DEVELOPMENT OF THE "IMPLEMENTATION DOCTORATE" PROGRAM IN POLAND IN THE FIELD OF ENGINEERING AND TECHNICAL SCIENCES ON THE EXAMPLE OF TOPICS RELATED TO METALLIC MATERIALS

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Abstract

Currently, the 8th edition of the "Implementation Doctorate" program is being implemented in Poland. This is a unique program on a global scale, the idea of which is that the program. This program is dedicated to all scientific disciplines. This paper focuses on detailed assumptions of the program, the functioning of this program in the context of changes in the implementation of the third degree (doctoral studies) and entrusting them in scientific units to the so-called doctoral schools, the problem of defining and dividing the activity of doctoral students into scientific and implementation, the problem of defining the so-called implementation, defining the principles of evaluation of industrial entities whose employee is to implement the program, defining the principles of evaluation of the doctoral promoter and the scientific unit in which the doctoral program is carried out, the issues of assessing the progress of a doctoral student and how to verify it, and the problem of maintaining the secrecy of sensitive information of entities in the context of reporting the progress of the implementation of the doctorate and the defence of the doctorate. This paper focuses on the analysis of doctorates in the field of engineering and technical sciences, which seem to have the greatest potential for the implementation. In particular, the focus was on the analysis of issues related to metallic materials. Qualitative analysis indicates that the idea of the "Implementation Doctorate" program has proven itself in the field of metallic materials topics.

Keywords: Metallic materials**,** implementation, science, doctorate, doctoral schools

1. INTRODUCTION

Programs related to the realization of a doctorate by the people working in the commercial companies successfully operate in some European countries, including Denmark, Sweden, Germany or France but by taking into account the experience from these countries, it was possible to create a unique program “Implementation Doctorate” in Poland. In May 2017 the Ministry of Science and Higher Education announced the first edition of the program in Poland. It was a response to the need to support companies in hiring scientific personnel involved in R&D projects. The design of the program was intended to eliminate the key dilemma of a future PhD student - science or business? He or she could realize his or her scientific ambitions by working for a company as part of his or her duties, rather than as an additional work. At the same time, an implementation doctoral student would receive financial support. In this way, well-paid jobs are created. The

entrepreneur has the opportunity to hire a motivated employee or enable the personal development of those already employed. The entrepreneur also gains access to the knowledge and research infrastructure of universities, which, thanks to doctoral students, will be able to help build a network of cooperation with entrepreneurs, use the results of basic research and their infrastructure in application projects, and receive additional funding for this.

Such a paradigm for the creation of the “Implementation Doctorate” program was presented in a study [1] summarizing the first 5 years of its operation. Work [1] also presented the main findings related to the operation of the program. At that stage, 69.6 % of implementation doctorates were carried out in the private sector. Of these, 96.9 % were realized in enterprises. Thus, the primary goal of implementation doctorates, which is to build human resources for companies, was successfully realized. More than 60 % of projects were then carried out in the field of technical sciences. A similar percentage was maintained in each edition. About 10 % of the projects were in the social sciences and theoretical sciences. Most often, doctoral students wanted to implement their projects in companies dealing with electrical machinery and equipment (10.3 %), as well as with raw materials and metal industries (10.1 %). 26.7 % of implementation doctorates were carried out by women. The rate remained similar regardless of the edition. Men were more likely to pursue topics related to engineering sciences, while women were more likely to pursue topics related to the humanities and arts. For editions II, III and IV, the ratio of approved projects to ongoing projects after 5 years was 97 %, 96 % and 99 %, respectively. This means that the vast majority of approved projects were implemented.

Although most projects were implemented in large Polish cities such as Warsaw, Krakow, Wroclaw and Katowice, smaller towns and cities also have representation in this regard. Implementation doctorates were carried out in almost half of Poland's counties and district cities. In addition, 61.6 % of the projects were implemented outside the cities where the universities where the implementation doctorate is created are located. The data showed that the “Implementation Doctorate” program represents a major opportunity to transfer knowledge to centers far from large cities. Given the demographic problems of many cities, allowing ambitious scientists to pursue their careers and research fosters the development of medium-sized cities. The COVID-19 pandemic has not contributed to the decline in interest in implementation doctorates. On the contrary, an increase in the number of submitted and approved projects has been evident since 2020. In the first five editions, 2,293 projects were positively evaluated and recommended for implementation. Comparing this with the number of all doctorates implemented over the past five years (27,597), it can be seen that more than 7 % of doctoral students in Poland participated in the “Implementation Doctorate” program. With few exceptions, implementation doctorates were carried out in Poland. In the case of the I-V editions, projects were also implemented in Germany (4 projects), the Czech Republic (2 projects), the United Kingdom (1 project), Latvia (1 project) and Norway (1 project) [1].

