrasive grain and the distance between the grains during the process (Fig. 2) [1]. When analyzing the experimental results he was the first to consider the random character of the abrasive process and introduced the statistical valuation of the measurements.

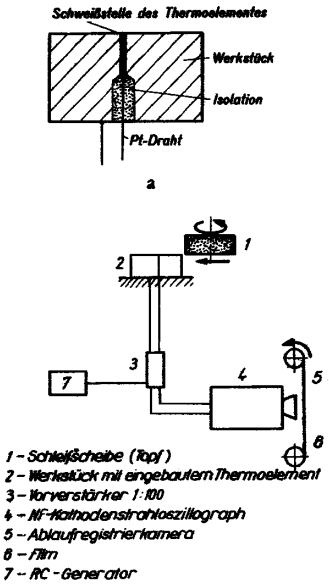

Fig. 2. Measuring of temperature and distance between abrasive grains during abrasion [1].

After finishing his PhD he continued research work at the same institution, first as scientific associate and then, after his habilitation in 1961, as Assistant Professor. The topic he dedicated himself to work on during this period, was related to the issue of accuracy in production automation. With this he entered the field of manufacturing systems and paved the way for the establishment of the concepts of adaptive control of manufacturing processes.

After the publication of his research work in Aachen, Janez Peklenik started to make a name for himself in the world. In 1962 he was invited to the Carnegie Mellon University in Pittsburgh, USA, as a visiting Associate Professor. During this residency he started to work intensively on the characterization of technical surfaces, their random features and interfaces.

In 1964 he received an invitation from Great Britain to join the University of Birmingham. So he moved to Birmingham, where he was elected Full Professor and introduced the first Chair for Manufacturing Systems in the world. At the same time, he was elected Full Professor at the University of Illinois in Urbana-Champaign, USA.

While working in Birmingham, he carried on his research in the field of identification of machining processes and the characterization of surfaces. After the results in grinding, he found out that the deterministic models of the machining processes were inadequate.

This is why he grounded his research work on the random character of the processes and respective statistical treatment of experimental data, by means of which he set new baselines for research work in the field of modern production technologies. Furthermore, he started developing concepts of work and manufacturing systems. His concept, as can be seen in Fig. 3, is unique, as it puts the main elements of the system, the machining process and the machine tool, into a solid closed-loop connection [2]. This concept was the base for research in the fields of online identification and adaptive control of manufacturing processes and systems, where he was most successful. His papers on these topics have been cited by numerous researchers as the fundamental discoveries.

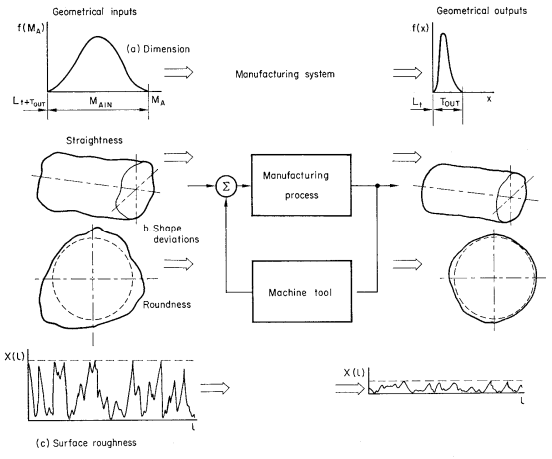

Fig. 3. The concept of first-order elementary manufacturing system [2].

In Birmingham he participated in numerous projects with top-class British industry, inter alia the project of the development of the system MOLINS 24, which was the first computer-controlled flexible manufacturing system (FMS) in the world.

Even during his service abroad, Janez Peklenik continued to cooperate with the University of Ljubljana. In 1972 he returned to Slovenia for good and took the position of a Fulltime Professor at the Faculty of Mechanical Engineering, University of Ljubljana. He established the Chair for Control and Manufacturing Systems and the laboratory LAKOS, that later developed into a powerful research group.

The laboratory LAKOS started to intensively integrate into the research and development work for industry. Thus, a part of the activities of the laboratory was focused on the field of manufacturing systems and the introduction of computer-aided technologies. The research was concentrated on the development of systems for the support of group technology (CAGT), computer-aided design (CAD) and computer-aided process planning (CAPP). An extensive part of the research covered the field of adaptive control of manufacturing processes on the basis of the original process identification method founded on energy quanta developed by Prof. Peklenik.

That period of time was marked by intensive development of computer technologies and Prof. Peklenik was one of the first who were aware of the industrial meaning and potential of introducing computer-aided manufacturing and control technologies, as well as their integration. He found out that Taylor's production paradigm needs to be changed and therefore started to look for more appropriate solutions. He was one of the first who were aware of the problem of the growing complexity in manufacturing and of the meaning of the role of the people, or as he called them, the human subject. Thus, he introduced the subject as a vital system element into the manufacturing system (Fig. 4) [3]. In response to these findings he developed the theory of manufacturing cybernetics, which enables systematic planning, design, realization and operating of complex systems with subjects, as this is typically in manufacturing systems [4].

