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Polish Foundry Engineer with Regard to Changes Carried by the Industry 4.0

K. Liszka [a,] *, K. Klimkiewicz [b], P. Malinowski [a]

[a] AGH University of Science and Technology, Faculty of Foundry Engineering,
ul. Reymonta 23, 30-059 Krakow, Poland

[b] AGH University of Science and Technology, Faculty of Management
ul. Gramatyka 10, 30-067 Kraków, Poland

* Corresponding author. E-mail address: kasia-liszka@wp.pl

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Abstract

The profile of the Polish foundry engineer in the Industry 4.0 age is presented in the present paper. The presented results were obtained by means of three research methods consisting of: analyses of professional expertise documents, questionnaires filled-up by the executive staff of foundry enterprises and analyses of work offers for the foundry engineer position. The investigations indicated the key competences of the foundry engineer, demanded currently by employers and meeting the requirements of the Polish foundry sector.
The obtained results were discussed in relation to the fourth industrial revolution and its requirements with regard to the engineering staff. This concept is based on information technology and robotizing, which means the total automation of industrial production processes as well as the widespread access to data and machines. Such an approach requires changes in applied machines, technologies and employees' competencies. The competences of employees constitute the element deciding on the company success, aimed at obtaining a competitive advantage. Therefore adjusting the employees' competencies to continuously changing reality is so essential.

Keywords: Competences, Engineer, Foundryman, Industry 4.0, Training

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1. Introduction

The concept of the fourth industrial revolution becomes, to a higher and higher degree, the reality. The foundry industry is also on the eve of the Industry 4.0. Its aim is a better integration of people, machines and processes to achieve more elastic and more efficient production, which is forced by strong competition and higher and higher expectations of clients. The concept of the fourth industrial revolution is based on informatisation and robotisation, which means the full automation of production processes as well as the universal access to data and machines. This approach means a necessity of introducing changes within the range of applied machines, technologies and also in competences of employees.

The human capital is the main asset of every enterprise [1], and its proper use allows to achieve the aims of the company as well as to meet the present and future requirements of the market [2], and - first of all - to obtain the competitive predominance. Thus, adjusting of employees competences to constantly changing work specificity in casting houses, becomes the key task.

Competences of the key employees of foundry plants, including competences of the foundry engineer are analysed in the present paper. In the first part of this work, the requirements set to foundry engineers and ways of obtaining these competencies are presented. In the second part, based on the analysis of competition

requirements related to Industry 4.0, the potential competence zone was identified. This zone, the so-called competence gap, will have more and more meaning in the future [3].

2. Methodology of investigations

Obtaining information concerning essential - from the point of view of employers - professional and social competences of persons employed at the engineer post, necessary in the foundry engineer work, indispensable in the proper performance of the current tasks of the job as well as in the production process according to Industry 4.0, was the purpose of the performed research. The investigations were based on the triangulation of research methods: analyses of professional documents, questionnaires and analyses of the published work offers for the foundry engineer post.

Preliminary investigations contained analyses of professional expertise documents, i.e. education standards in the studies of the I and II degree in the Faculty of Foundry Engineering AGH and the description of the foundry engineer profession (214607) in the Qualification of Professions and Specialties of the Ministry of Family, Labour and Social Policy.

The successive stage of research was investigating of questionnaires filled-in by the executive staff of 24 Polish foundry plants (17 – cast iron foundries, 7- non-ferrous metals foundries), including 16 representing SME sector, concerning the competitions required from a foundry engineer. In one part of the questionnaire, respondents were asked to indicate 10 most important competences from their point of view, in the foundry engineer work. The last stage of research contained a comprehensive analysis of 47 job offers for the foundry engineer post, originated from the Internet, published directly by employers and by employment agencies in years 2016-2017.

3. Foundry engineer – requirements and expectations of the foundry industry

3.1. Industry 4.0 and the foundry industry

According to the concept of Industry 4.0 machines are more intelligent, communicate with each other and are using the common database. Thus, it means that the modern foundry plant should be automated and robotized where processes are coordinated and controlled by the intelligent system, allowing their monitoring from any place in the world. The machines coordination is possible in any time and place, due to the control system placed in the 'cloud'. The new concept influences also the remaining processes. Orders are submitted by the centralised system, and the application of the integrated system MRP (Material Requirements Planning)/ERP (Enterprise Resource Planning) allows for the automatic management of delivery chains as well as of the current and future production needs.