One of the most important conclusions of the paper [1] was that a complete evaluation of the “Implementation Doctorate” program should be carried out - after two years of the realization of doctorate at the earliest - when a larger number of completed doctoral dissertations can be evaluated. This paper is a prelude to such an analysis being prepared. It mainly describes changes in the program regarding recent years. These changes were made on the basis of the experience gained in previous years.

2. CHANGES IN THE CONTEXT OF THE INTRODUCTION OF DOCTORAL SCHOOLS

Doctoral Schools in Poland have been operating since the 2019/20 academic year under the Polish law established on July 20, 2018. - Law on Higher Education and Science [2]. They replaced the previous system of doctoral studies (third-degree studies), under which education was conducted at university departments. It introduced the so-called mid-term evaluation after the second year of study (doctoral studies generally last 4 years) to monitor the progress of the doctoral student. Doctoral schools have taken over the conduct of doctoral studies in the framework of implementation doctorates. There are cases where doctoral schools dedicated only to implementation doctorates have been established (e.g., Gdansk University of Technology -

Implementation Doctoral School). However, as a rule, doctoral students pursuing implementation doctorates participate in the educational process with doctoral students pursuing work in the standard program. This has affected the requirements for requesting and reporting on the progress of the implementation doctorate.

Participants in the „Implementation Doctorate“ program, annually prepare a report on the progress of the doctorate (both to the Doctoral School and to the Ministry of Science and Higher Education) and after the final year submit a final report. After the first year they additionally submit an Individual Research Plan and after the second year the result of the so-called mid-term evaluation. However, the procedures for conducting implementation doctorates at Doctoral Schools differ in some aspects from the reporting requirements of the Ministry of Science and Higher Education. This applies, for example, to the summaries of activities in the Individual Research Plan in the case of the Doctoral School, the Individual Research Plan should, for example, be divided into a concise description of the task and the relationship to the completion of the dissertation, while in the case of the report to the Ministry of Science and Higher Education, it should consist of scientific activities and implementation activities described for each semester of study.

3. IMPORTANCE OF SCIENTIFIC AND IMPLEMENTATION ACTIVITIES

Doctorates carried out in the “Implementation Doctorate” program have the same scientific level requirements as other doctorates. The implementation nature of the doctorate is intended to be an added value and not an explanation for the lowering of the scientific level required for a doctoral degree. It is not tied to the need for an engineering degree. On the other hand, it is necessary for admission to the program to demonstrate the implementation nature of the doctorate. This is a basic criterion evaluated both in the application and for a positive recommendation for acceptance of annual reports and further funding of the doctorate as well as acceptance of the final report. It remains problematic to define the concept of implementing character. In recent years, it has not been possible to develop a universal definition of implementable character. For the most part, this is subject to the evaluation of an interdisciplinary expert team appointed by the Ministry of Science and Higher Education and, in particular, an expert in the subject area designated by this team.

The implementation nature may already be evident in the topic of a doctoral dissertation on metallic materials, for example: System for evaluating materials used in nuclear power using the Small Punch Test method; Sustainable Pb free fittings for drinking water and gas installations - machinability and joinability; Development of rolling technology to ensure the stiffness of steel strips while reducing their weight. This does not mean that the title must be formulated with a clear indication of the subject of implementation. Examples include doctorates with the following topics: Material and technology factors in production of DP steel grades and its effect on stamping process; Evaluation of chemical composition and non-metallic inclusion in high-silicon steelmaking process in terms of magnetic properties. In these cases, special attention should be paid in the application description and reports to the specific object of implementation. For example, in the proposal for the last project, the rationale is as follows: To propose implementable technological changes and procedures for evaluating metallurgical purity in terms of magnetic properties of the product. It is also helpful to introduce an appropriate milestone such as: Development of implementation procedures. The scope of risk should also be defined, e.g.: Technological limitations not allowing rapid implementation of project results - Management strategy: in this case, the project results will remain the company's capital for future investment plans.