Prof. Peklenik was also aware of the meaning of cooperation with the national industry. This is why a part of the activities of the laboratory was focused on the design and development of computer-controlled manufacturing systems, machines and devices with the aim of implementing them in industry or, even more desired, that industry would take them over and would start placing them on the world market.

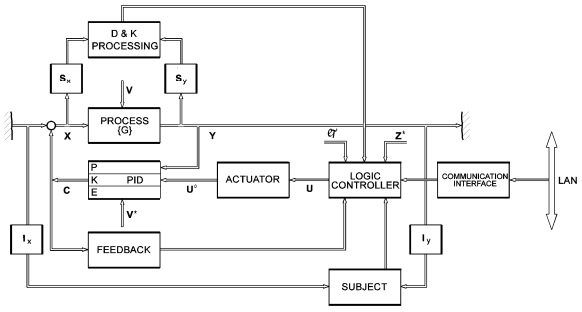

Fig. 4. Elementary work system - a building block of manufacturing systems - with a human subject as its vital element [3].

Fig. 5. Computer controlled system for the wiring of telephone exchanges (personal archive).

At that time, the Slovenian industry did not have many globally oriented high-tech products and this advanced kind of cooperation among academia and industry was valuable.

The following are only some examples of such projects. In the seventies a computerized system for the wiring of telephone exchanges was developed for the company Iskra. The control was performed by a process computer IBM System 7 (Fig. 5). The system for alkaline battery production was developed for the company Iskra Zmaj, at the beginning of the eighties. It was a fully automated high capacity production system controlled by an 8-bit Motorola 6800 microprocessor (Fig. 6). After that came the development of a CNC-insertion machine for the mounting of axial electronic components onto printed boards (Fig. 7). The system was controlled by a Siemens CNC controller Sinumeric 3M and was also developed in cooperation with Iskra, where it was implemented in production for many years.

In the nineties the laboratory developed a concept of modular CNC-machines LAKOS 250 and, based on that, realized the prototype of a horizontal milling machine (Fig. 8), which was later followed by a lathe and a laser sheet metal cutting system. The machines were controlled by own CNC controller based on an industrial PC. The idea behind this development was to develop building blocks of Lean Flexible Manufacturing Systems (LFMS) to be placed and operated in developing regions of Slovenia [5].

Fig. 6. Computer-controlled system for production of alkaline batteries (personal archive).

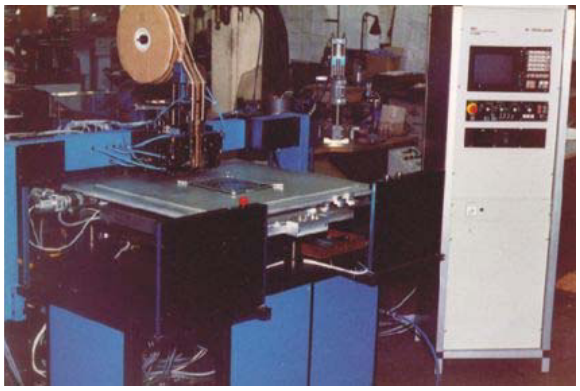

Fig. 7. CNC-controlled insertion machine for the mounting of axial electronic components onto printed boards (personal archive).

Quite a few ideas by Prof. Peklenik remained unrealized. In the late eighties the laboratory started developing a flexible manufacturing cell for cleaning of steel castings with an industrial robot of a greater carrying capacity (60 kg) for Železarna Ravne. Unfortunately, this project underwent the times of changes which happened in Slovenia, so it was never completed. In the nineties the laboratory started to develop the concept of a small, electrically driven city car, which was ahead of time. Such cars started to emerge on the streets only much later and have become interesting nowadays with the ongoing electrification progress in the automotive industry. The concept COMPA was developed as well. This is an automatized system for parking garages, which solves the problems of modern cities where there is a constant need for parking spaces while struggling with the lack of actual construction space; the emphasis of design lies on the sustainability aspect of building, which demands simple and safe assembly and disassembly of constructions. This solution places the user into the center, as the system is adapted to people. The essential cornerstone of the system COMPA is a modular compact parking garage (Fig. 9), which is completely automated [6]. The modules are made of steel truss in the clearances, which enable easy transport, assembly and disassembly. The proposed version is particularly suitable for metalworking companies in Slovenia for adopting and starting its production and marketing, and would still be actual nowadays.