The essential part of this approach constitutes the foundry employees. Their role is not decreased but requires another set of competences [4]. Qualifications in such fields as a digital production, robotics and automatics are becoming more needed by employers [5]. Adjusting of foundry plants to the concept of Industry 4.0 will improve their yield and production abilities. Simultaneously, due to the system flexibility allowing for cheaper and shorter production series, it will make them more reactive for the client's needs and - in effect - more competitive.

Investigations of the automation degree of companies in Poland, performed in 2016, indicated that this degree is not high. Only 15% of Polish factories are fully automated, 76% indicated partial automation while only 6% are introducing Industry 4.0. This means, that the Polish industry still faces challenges of the third industrial revolution. This technological delay is a result of low work costs, a lack of access to a proper capital, a lack of expertised engineering staff and concentration on marketing and sales operations to establish the market position [6].

However, it does not mean that the Polish industry, including foundry, should not be preparing for the coming changes, which - in the near future - will be necessary for maintaining the competitive predominance in the domestic as well as international market. The implementation of the Industry 4.0 idea among Polish foundries is not easy also because of the required financial outlays. As it is suggested by experts, it is possible to modernise the enterprise gradually without changing its method of operations, up to the moment when the investment outlays for the modification will drop to a low level. That time the investment in the new software, supplementing equipment with new components and the implementation of new rules in accordance with the Industry 4.0 idea will be enough [7].

An employee, a well-qualified engineer, should be prepared for the arriving changes. This is possible by adjusting ways of obtaining competences and skills needed in the future.

In preparations for the fourth revolution, the employee's competences are becoming more important, than his qualifications. A concentration on qualifications instead of competences can hinder the competitive adjustment of employees to the requirements of Industry 4.0. The concentration on qualifications will be justified only when the program of studies will be dynamically adjusted to the requirements of Industry 4.0, which requires close cooperation between universities and the industry.

3.2 Foundry engineer of the Industry 4.0 format

The new trend – Industry 4.0 – is the new approach to the production process, which formulates new requirements for employees including the foundry engineers. The engineer of the fourth industrial revolution format, will be obliged to follow the technological progress within his specialty field and cooperate with other specialties.

As the result, the contemporary engineer should acquire new technical competences related to new technological fields i.e. the integration of cyber-physical systems, advanced production management systems, robotisation and complex systems of production and data analyses. The engineer should have competences in technologies allowing personalization of the

production i.e. 3D printing, advanced simulations, virtual and augmented reality [8].

Processing and analyzing of large amounts of data originated from several sources, assessing the importance and reliability of this information as well as drawing - on their bases - proper conclusions, will be the duty of contemporary engineers. The work of the modern engineer will be based on electronic media and Big Data tools.

Thus, summarizing: the foundry engineer of Industry 4.0 is the expert having professional knowledge concerning the specific production process and proper engineering skills as well as widely comprehended IT skills.

The Industry 4.0 idea will also cause increased importance of psychosocial skills (the so-called 'soft skills'). The engineers will be required to be more open to changes, flexible in operations, subjected to continuous training and to learning elements of other fields. Work in virtual, often multicultural teams causes a need for the design and teamwork approach to work, as well as interpersonal skills and the efficient communication ability [9].

To achieve success in the enterprise transformation to the fourth industrial revolution standards the engagements of the management and personal sectors in building the proper human resources policy, mainly supporting the development of employees, is necessary.

The analysis of the Industry 4.0 requirements with regard to foundry engineers was performed mainly to determine the adjustment degree to human resources management.

4. Results of empirical investigation

The foundry engineer profession (214607), according to the classification of professions and specialties of the Ministry of Family, Labour and Social Policy, belongs to a large group of specialists (2) and - within this group - to the elementary group of mining and metallurgy engineers (2146). It is characterised by the fourth qualification level, reflecting the fifth and sixth level of education according to ISCED [10].

Characteristic of this profession prepared by the Ministry defines the foundry engineer as the person developing technological processes of making castings of various materials i.e. cast iron, cast steel and non-ferrous metals alloys, organising and supervising the metal melting process course at applying various machines and casting devices. Independence of the character and workplace, the foundry engineer can perform the research and innovation operations in foundries, work in technological offices and design companies as well as in the scientific-research institutions.