It is important that the nature of the implementation is evaluated and the implementation itself may remain to be implemented in the future - not necessarily during the realization of the doctorate. The significance of the implementation for the company (cooperating entity) is evaluated in the annual reports by an assistant supervisor from this company, who should meet the requirements for: employment in the company, many years of experience in the industry and experience in cooperation with scientific centres. Scientific activity is sometimes misunderstood by the authors of the implementation doctorate reports. Doctoral students are required to disseminate scientific achievements in the form of conference presentations as well as publication activities [3-10]. Often the results of such activity are erroneously considered scientific achievements. In reports

regarding scientific achievements, it is understood to set hypotheses and explain the results obtained as well as the relationships between them.

4. INDIVIDUAL RESEARCH PLAN

Proper formulation of an Individual Research Plan requires distinguishing between scientific and implementation activities. An example is the Individual Research Plan prepared for the topic: Material and technology factors in production of DP steel grades and its effect on stamping process. The following plan was given as a “Concise Task Description”: Semester 1 - Literature review of issues related to the production characteristics of steels with a two-phase structure, with particular emphasis on the effect of structure on susceptibility to cold forming; Semester 2 - Strength and microstructural studies. Recognizing the feasibility of carrying out pressability tests and internal stress level tests. Hardening of intercritical range material samples. Dilatometric tests; Semester 3 - Carrying out preliminary qualitative and quantitative tests of the phase composition in terms of strength parameters in the intercritical region. Collection of material samples from current production to perform statistical analysis for the relationship between process parameters and product properties; Semester 4 - Perform full material characterization for the current state of process settings in the production line. Define critical process parameters affecting the structure and properties of the material; Semester 5 - Determine the extent to which it will be possible to control the process line settings in order to achieve the assumed improvement in product properties. Determine the anticipated impact of planned changes on product properties; Semester 6 - Evaluate the actual impact of technological and microstructural parameters on the properties of the semi-finished product. Development of the best in terms of feasibility and ensuring the highest reproducibility of the results of the technological process change; Semester 7 - Evaluation of the impact of the technological process correction on the final parameters of the product. Production of trial batches of material and analysis of the results; Semester 8 - Editing of the dissertation and preparation of documentation for the application for the award of the doctoral degree.

With regard to the issue “Relationship to the implementation of the doctoral dissertation”, the following plan is given: Semester 1 - Determination of the current state of scientific knowledge. Determination of future directions for further research in areas hitherto insufficiently studied. Preliminary identification of material and process characteristics; Semester 2 - Preparation of a conference speech. Speaking at an international conference. Speaking at a national conference. Preparation of materials for publication. Preparation of results for the part of own research in the dissertation; Semester 3 - Development of the detailed scope of research implementation. Preparation of a preliminary review of the issue. Preparation of a description of the scientific issue in correlation between technology, microstructure and properties; Semester 4 - Preparation of a complete characterization of the technological process in terms of the kinetics of phase transformations and its impact on properties. Scientific publication in a journal from the ministerial list; Semester 5 - Preparation of a description of cause and effect issues for the topic of the work. Compilation of complete results for the technological process; Semester 6 - Development of the range of possible adjustments to the technological process with an assessment of their anticipated effects. Completion of the scientific description stage of the process; Semester 7 - Editing of the final results of the research. Preparation of graphs and diagrams of the relationship between parameters, microstructure and properties in the aspect of cold sheet forming; Semester 8 - Final version of the dissertation.