Apart from being a distinguished scientist, Professor Peklenik was also an excellent teacher. After returning to the University of Ljubljana, he got involved in reforming the study programs. He introduced new systemic disciplines such as cybernetics, experimental methods and computer technologies in manufacturing. His proposition of the education system was very progressive and could be the base for study reforms even nowadays. The study program that he introduced was based on modules, consisting of major, systemic, technological and supplementary subjects. He prioritized the students' project teamwork on realistic, industrially relevant topics. He was led by the recognition that young people find it hard to connect separate parts of knowledge into a whole and cannot apply their knowledge to specific problems. The students welcomed this study concept as it encourages creativity and develops professional as well as social skills.

Fig. 8. CNC-milling machine LAKOS 250 (personal archive).

Young people need such opportunities to test and prove themselves. In order for the students to get a better picture and understanding of the processes, the laboratory LAKOS was set up as a learning factory, already in the eighties, with all elements for the development and creation of high-tech products.

The students were especially enthusiastic about the study excursions to the USA and to Japan which Prof. Peklenik organized with the help of his numerous international contacts within the CIRP community and elsewhere. Those really high-level professional events opened to many students the doors to numerous global enterprises and universities from all over the world (Fig. 10).

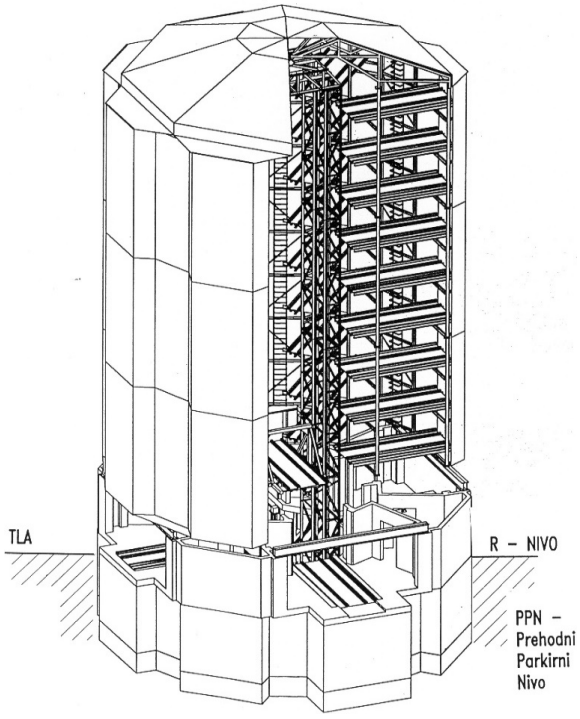

Fig. 9. Concept of a compact automated parking garage COMPA [6].

Fig. 10. A group of Slovenian students visiting the Boeing plant in Seattle (personal archive).

While modernizing the study program in the nineties, Prof. Peklenik introduced the study field of mechatronics to the program of mechanical engineering practically at the same time as this was happening at the universities of the developed world. This program was again focused on students' project work where students worked in teams on high-tech engineering problems (Fig. 11). Even in the field of post-graduate studies, Prof. Peklenik introduced fresh ideas. He established the Post-graduate school for Automation and Manufacturing Cybernetics. When he was the Rector of University of Ljubljana he proposed the establishment of a Post-graduate School Campus at university-level but his suggestion was, as time showed, too early at that point.

Under his tutorship, 226 graduates, 86 Masters of Science and 30 Doctors of Science finished their studies.

During his employment at the Faculty of Mechanical Engineering of University of Ljubljana he also performed a number of leading functions. For many years he was a Head of the Department, he served also as a Dean and Vice-Dean. In 1987, he was elected as Rector of the University of Ljubljana.

After retirement in 1996 he cooperated with the laboratory for several years and was committed in many other fields.

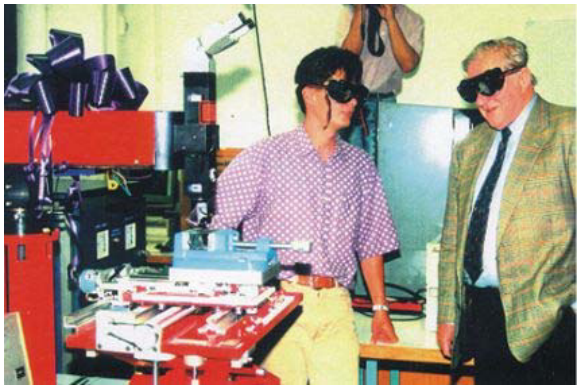

Fig. 11. An example of a students' project: a demonstration of a prototype to Prof. Peklenik (personal archive).

Over the years his engagement started to fade and he spent his last years among his beloved.

The results of the work of Prof. Peklenik are published in 352 papers, mostly in esteemed international, American, British and German scientific journals. He held 11 international and 4 Slovene patents. He brought to life 15 big projects in industry and at educational institutions.