The analysis of the professional documentation allowed to reveal the most essential competences of the engineer. These are: the professional knowledge with several skills from the metallurgy field with several technical abilities allowing for its proper utilising as well as soft competencies depending on the character of position taken in the foundry, - it means the ability of managing the team of employees, cooperation with the group, undertaking independent decisions or the mutual solving of problems. In consideration of the social responsibility of his activity, the engineer should also have such competencies as: accuracy and scrupulosity in performing tasks as well as responsibility for the process, people and machines.

The analysis of educational standards in the Department of Foundry Process Engineering and Department of Computer Aided Process Engineering realised in the Faculty of Foundry Engineering of AGH indicated, that the graduate having the Master of Engineering title should have the professional knowledge from metallurgy, applied materials, metals and their alloys processing, ecology including wastes waste management and metals recycling, heat treatment, automatics and ability of modeling production processes and computer aided engineering works (CAD, CAM, CAMD, CAE). The graduate of the specialty: Computer Aided Process Engineering should have added the knowledge and abilities of the informatics systems. The graduate should be prepared both for the team and for the individual work [11].

Employers representing foundry enterprises, subjected to the questionnaire research, indicated 10 key competences for the profession of the foundry technologist, equated with the person of university education (foundry engineering, metallurgy). The obtained results are shown in Table 1.

The obtained research results indicate that the most important social competence of this profession is the responsibility (75%), meaning the responsibility for the whole production process, stock of machines and employees.

These results also confirmed that the professional knowledge (71%) constitutes one of the most essential competence in this profession. Among professional abilities, the ability of reading and working out technical documentation (83%, 75%) and the ability of optimizing the production process (83%), were considered the most important.

In dependence on the size of the enterprise the foundry engineers have required the independence - in case of SME sector (63%) - and the ability of team works in case of large enterprises (88%). Large enterprises equally often require the creativity (88%), which is related to new challenges undertaken by foundries, to searching and introducing innovatory technological solutions.

Among the key competencies are also abilities of solving production problems (71%) and of using the newest informatics tools aiding the casting process (67%). This last ability is especially important for employees of large casting enterprises, which use special software for designing and managing the process.

The obtained data were subjected to the verification with the requirements put up by employers to candidates for the post of: foundry technologist/foundry engineer. To this aim the broad analysis of the selected 47 work offers originated from Internet sources, published directly by employers and by work recruitment agencies in years 2016-2017, was performed. Announcements published - on the average - every two months during the tested time, were subjected to analyses.

The decision on this information source was undertaken on account of a large geographic dispersion of potential employers, which made the observations of publications in local newspapers impossible.

Recruitments were performed in the majority by foundries from the SME sector and by large casting houses.

Table 1.
10 key competences - acc. to employers - for the foundry technologist post, according to foundry enterprises from the SME sector and large enterprices

	Altogether		SME		Large enterprises	
	Number of indications	%N=24	Number of indications	%N=16	Number of indications	%N=8
Social and other competences						
Responsibility	18	**75%**	11	**69%**	7	**88%**
Organising of own works	14	58%	8	50%	6	75%
Creativity	14	58%	7	44%	7	**88%**
Independence	14	58%	10	**63%**	4	50%
Sharing knowledge and experience with others	14	58%	8	50%	6	75%
Team cooperation	14	58%	7	44%	7	**88%**
Logical thinking	13	54%	9	56%	4	50%
Decisions making	13	54%	8	50%	5	63%
Analytical thinking	12	50%	8	50%	4	50%
Hard competences (professional)						
Knowledge of technological processes	21	**88%**	13	**81%**	8	**100%**
Ability of reading technological documentation	20	**83%**	13	**81%**	7	88%
Ability of optimizing casting processes	20	**83%**	12	**75%**	8	**100%**
Ability of drawing up the technical documentation	18	75%	10	63%	8	**100%**
Professional knowledge	17	**71%**	10	**63%**	7	**88%**
Solving problems related to the selection of casting methods, making moulds and cores, preparation of charges, melting, secondary reclamation, moulds pouring, finishing and repairing of castings	17	71%	11	69%	6	75%
Knowledge of software: 3D/ Solid Works/ Solid Edge or similar	16	67%	10	63%	6	75%
Ability of selecting technologies, machines and casting devices for the particular casting	15	63%	9	56%	6	75%
Ability of using control-measuring devices	12	50%	9	56%	3	38%
Knowledge of technical sciences	11	46%	6	38%	5	63%
Knowledge of principles of casting devices operation	11	46%	8	50%	3	38%

