

PRODUCTION ENGINEERING IN POLAND: A POINT OF VIEW

Jan KAŻMIERCZAK
Silesian University of Technology

Abstract:

This paper follows some earlier works of the author, who tried to look widely at important questions, concerning the "Production Engineering" as a new discipline, formally established two years ago in the domain of technical sciences in Poland. In the introduced approach, the author proposes some general structural model which could be a base for identifying and describing the actual and perspective areas of scientific activities belonging to this discipline. Additionally, potential benefits of opening the research on multidisciplinary problems and being active in some new challenges are indicated as well.

Key words: *production engineering*

INTRODUCTION

Let me start with an information which is trivial for Polish scientists, but probably is not fully evident for foreign readers of this paper. The Polish science is – because of various reasons – strongly structured in the legal meaning of this term. The field of scientific activities is formally divided into general domains, such as domain of humanistic, technical, law or medicine science. Inside of these domains, a fixed number of the "scientific disciplines" is defined by suitable law regulations. First of all, the system creates a base for scientific degrees: doctoral as well as post-doctoral thesis ought to be prepared and – next – defended in the disciplines of science. The scientific discipline established in a domain of science can be also seen as an element of a specific "feedback" between two main activities of Polish universities. The disciplines enable scientific promotion of academic teachers and therefore should be considered as a background of didactic activities. When the new areas appear in higher education, in many cases it means that a new scientific discipline is needed as a formal base of promoting academic staff (as well as students of third level of studies in Bologna System).

PRODUCTION ENGINEERING IN POLAND

The above presented path described also a history of establishing in Polish system of science the discipline "Production Engineering" (PE) as the youngest one in the domain of technical science three years ago. It was assumed that the new discipline will fulfill the gap between technical and other points of view on the contemporary world in the domain of engineering sciences. As intended by the initiating persons, this discipline should cover the areas similar or even identical with "Industrial Engineering" or "Engineering Management" which exists as concepts in international science. The final decision in this matter was preceded by the wide debate of scientists, involved in this

project. In the debate, focused on identification of the scientific area of the new discipline, it was strongly indicated that the new discipline has a significant potential of development. In order to identify this potential, the new Committee on Production Engineering established in 2009 by the Polish Academy of Science decided to elaborate (and publish) the initial report, intended as an "opening inventory". The report [15] contains the list of scientific centers and/or scientific teams declaring to be active in the new discipline and introduces a general description of the scientific field, which – in that stage of the debate – was mainly formed by previous area of scientific activities of the centers mentioned above and teams (or even persons). Such an inventory created a good "stating point" for further debate.

The content of this report shows the current state of research as well as perspective of new directions in optics of scientists who in 2009 declared their „belonging" to the newly established discipline. To the "opening resources" we can also include earlier publications in many other fields. This situation can be well-illustrated by some of earlier works of the author of this paper ([9 or 10]), published in years when the problems of management in engineering were treated as immanent part of Managements sciences (domain of economics). It was also well-seen in another significant works of Polish authors, i.e. [3 or 11].

It is also worth mention that in many foreign publications (for instance work of O'Connor [11]), much earlier than in Poland, the problem of presence of technical (engineering aspect of management was mentioned as the factor which should have a significant impact on these area of scientific projects).

Both the "pre" as the "post-establishing of the discipline" stages of the debate, concerning the presence of PE in the Polish net of scientific disciplines, have shown that

the “Production Engineering” as the discipline of engineering science should be based on defining:

- Sub-areas of “classic” disciplines which were/are subjects of interest of scientists who are active PE. Such subareas in many cases need to be re-defined as belonging to the field of PE.
- Niches (“empty areas”) in the domain of engineering science which are still not “occupied” by classic disciplines,
- Interdisciplinary fields which – before establishing PE as the new discipline in technical sciences – have been not considered in the “classic” disciplines as worth to be explored.