For his scientific achievements, Prof. Peklenik received numerous important international awards, among others: the Taylor award of the International Academy for Production Engineering CIRP (1960), the Okoshi medal in Japan (1974), the Taylor award SME in the USA (1980), the Georg-Schlesinger award in Germany (1988), and the Goldene Doktorkunde form RWTH Aachen in Germany (2008). His international prominence is distinguishable from numerous chairmanships at scientific conferences and seminars, as well as his guest lectures which he had at several conferences and universities all over the world. The University of Birmingham in Great Britain (1972) and the Nanjing Aeronautical Institute in China (1982) awarded him the title of Honorary Professor for his contribution to science.

Among the Slovenian recognition awards, it is worth mentioning the Kidrič award for scientific achievements (1974), the title of Ambassador of Science of the Republic of Slovenia (1992), the Award of the Republic of Slovenia for scientific research work (1996), the title of Emeritus Professor of the University of Ljubljana (1996) and the title of Honorary Citizen of the municipality of Kranj (2012).

On the basis of the results of his work, he was elected to several national and international academies. He was a Full Member of the Slovenian Academy of Sciences and Arts, the founder and the Honorary President of the Slovenian Academy of Engineering, an Honorary Fellow of the International Academy for Production Engineering CIRP, a Fellow of the Russian Academy for Engineering and the Academia Europea.

In particular, we would like to point out the contribution of Prof. Peklenik to the CIRP Conference on Manufacturing Systems.

Prof. Peklenik was much inspired by the work of Eugene M Merchant, his close CIRP colleague and friend, who proposed in 1962 an innovative concept in manufacturing technology called 'The Manufacturing System'. The concept was based on the integration principle of hardware and software. Merchant's idea was soon followed by the first industrial implementations of computer integrated flexible manufacturing systems: Molins 24 in Great Britain, Variable Mission in the USA and Ikegai in Japan.

These ideas revolutionized the manufacturing world. The computer integrated manufacturing, the built-in system's intelligence and search for new, more adaptable manufacturing systems with the ability of learning, self-organizing, and optimizing have speeded up the control revolution in manufacturing.

Since then significant scientific and industrial developments have followed, generating the conditions for computer-aided flexible engineering tools for design, process planning, manufacturing and quality control as well as for computer control and automation in the fabrication of mechanical parts, measuring, assembly and handling.

Fig. 12. Three of the founders of the CIRP CMS. From left to right: Prof. Colding, Prof. Peklenik, and Prof. Spur, at the occasion of Prof. Peklenik retirement in 1996 (personal archive).

Prof. Peklenik was personally involved in these developments and innovations. Hence, he soon recognized the need for systematic research, cooperation and exchange of ideas on the international level. He proposed to his CIRP colleagues and friends Bertil Colding from Sweden, Toshio Sata from Japan and Günter Spur from Germany an idea about organizing an international seminar as a platform for presenting and discussing ideas especially among young researchers from academia and industry on this new emerging topic of manufacturing systems. They supported his idea and they founded together within CIRP in 1968 the CIRP International Seminar on Manufacturing Systems, later renamed into the CIRP Conference on Manufacturing Systems (CIRP CMS). This series of conferences became the first CIRP conference. It has become a success story with the longest tradition within the CIRP community and has been running form year to year for five decades. The conferences were held in places on five continents. Fig. 12 shows three of the CIRP CMS founders at the occasion of Prof. Peklenik retirement in 1996. At that occasion also a monography with selected papers of Prof. Peklenik was published [7].

Prof Peklenik said at the occasion of the first Seminar held in Birmingham in 1969: *"The optimization of manufacturing systems by combined study of NC-machine tools, metal removal process identification, degree of automation, reliability of the system, economic assessment of new technology, and other problems, will undoubtedly depend primary upon the ability of research engineers to develop new concepts. These will be based on advances in the fundamental disciplines including control systems, information and communication theory, topology, switching and automata theory, probability and random process theory, dynamic programming, material science, reliability theory, etc."* [8].

This sentence fully describes the vision of one of the pioneers of manufacturing systems, who recognized among the first the need of combining profound theoretical knowledge into engineered solutions for advanced manufacturing systems.

Since then, the CIRP CMS has evolved into a first class scientific platform where researchers from all over the world meet and present their work to a public of young and senior researchers and engineers, discuss their ideas, try to find solutions for their problems and search for partners for international cooperation on research and development. It is a high quality event, running in a working, creative, and pleasant atmosphere, where new contacts and friendships are built up.

With the death of Prof. Janez Peklenik, we have lost a great scientist, engineer, teacher and a role model who led us and guided us with his vision for many years. He will be retained as a great man and a good friend who knew how to examine problems with a critical eye and at the same as somebody that anytime enthusiastically and readily provided help to a younger generation, not only his students but also his associates and colleagues. He will be remembered. We are happy to have his rich and profound legacy from which the future generations will be drawing for knowledge and inspirations for years to come.

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