Source: own study

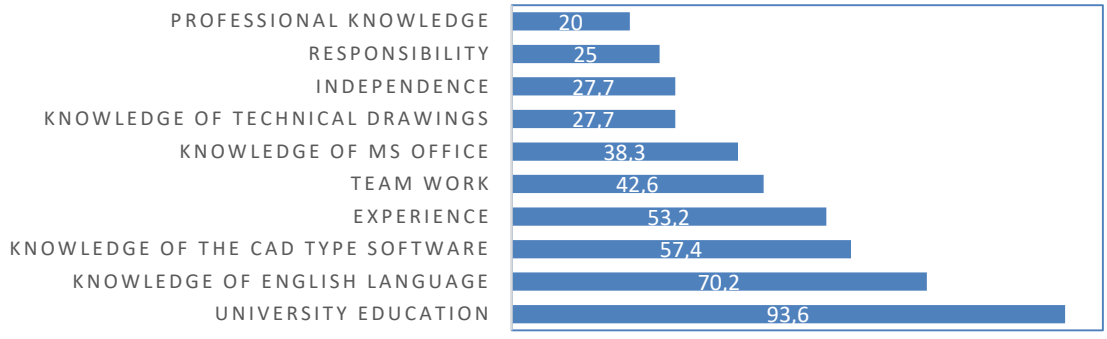

Fig. 1. Requirements set up by the foundry enterprises for candidates for the foundry engineer post (%)
Source: own study

The university education, specialist field of study (foundry engineering or metallurgy) as well as a good knowledge of English language can be considered the obligatory requirements. Only 20% of employers indicated the professional knowledge as

the essential competence for the recruited post. It can be expected that employers consider the professional knowledge as directly related to the requirement of the university education and are convinced that such education provides necessary competences for the advertised post. Attaching the significance to formal qualifications can confirm, that the university education is properly related to the employers requirements. It is worth to notice that - within the professional knowledge - the most often requirements concerning casting technologies and structures (25.5%) as well as the knowledge of the production procedure (21.3%) occurred in announcements.

Equally important for the employers is the familiarity with informatics tools aiding casting designing. The most often knowledge of software: Solidworks (27.7%), Solid Edge (19.1%), MagmaSoft (19.1%), were required. The professional experience understood as the practical preparation for the profession was also required. The most often employers were demanding a minimum 3 years experience at the same or similar post. Among the social competences the employers were mostly expected to have the team work ability, which is often related to work in teams of experts created in technological offices of large enterprises. The independence in undertaking operations was also expected. It can be assumed that this competence is essential for SME enterprises, in which the technological office work is reduced to the work of one or two technologists.

Tests of work offers indicate that the most important professional tasks of the foundry technologist/foundry engineer are:

– supervision of the process functioning (55.3%),
– preparation of technical documentations and their supervision (48.9%),
– improvement of the process functioning and its optimisation with utilising the company resources (46.8%),
– development of the process parameters and designing the technology (31.9%),
– initiation and implementation of new technological-metallurgical processes (29.8%),
– analysis of processes and incompatibilities (23.4%).

Tasks, which are assigned to the foundry technologist, depend on the post taken by him and on his responsibility for the process. The operations of the foundry technologist concentrate mainly on the process preparation, its control and optimisation. Still not many companies place emphasis on implementations of new technological solutions and on the analysis of incompatibilities, which occurred during the process.

On account of analysing work offers for foundry technologists, it is worth to emphasize that according to investigations performed in 2015 by the AGH Carriers Center [12] 65.8% of this Faculty graduates found the employment according to their education, mainly in the foundry sector. Such results can suggest a relatively high similarity of didactic issues during studies and the current requirements of employers.

As a result of the performed investigations, it is possible to determine the general - and usually set - requirements (education, experience, competences) for the foundry engineer/technologist post in the foundry enterprise as well as competition requirements in the light of the new Industry 4.0 approach. The list is shown in Fig.2.