First of the above described demands is now in progress (as shown in [15 and 7]). The second and third demands are still in the front of us. The efforts focused on these demands will – in my opinion – disclose the full potential of PE as the new discipline and fix further activities of scientists as well as scientific team involved in it.

I am absolutely convinced that in order to use fully the potential and perspectives of PE in Poland, simultaneously with the complex inventory of resources a general methodology of analyzing the potential as well as perspectives is needed. Some important aspects have been still recognized in the debate reported above. A potential impact of research, carried on in the new discipline, on increasing level of innovativeness in Polish economy is in my opinion especially important. The current place of our country in rankings of European national economies [4] seems to be absolutely not satisfying. The general knowledge about innovation (for instance presented in the OECD report [16]) and more detailed descriptions of points of view [17] as well as activities of participants of the global market are obtainable. The key question is, who should apply this knowledge and how to do it?

The problem is of key importance for our country, both because of cognitive and application considerations. Therefore, this is a serious challenge for all parts of scientific society to support all possible efforts focused on implementing in Poland the model of knowledge-based economy and increasing the level of innovation in practice. I am sure that the society of Production Engineering is able to lead these activities and this problem should be targeted on further development of our discipline.

However the question about the practical aspects of such an engagement is still open. In my opinion, such an answer should be formulated as the results of wide and open discussion about “strategy” and “tactics” of developing our new discipline. Let me repeat:

- we have to strengthen our presence in recent fields of research, reformulating scientific tasks according to the general idea of PE,
- we have to look for niches which are still not (or very weakly) explored in technical science and “incorporate” them to PE research area
- we have to be truly open on interdisciplinary projects which just in the framework of PE are potentially the best way of developing and enlarging of the new discipline.

Especially the last one the above formulated postulates can be prospectively fruitful in my opinion. There are numerous research areas which are treated with a lot of caution to fit in the “classic” disciplines of science which – in fact – show very often tendencies to be rather “hermetic” then open for new interdisciplinary perspectives and ideas.

In next chapters of this paper I intend to put my part into the debate about the future of Production Engineering in Poland. First, I want to present my concept of creating a kind of “philosophy of the discipline of science” for the needs of PE development. Next, I would like to show some research areas which are to me prospectively promising for PE future.

PROPOSAL OF LOGICAL MODEL OF THE DISCIPLINE „PRODUCTION ENGINEERING”

Let’s start with a semantic analysis of the terms „Engineering” and “Engineer” which are the natural background for the considerations about nature of “Production Engineering. Of course, there is a lot of various definitions as presented in various sources. For example, the definition presented by „Wikipedia” are as follows [6]:

- **Engineering** is the science, skill, and profession of acquiring and applying scientific, economic, social, and practical knowledge, in order to design and also build structures, machines, devices, systems, materials and processes. The American Engineers' Council for Professional Development (ECPD, the predecessor of ABET has defined "**engineering**" as: The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation or safety to life and property. One who practices engineering is called an engineer, and those licensed to do so may have more formal designations such as Professional Engineer, Chartered Engineer, Incorporated Engineer, Ingenieur or European Engineer. The broad discipline of engineering encompasses a range of more specialized sub disciplines, each with a more specific emphasis on certain fields of application and particular areas of technology.
- An **engineer** is a professional practitioner of engineering, concerned with applying scientific knowledge, mathematics and ingenuity to develop solutions for technical, social and economic problems. Engineers design materials, structures and systems while considering the limitations imposed by practicality, safety and cost. The word engineer is derived from the Latin roots *ingeniare* ("to contrive, devise") and *ingenium* ("cleverness"). Engineers are grounded in applied sciences, and their work in research and development is distinct from the basic research focus of scientists. The work of engineers forms the link between scientific discoveries and their subsequent applications to human needs and quality of life.

