Method of Analysis of the Topic of Doctoral Thesis in the Field of Castings Production. Case Study on the Situation in Romania

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Abstract. The paper presents a method of analysis of doctoral theses in castings production, elaborated in Romania, the analysis period ranging from 1918 to 2016. The procedure, based on the evolution of the analyzed problem, consists of the following steps: establishment of a coding system for the domains and subdomains established in the thematic characterization of doctoral theses; the establishment of the doctoral organizing institutions, the doctoral specialties, the doctoral supervisors and the time frame for the analysis; selecting the doctoral thesis that will be included in the analysis; establishing the key words for characterization of doctoral theses, based on their title; the assignment of theses to the domains and subdomains according to the meaning of the keywords, to the existing groups of the coding system; statistical processing of results and determination of shares for each domain and subdomain; conclusions on the results obtained and their interpretation in the context of economic and social developments. The proposed method being considered as general, the case study is carried out at the level of the specific field of castings production, the territory of the analysis refers to the institutions organizing doctoral studies.

1. Introduction
From the analysis of the specialized literature, we found that there is no particular presentation of a method of analysis of doctoral theses at the level of the castings, especially in Romanian literature. There are general studies showing the evolution of the Romanian technical education [1] or the development of science and technology in the interwar period [3]. Among the monographic works there are some from the most representative unit in the Romanian technical education, the Polytechnic University of Bucharest [6] or the Technical University of Cluj-Napoca [5]. At an international level, we note the synthesis paper on the evolution of casting processes in the French industry [4] or a complete history of castings present at the global level [9].

2. Considerations on the evolution of engineering training at the manufacturing stage of castings
The spatial location of the study at the level of Romania is not coincidental, because on December 1st 2018, one hundred years will have passed since the Great Union, when the provinces with a major Romanian population (Transylvania, Banat, Crișana, Bucovina, Basarabia) decided to unite with Romania. In the analyzed period, the country went through a period of construction of the market economy according to the specifics of the interwar period (1918-1940); the war period (1940-1945);
the period of centralized economy (1945-1989); the transition period of the construction of the market economy (1989-present).

In a primary assessment, from the point of view of general engineering training, it is estimated that there are four periods: the period of preliminary accumulation structured in the beginning of the engineering training, without the recognition of the engineering diplomas issued in Romania - up to the level of 1890; the period of accumulation and structuring of engineering training according to Western models - positioned between 1890 and 1948; the period of engineering formation that coincides with the period of Romania’s high-speed industrialization in a centralized economy - positioned between 1948 and 1990; the period of engineering training during the transition from the "centralized economy" to the "market economy" - positioned between 1990 and the present.

From a historical perspective, the evidence of the development of casting production and the structuring of the training tools in the manufacturing of molded parts is represented by the "foundry manual" of engineer Petre Dumitrașcu [2], of which the cover and the first page are presented in Figure 1. Speaking about historical events, in 1936, the first "engineer doctor" diploma was awarded by "Politehnica of Bucharest" to the American engineer W.J. Crook, the leadership being provided by Prof. Traian Negrescu, the presentation being carried out in French (Figure 2). The theme of the thesis is from the metallurgical field, which proves the level achieved by this specialty in the Romanian higher technical education.

3. Consideration on the casting industry

In the characterization of the production of the castings we tried to present the evolutions existing at the global level in relation to the situation existing in Romania. The evolution of casting production is presented using the "World Castig Production" annual reports, produced by WFO and published in each December in Modern Casting.

Figure 1. Foundry manual, Eng. Petre Dumitrașcu (1939).