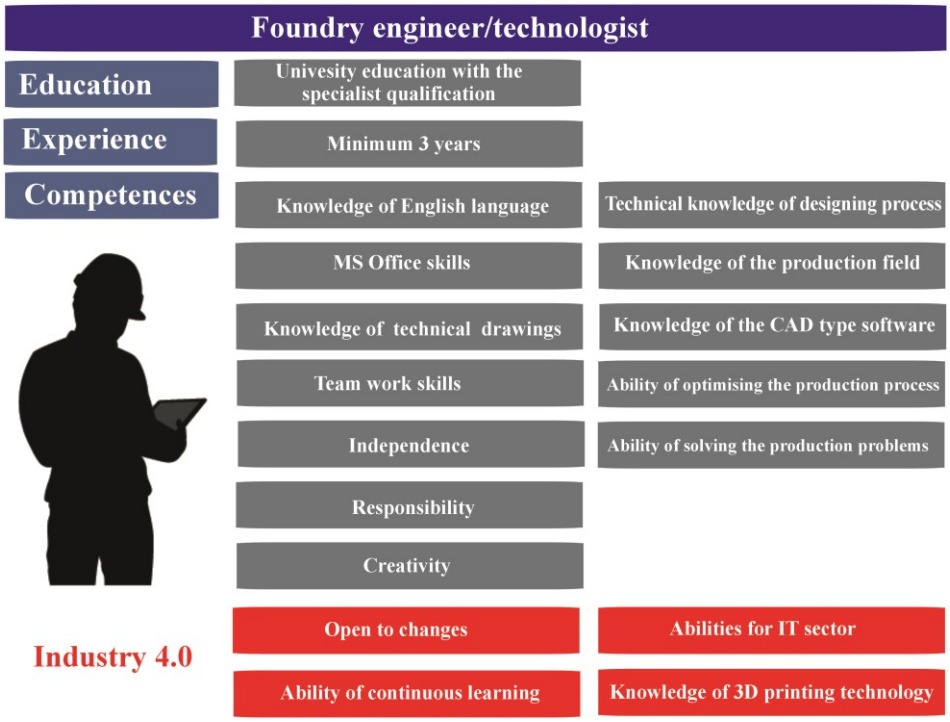

Fig. 2. Requirements for the foundry engineer/technologist post
Source: own study

Among competences required up to now by employers, the new ones, related to the fourth industrial revolution, will soon appear. This constitutes the signal for the universities, enterprises and the candidates for the foundry technologist posts.

The education system is of a key meaning for the enterprise success in the knowledge based economy. Technical universities in their educational programs, especially in specialist qualifications, are already trying to meet the Industry 4.0 requirements. Informatics is a necessary element of nearly every speciality, including the Faculty of Foundry Engineering, which has the speciality: Computer Aided Process Engineering.

An indispensable element of the modern engineer education should be practical training in enterprises. The most suitable would be the dual training, since it will allow engineers to get practical skills in a direct contact with newer and newer technologies, machines and devices. Such way will prepare employees to meet the requirements of entrepreneurs. The dual system is also the way of shortening the adaptation period of an employee in the new work place. Thus, a direct and close cooperation between the industry and universities, should be the main issue of the future engineer's preparation.

The introduction of the Industry 4.0 idea means also the necessity of performing additional technical training, allowing the employees to get skills in using modern informatics tools.

The attention should be drawn to the fact that in the Industry 4.0 age, soft abilities are gaining a higher importance. Engineers functioning in the labour market should demonstrate openness for changes and become interdisciplinary experts.

5. Conclusions

Industry 4.0 is the knowledge-based operation. Poland, with its well-educated cadre, should see its chance of performing the development jump. The new approach demands from the foundry industry the assurance of the accessibility of the infrastructure, which will provide automation and informatisation of the production as well as investments in the engineering staff - responsible for the implementation and maintaining the newest technologies.

The new Industry 4.0 trend, within the management of human resources, requires the employee not only - as up to now - to use the previously gained competences, but to be ready for the continuous training allowing him to improve his qualifications, in accordance with the actual requirements and needs of employers [13].

Engineer of Industry 4.0 is open to change and learns through his whole life.

His IT skills are of most importance, not only handling ERP programs but also working with big database and its analysis.

Familiarity with newest technologies and application of innovative materials will also gain significant importance. Knowledge of more and more popular 3D printing technology, usage of robots in casting production and ability of optimizing the production process will become an inseparable part of engineer's work.

Because of that didactic programs of universities require constant improvements and adjustments to the actual needs of the domestic foundry sector and of the coming fourth industrial revolution. This will ensure the highest level of the engineering cadre allowing for the competitiveness of the Polish foundries.

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