We can note in these definitions evident reference to practice, but creative and conceptually related. This is also clearly expressed that the engineering is based on applied sciences, with important relation to basic research. Let’s add that for engineers such tasks as streamlining and modernizing products, services and processes are of high importance. I am sure that just this asset of extending the “classic” sense of the role of engineering (and an engineer as the entity of engineering) should form our thinking about problems set in a field of Production Engineering.

Evidently, the term „Production” should be considered as the second base for the logical model of the PE as a discipline of sciences. I am convinced that this term – in the aspect as taken here – can be effectively based on concepts presented in works of Professor Janusz Dietrych [2]. In particular, we can base the considerations about the engineering as the field of creation and the role of the engineer as a creator, who forms – both in the dimension of abstractive “track” and materialized “product” – the environment of humans in the range of “technosphere” (in opposition to “biosphere”), on the proposed by Professor Dietrych model of the “process of meeting needs” (as shown in Fig.1).

In accordance with the mentioned model, successive types of engineering activity (**rp** – recognition of needs, **pr** – conceptual designing, **ks** – constructing, **wt** – manufacturing (production) and **ep** – operating with manufactured product) are forming a close loop. The author of this model assumed that:

1. The “general” engineering contains some “partial” types of engineering activities, in particular: engineering of needs, engineering of designing and constructing, engineering of manufacturing and engineering of exploitation (and maintenance),
2. Because of existing relationship, none of the “sub-engineering areas” can be considered in separation from others,
3. The relation between the phase of operating with product and phase of recognition of needs is of special meaning: set of observation from exploitation and maintenance processes creates the background for starting the recognition of needs in a “next cycle”.

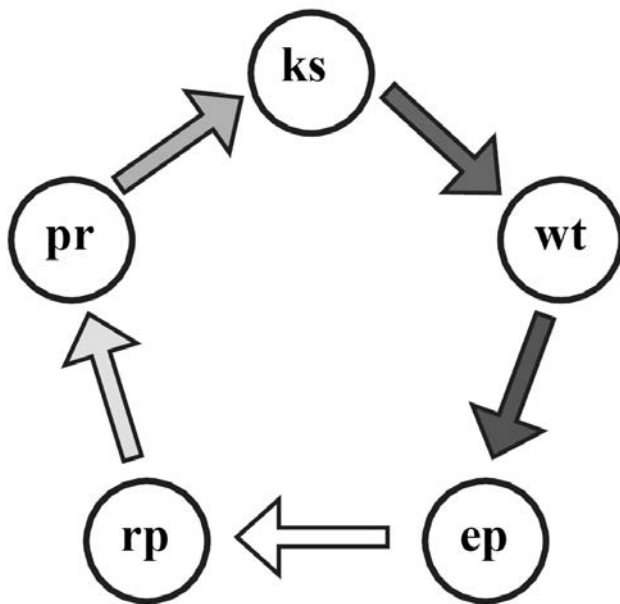


Fig. 1 Model of the process of meeting needs (according to [2])

In the next cycle as mentioned above, the identified needs should lead to “new or significantly modified” product, process or technology. We can see here the reference to the idea of innovation in its technological aspect. But – if we intend to apply the approach proposed by Dietrych as a base of modeling an “enlarged” concept of Production Engineering – another feature of the model is of key importance. In a “minimalistic” version, PE could be considered as the field of research limited to the problems of manufacturing. Such opinions (“we should limit ourselves to production processes”) have appeared in the above re-

ported debate on PE as a new discipline in technical sciences. Of course, this option is very safe (“we do not occupy someone else’s backyard”) but – for me – too passive. A passiveness in this case is potentially “dangerous”. Every new existence needs a space to grow up. We cannot close our research in a “shell” because it is the simplest way to closing chances of development.

If we accept the model of PE area of scientific activities as derived from the model shown in Fig.1, it will lead us to some formal operation: “dividing” the field of engineering into some (autonomous ?) parts. I propose to consider four sub-areas in this meaning:

1. Engineering of recognizing needs („Engineering of Needs” ?)
2. Engineering of designing and constructing (it seems to be reasonable to consider the activities dealing with abstractive parts of engineering together)
3. Engineering of manufacturing („Engineering of Production Processes” ?)
4. Engineering of products’ operation („Engineering of Exploitation and maintenance of Technical Systems” ?)