Figure 2. Welton Joseph Crook - First PhD thesis in engineering in Romania (1936).
So far, there have been presented 50 global analyzes "World Castig Production", the last one being presented in December 2016, about the situation in 2015. For the year 1996, the data included in the analysis of Professor Iulian Ripoșan were used [7]. The study also mentions the situation in 1989, when Romania was producing 1.5 million tons of castings, ranked as 9th in the world. In order to have a correct picture of the evolution of the production of castings in Romania over the last years (2000-2015) the following table shows the evolution of the production of castings in Romania compared to the production achieved globally (Table 1).

| Year   | 2000       | 2005       | 2012       | 2015       | Production ratio-PR |
|--------|------------|------------|------------|------------|---------------------|
| Global situation | 64,750,239 | 85,741,076 | 91,673,839 | 104,129,257 | 1,608               |
| Romania| 360,120    | 154,319    | 101,427    | 129,053    | 0,358               |

Therefore, from the correlation of the data, it is estimated that the molded casting industry has reached a peak of production in 1990, amounting to one million tons of molded parts, and a minimum of 80,000 tons was generated in 2009. At present, it is stabilized at between 100,000 and 150,000 tons. The domains served over time include means of transport, metallurgical equipment, machinery for the chemical and petroleum industry, machinery and equipment for the extractive and energy industry, textile machinery and others.

4. Methodology of analysis

The knowledge of the topics of doctoral thesis is important from two perspectives, a historical one determined by the establishment of a natural correlation between the researches made and the existing technological problems and the second one related to the suggestion of the expertise accumulated at the level of the main institutional acts validating the activities carried out, the title of Doctor of Engineering. Therefore, the establishment of this methodology is important in order to be able to assess the evolution of doctoral thesis in Romania throughout an entire century (1918-2016).

The method, based on the evolution of the analyzed problem, consists of the following stages: establishment of a coding system for the domains and subdomains established in the thematic characterization of PhD thesis; the establishment of the doctoral organizing institutions, the doctoral specialties, the doctoral supervisors and the time frame for the analysis; selecting the doctoral thesis that will be included in the analysis; establishing the key words for characterization of doctoral theses, established on the basis of the title they have; the assignment of theses to the domains and subdomains, according to the meaning of the keywords, to the existing groups of the coding system; statistical processing of results and determination of weights for each domain and subdomain; conclusions on the results obtained and their interpretation in the context of economic and social developments. The detailed presentation of the method is carried out at the level of the doctoral thesis elaborated within the PhD thesis [8].

5. Identifying the spatial and temporal framework and its characterization

The spatial location of the study is made at the level of Romania, and the analyzed period is related to the events that took place from 1918 to the present. In the analyzed period, the following organizing centers of doctoral studies have functioned (using the current name) in the field of casting manufacturing: "Politehnica" University of Bucharest started in 1936 - the year of the first PhD thesis, "Politehnica" University of Timisoara, Technical University from Cluj Napoca since 1960, "Transilvania" University of Brașov, "Gheorghe Asachi" Technical University of Iași, "Valahia" University of Târgoviște, "Dunărea de Jos" University of Galați. The fields of doctoral studies in which doctoral theses have been elaborated, refer to materials technology, metallurgy, materials engineering etc.
6. Establishing domains and subdomains for identifying the subject
The keyword method was used to assign PhD theses in the subject area of a doctoral thesis. The topic, identified from the title of the thesis, falls within the established domains, and at their level, within the constituent subdomains. The domains will be similar to the first group of figures and, given the purpose of the present paper, each field will be divided into subdomains, which will be characterized by the second group, the subdomains being considered in this case as the first rank. The division process can continue, in order to refine it, so that for each subdomain the development continues, the resulting subdomains will be called the second rank. The procedure can continue in the same way. Within the framework of this study, 27 domains of the molding process were identified and each field is divided into subdomains. By way of the construction of the coding system, there are possibilities to enter 99 subdomains for each domain.