From the angle of “Scientific activity”, the following semester division can be presented: Semester 1 - Getting acquainted with the current state of knowledge on the basis of scientific publications. Gathering materials for the preparation of the theoretical introduction of the future dissertation; Semester 2 - Performing research and scientific analysis of the results in the field of microstructure and strength properties. Active participation in scientific conferences. Preparation of materials for publication; Semester 3 - Determination of the relationship between the currently used technology and the properties and microstructure of the material, as well as its suitability for stamping applications; Semester 4 - Full recognition of the impact of the unavoidable in industrial

practice variation of technological process parameters on the microstructure and properties of the semi-finished product; Semester 5 - Determination of the desired microstructural characteristics and sheet properties that give the greatest benefit for the application of the cold-forming material in the rim-pressing process; Semester 6 - Scientific analysis of the effect on the properties of the semi-finished product of changing one or more process parameters at the same time; Semester 7 - Scientific justification of the identified relationships between technology and the microstructure and properties of the material; Semester 8 - Evaluation of the reproducibility of the results after the introduced changes.

On the other hand, “Implementation activities” can be divided into: Semester 1 - Securing historical process data, conducted tests and analyses. Gathering available material samples from previously produced material; Semester 2 - Arranging for the collection of additional material samples from subsequent rolled campaigns. Gathering material to conduct research not previously conducted at the company; Semester 3 - Planning research using the company's research facilities (including foreign branches and R&D centers) to verify the effectiveness of future implementation activities; Semester 4 - Identifying parameters and process steps for which future changes are possible. Preliminary evaluation of possible process changes in terms of feasibility, cost and impact on other aspects of the company's operations; Semester 5 - Evaluation of the impact of individual process parameters on microstructure and sheet properties; Semester 6 - Verification of the technical feasibility of applying process changes. Development of a program of technological trials with risk analysis; Semester 7 - Implementation of trial production with changed process parameters. Evaluate the results of the implemented changes based on feedback from the Quality Department and the end customer; Semester 8 - Continue to track the results of the implementation.

5. PROBLEMATIC ASPECTS OF AN IMPLEMENTATION DOCTORATE

One of the more significant problems encountered in the implementation of the "Implementation Doctorate" program is how to relate to the company's sensitive data. First of all, a company referring its employee to the program must be aware of the need to make public at least some of the information obtained in the implementation of the PhD. It is unacceptable that all data obtained as part of the implementation of the doctorate should be covered by complete secrecy. The evaluation team on behalf of the Ministry of Science and Higher Education signed a confidentiality disclaimer. Therefore, it should be recognized that the scope of information submitted for the annual reports and the final report requires the inclusion of exemplification of results in terms of scientific and implementation achievements. It is also important that the settlement of the project is not the defended dissertation, but its submission on time. In recent years, different approaches have been taken to defending implementation doctorates with reported confidentiality. Such defences have been held before the committee itself with the signing of a confidentiality clause by its members, and there have also been cases of defending the doctorate in two parts: closed, i.e. before the committee in confidentiality, and open. Reviews can be fully classified or made public with parts obscured. Still, most doctoral thesis defences are conducted in open form. In terms of how companies approach the dissemination of the results obtained, there is an approach from blocking all information to secure patentability to full dissemination so as to protect against the patenting of a similar solution by competitors.

Under this program, the doctoral student receives a monthly stipend and the university where the program is implemented receives an annual grant to support the doctoral student's research. However, this funding is only triggered after a positive evaluation of the annual reports. Due to the very large number of implemented doctoral theses under the “Implementation Doctorate” program and the annual evaluation, there are significant delays in the transfer of funds. One of the significant changes in this regard was the assignment of one doctoral thesis to one application (previously, doctoral theses from a given unit were assigned to one application) which has significantly cleaned up the evaluation and funding procedure. There has also now been a significant reduction in the referrals. Previously, about 4/5 of the proposals were referred for implementation and now it is about 1/4 of the proposals with little reduction in the number of applications submitted to the program. This

may result in a shift from seeing implementation doctorates as scientifically weaker doctorates to seeing them as elite doctorates.

6. CONCLUSION

In conclusion, it can be stated that:

- The “Implementation Doctorate” program continues to meet its original objectives.
- The scientific requirements for implementation doctorates do not differ from the requirements for other doctorates.
- The implementation nature of the doctorate is to create its distinction and elitism.
- As a result of the adjustments made, the operation of this program has been improved.
- This is a program in which the progress of individual projects (doctorates) is controlled in great detail.
- It is still possible to see the need for adjustments in the “Implementation Doctorate” program. The development of a model for the implementation of such a doctorate should be helpful in this regard.
- The “Implementation Doctorate” program provides great opportunities for scientific and economic development in the area of the metal industry.

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