It can be easily seen that the proposed areas contain some new challenges. For instance, in the model of meeting needs the new need is coming from experiences of operating with products. In contemporary times, we can note that needs are recognized, but also are stimulated or even designed. Therefore the term “Engineering of Needs” fits a real situation and – from the view point of Production Engineering as well – opens a new area for research (not only in technical sciences).

I do realize that every case of „segmenting” science can cause some threat. All the divisions are potential sources for stiffening and/or self-insulation of scientific societies. Keeping it in mind, I propose to use the “division” presented above as a kind of road map which should facilitate:

- Detailed identification of research areas which are worth to be explored by PE scientists (including interdisciplinary areas),
- Recognition of existing scientific disciplines which are potential partners in PR scientific activities.

If we accept the assumption that all the “types of engineering” are strongly related, it leads us to the “enlarged” point of view (and this is my preferred approach). The research area of Production Engineering certainly ought to cover problems of producing goods. But the main research efforts of PE should concentrate not on particular aspect of technology (“these backyards are effectively served by narrow specialists”), but just on relations linking the elements of production processes with their technical and non-technical “interior” and “surroundings”. This postulate is still well-seen in reports [15] and [7] and reflects some specific position of Production Engineering in domain of technical sciences. This specificity is caused – first of all – by the origin of the PE discipline. As mentioned above, PE was created as a specific result of “extracting” technical/engineering elements from the general area of management sciences. But this “extraction” was not perfect: many important non-technical elements of management knowledge and skills were transferred to the new discipline. For example, we can mention here the area of Quality Management which was almost totally “incorporated” by PE.

Concluding, I propose to accept – as a logical model of the discipline “Production Engineering” – the whole model of the process of meeting needs with special attention paid

on relations between elements representing the sub-areas of engineering activities. In a such approach, the Dietrych's model ought to be extended. In particular, it is possible to analyze links between elements which were not identified by the author. First of all, a lack of feedback-type relations can be noted. Perhaps in 70ties some of potential links of this sort looked like a total abstract, but in contemporary world they are really existing (and in many cases not yet properly investigated).

A big chance for the new discipline, which grows up "at the crossroads" of various domains of science and still evidently absorbs and creatively develops achievements of scientists and scientific environment, is potential openness on solving interdisciplinary problems. Secondly, thanks to its background the PE has unique opportunities of looking for new areas of research. The process of looking for "niches" should contain not only investigations of the areas of technical sciences which are for instance newly appearing and because of that give a chance of being explored by scientists. In my opinion, scientific activities in the new discipline like PE ought to contain searching of new approaches to the problems which are located inside the "classic" disciplines but – in the current state of knowledge – are worth to be seen from many points of view. This approach can be well-illustrated in the model as proposed in this chapter. If we consider separately all "sub-areas" of engineering, every of them represents the wide field of research "served" by many disciplines of technical sciences. The PE creates the opportunity to look at the "process of meeting needs" as a whole one and to consider both the relations between internal elements of the process and relations between technical side of the process and its non-technical environment.

In order to illustrate a general concept as introduced above, I am going to show in next chapters of this paper some practical proposals, coming out of my experiences as well a experiences of research teams led by me.

„PRODUCTION ENGINEERING” AS THE AREA OF TEACHING AND INTERDISCIPLINARY RESEARCH

As I have stated above, I am convinced that a basic asset ("strong side") as well as a chance for development for the new (not only!) discipline of science can be and ought to be an openness for interdisciplinary approach.