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The domains identified by the keyword identification and characterization groups of the PhD thesis are as follows: Group of cast alloy family, coded with (01); Group of cast alloy characteristics, coded with (02); Group for the characterization of casting applications, coded with (03); Group of casting functionality, encoded with (04); Group of casting weight characterization, encoded with (05); Geometrical shape characterization group of castings, coded with (06); Group for characterizing the complexity of the castings construction, coded with (07); Group for the characterization of casting production type, coded with (08); Group of physical and chemical phenomena present in the development and casting of alloys, coded (09); Technological elements characterization group, coded with (10); Process elaboration characterization group, coded with (11); The alloy casting characterization group, coded with (12); Casting procedures characterization group, coded with (13); Group of characterization of the model gaskets and the SDV necessary for making shapes, coded with (14); Group for the characterization of auxiliary operations in casting manufacturing processes, coded with (15); Group for the characterization of the eco responsibility shown in casting production, encoded with (16); Grouping of equipment and installations used in foundries, coded with (17); Group for the characterization of the control, investigation and quality assurance activities of casting parts, coded with (18); Group with reference to the laboratory techniques used in the casting process, coded with (19); Group for the characterization of standardization and normalization activities of the casting industry, coded with (20); Group regarding the modeling of casting processes and the use of information tools at the manufacturing stage of the molded parts, coded with (21); Group on the intelligent use of information in casting manufacturing, coded with (22); Group with reference to the preparation of castings production, coded with (23); Group with reference to the manufacture of materials with special properties obtained by casting, coded with (24); Group with reference to technological processes competing with the manufacture of castings, coded with (25); Group relating to training in the manufacture of castings, coded with (26); Group with reference to the history of the manufacturing processes of the cast parts, coded with (27).

The subdomains that characterize the first domain have the following form: Ash Fonts - (01). (01); Fonts with nodular graphite - (01). (02); Malleable Fonts - (01). (03); Cast steels - (01). (04); Copper alloys - (01). (05); Alloys based on Aluminum - (01). (06); Zinc alloys - (01). (07); Magnesium alloys - (01). (08); Other types of alloys - (01). (99). Other domains have been divided in a similar manner.
7. Calculation of the appreciation indicators of the frequency of the structured topics in the PhD thesis

The calculation procedure follows the following steps: selection of doctoral thesis with significance for the manufacturing of cast pieces; allocation of domain and subdomain codes based on the keywords set at the level of each thesis selected in a primary and secondary characterization; frequency calculation for each characterization code; the calculation of the share indicators at the level of each characterization code.

In the analysis made, that of doctoral thesis with significance for the manufacturing of castings, out of the total theses analyzed, determined at the doctoral studies organizing centers, a number of 76 were selected, those which are relevant to the field of casting production. The indicators of appreciation for the doctoral thesis analyzed are related to the following aspects: the share of belonging to a field; the share of belonging to a subdomain within the domain; the dissemination of theses at the level of the doctoral studies organization centers and the annual distribution of the doctoral thesis defence over the analyzed period of time. Table 2 shows the number of frames for each domain coding structure at the level of doctoral thesis analyzed, as well as their calculated weights.

Table 2. Appreciation indicators for the PhD thesis analyzed.

| Nr. | Domain coding | Number of frames | Framing Frequency % | Nr. | Domain coding | Number of frames | Framing Frequency % |
|-----|----------------|-----------------|---------------------|-----|----------------|-----------------|---------------------|
| 1.  | 01             | 34              | 44.73               | 15. | 15            | 0               | 0                   |
| 2.  | 02             | 0               | 0                   | 16. | 16            | 5               | 6.57                |
| 3.  | 03             | 3               | 3.94                | 17. | 17            | 0               | 0                   |
| 4.  | 04             | 0               | 0                   | 18. | 18            | 0               | 0                   |
| 5.  | 05             | 0               | 0                   | 19. | 19            | 2               | 2.63                |
| 6.  | 06             | 0               | 0                   | 20. | 20            | 0               | 0                   |
| 7.  | 07             | 0               | 0                   | 21. | 21            | 5               | 6.57                |
| 8.  | 08             | 0               | 0                   | 22. | 22            | 0               | 0                   |
| 9.  | 09             | 9               | 11.84               | 23. | 23            | 1               | 1.31                |
| 10. | 10             | 3               | 3.94                | 24. | 24            | 8               | 10.52               |
| 11. | 11             | 1               | 1.31                | 25. | 25            | 0               | 0                   |
| 12. | 12             | 1               | 1.31                | 26. | 26            | 0               | 0                   |
| 13. | 13             | 2               | 2.63                | 27. | 27            | 0               | 0                   |
| 14. | 14             | 2               | 2.63                | 28. | Total         | 76              | 100 %               |