Production Engineering has the interdisciplinarity fixed in its "act of creation". The establishing the new discipline in the domain of technical sciences was preceded by creating in Polish universities of technology – in 90's of last century – numerous faculties focused on educating future engineers in the "art of management". Teaching programs of these faculties were based both on technical, social "ingredients" and – as I can state of this several year perspective – thanks to this interdisciplinary background gave our students very appropriate set of knowledge and skills. Just this nature of didactics programs has been transferred to the PE as the scientific discipline.

In addition, the experience of academic staff involved in teaching activities and then in building the "scientific foundations" of PE have showed that in many cases:

- a new look at "classic" problem of engineering is necessary when we try to teach students how to manage technical objects and systems. The good example of such situation – derived from my didactic experience – is the difference between the "classic" understanding of area of exploiting of machinery,

based on theory of reliability, and the new approach focused on management of exploitation and maintenance of technical objects and systems,

- it is reasonable to displace accents within the particular area of engineering. It is – for instance – the case when we put the main attention not on the base of physical examination but we teach students how to support effectively decisions concerned with the particular technical problems,
- the elements of programs were "classically" treated as belonging to economic or social sciences even if the "technical" aspects of the problem seemed to exist. Thus, it was necessary to extend a "technical leg" in the particular area of teaching. As our graduates have reported, such a "technically-extended" look at problems of management gave them significant advantage in their jobs.

Therefore, if we try to discuss about the current state and a future of PE basing on experiences of didactics, the above listed cases are also worth to be taken into consideration.

Looking for the potential areas of research and formulating new tasks and targets for developing PE as the discipline of (not only) technical science we ought to think about:

- Redefining the "classic" look at technical (as well as non-technical) areas of research based on needs of management in engineering activities,
- Looking for interdisciplinary areas, exploring both the borders of disciplines within the domain of technical sciences and the disciplines of different domains, "lying close" in a perspective of potentially important research,
- Considering potential niches for research which are still not well-explored or even are not finally defined,
- Looking for "external" as well as "internal" niches in the classic disciplines of sciences.

Let's remember that the contemporary understanding and use of the terms "engineering" and "engineer" is far wider than in the "siècle of technology". We are not astonished by terms "bio-engineering", "genetic engineering" or even "social engineering". This is a potential area of exploring for the "external niches" as the perspective research fields of PE.

The classically oriented scientists of technical science are usually rather hermetic in accepting these new ideas and existences. Perhaps it is a chance for the new disciplines (like for PE) for finding the "internal niches" of further research. Of course, I am not going to "have someone else's box" but the fresh look at particular problems can be – in many cases – fruitful and invigorating. In my opinion, the good illustration of the above presented thoughts can be the general problem of collecting, processing and using data in all the possible areas of activities, not only in engineering.

Problems of "Data Engineering", traditionally seen as owned by specialists on informatics, can be seen not only as concerned with technologies of designing tools and systems. Let's try to look at questions of implementing and using informatics tools for particular needs, for instance for supporting tasks appearing in industrial practice. We then are able to consider both the area of activities which can be disposed of under the Production Engineering "internal framework" and a potential area of interdisciplinary cooperation with researchers representing "non-technical" are-

as. This thesis can be well illustrated by experiences of the research team, led by me. An important part our research in last years was focused on implementing advanced informatics tools (among others: Geographic Information Systems – GIS) for the needs of management acoustical environment of urban areas [8].

And – last but not least – I want to mention as promising perspectives for developing new research in Production Engineering these areas of problems, when engineering point of view is, in my subjective look, not represented adequately.

In my opinion, disciplines of engineering sciences are not active in a full possible range in exploring numerous relatively new concepts and approaches, like the concept of Sustainable Development of variety of concepts concerned with Quality.

Because of multidisciplinary nature of such concepts, it opens also new challenges and opportunities for Production Engineering. Because of my personal engagement, I want to add to the above list of potential research activities of PE as the discipline of engineering sciences another promising concept. For many years we can observe intensive development – by researches representing a wide variety of disciplines of sciences – of the concept of Technology Assessment (TA). Very briefly, this concept covers every aspects of evaluating potential/possible impacts of technologies and engineering products on society (for example: [1, 12, 13]). TA offers very rich palette of research, including problems of methodologies [5] as well as applications [14]. Up to now, representatives of engineering sciences have been not very active in research concerning TA. I do hope, it is a challenge for Production Engineering.

CONCLUSIONS

My main intended message of his paper is: the Production Engineering as the new discipline In the Polish structures of science stays now in very important point of its way of development. There are two possible scenarios of the future of PE: one, very careful and conservative and second, focused on creativity and extension. In the considerations, as presented above, I tried to formulate my point of view in the matter of choice between these scenarios which is now in the front of scientific society identifying the PE. I do believe that our new discipline has an extraordinary chance to exist and develop when the scientists belonging to it will carry on a deep debate about the possible “directions of expanding” and next will put results of this debate into practice.

REFERENCES

- [1] Decker M., Ladikas M.: (eds.) Bridges Between Science, Society and Policy Technology Assessment – Methods and Impacts. Springer-Verlag. Berlin-Heidelberg 2004.
- [2] Dietrych J.: System i konstrukcja. WNT. Warszawa 1978.
- [3] Durlik I.: Inżynieria zarządzania, tom 1 i 2. Oficyna Wydawnicza PLACET. Gdańsk 1993.
- [4] European Innovation Scoreboard. www.proinno-europe.eu
- [5] European Participatory Technology Assessment – Participatory Methods in Technology Assessment and Technology Decision-Making. Project report TEKNO.dk. www.tekno.dk/europta October 18, 2000.
- [6] <http://www.wikipedia.org>
- [7] Istota Inżynierii Produkcji. Opracowanie Komitetu Inżynierii Produkcji PAN. Warszawa 2012.
- [8] Kaźmierczak J.: Network-Based System for Supporting Administrators of Strategic Acoustic Maps of Urban Areas, Proceedings of 18th International Congress on Sound and Vibrations. Rio de Janeiro, Brazil, July 2011.
- [9] Kaźmierczak J.: Innowacyjność: uwarunkowania i perspektywy w warunkach polskich. [w:] Knosala R. (red.): Komputerowo Zintegrowane Zarządzanie, tom I. Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją. Opole 2009.
- [10] Kaźmierczak J.: Inżynieria innowacji: techniczny wymiar wdrażania innowacyjnych rozwiązań w gospodarce. [w:] Knosala R. (red.): Komputerowo Zintegrowane Zarządzanie, tom I. Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole 2011.
- [11] O'Connor Patrick D.T.: The practice of Engineering Management: A New Approach. John Wiley&Sons, 1994.
- [12] Porter A., Rossini F., Carpenter S.R., Roper A.: A Guidebook for Technology Assessment and Impact Analysis. North Holland. New York 1980.
- [13] Porter, A.L., Porter, A.T., Mason, T.W., Rossini, F.A., Banks, J. Forecasting and Management of Technology. John Wiley. New York 1991.
- [14] Sclove R.: Reinventing Technology Assessment: A 21st Century Model. Washington, DC: Science and Technology Innovation Program, Woodrow Wilson International Center for Scholars, April 2010.
- [15] Stan i perspektywy badań naukowych w obszarze Inżynierii Produkcji w Polsce. Ekspertyza Komitetu Inżynierii Produkcji PAN. Warszawa 2010.
- [16] The OECD Innovation Strategy. Getting a Head Start on Tomorrow. OECD Publishing, May 2010
- [17] The Scientific Century: securing our future prosperity. RS Policy Document 2/10, The Royal Society. London 2010.

Prof. dr hab. inż. Jan Kaźmierczak
Silesian University of Technology
Faculty of Organisation and Management
Institute of Production Engineering
ul. Roosevelta 26, 41-800 Zabrze, Poland
tel.: +4832 277 7311; fax: +4832 277 7363
e-mail: Jan.Kazmierczak@polsl.pl