Figure 3. Frequency of assignment of doctoral theses in domains.
The topic distribution of the doctoral theses on the established domains is presented in Figure 3. The distribution analysis on the subdomains will be made on the characterization group with the highest share, that of the characterization of the family of the alloy. The results of sub-domain assignment are shown in Table 3.

Table 3. Distribution analysis on subdomains of the alloy family characterization (01).

| Nr. crt. | Coding the subdomains of the group (01) | Number of frames | Subdomain share (%) |
|---------|----------------------------------------|------------------|---------------------|
| 1       | (01) (01) gray cast iron               | 5                | 14.70               |
| 2       | (01) (02) cast iron with nodular graphite | 5               | 14.70               |
| 3       | (01) (03) malleable cast iron          | 5                | 2.94                |
| 4       | (01) (04) cast steels                  | 8                | 23.52               |
| 5       | (01) (05) copper based alloys          | 1                | 2.94                |
| 6       | (01) (06) alloys based on aluminum     | 7                | 20.58               |
| 7       | (01) (07) zinc alloys                  | 1                | 2.94                |
| 8       | (01) (08) magnesium alloys             | 6                | 17.64               |
| **Total** |                                       | **34**           | **100%**            |

From the point of view of the shares, the PhD thesis dealing with the issue of the cast iron in the first group (the family of alloys) is 32.34%, that of steels is 23.52% and the aluminium-based alloys is 20.58%. Within the cast iron, gray cast iron has the same share, that of 14.70%, with that of the nodular graphite cast iron, and the malleable cast iron has a weight of 2.94%. The graphical presentation of this distribution is shown in Figure 4.

Regarding the distribution for the periods mentioned at the beginning of the paper, this is how it looks like: II (1918-1940) 1 PhD thesis; III (1940-1989) - 5 PhD thesis; (1989-present) - 70 PhD thesis. The analysis shows that the share of theses sustained in the last analyzed period is 92.10%. This period coincides with the decrease in the production of castings to 100,000 tons. The production period reached 1 million tons, that of the years 1945-1989, the share of the PhD thesis was only 6.57% of the total of the PhD thesis defended during the 100 years analyzed, from the perspective of castings.

Figure 4. Subdomain distribution of alloy family 01.
8. Conclusions
From the presentation we can see that the doctoral thesis, which are part of the "Alloy family characterization group" - coded with (01), have a share of 44.73% and occupy the first position within the established hierarchy. The following are the results obtained from the succession within the domains: "Group of characterization of the physicochemical phenomena present in the elaboration and casting of alloys" - the codified group (09) occupies the second position, with a share of 11.84%; the "Group referring to the production of materials with special properties obtained by casting", coded as (24) occupies the third position, with a share of 10.52%; the "Group of characterization of the ecoresponsibilities of casting production", coded as (16) and the "Group referring to modeling of casting processes and the use of information tools in the manufacturing of casting parts", coded as (21) occupies the 4th position with a share of 6.57%.

At the same time, we notice that a number of key areas in the casting industry have not seen any approach to the doctoral thesis over 80 years, for example the following can be noted: the alloy casting characterization group, the group characterizing the functions of the casting parts, characterization group of auxiliary operations, characterization group of the machines and installations in the foundries, the group with reference to the laboratory techniques and the investigation of the quality of the cast parts, the group with reference to the preparation of the production of castings, etc.

From the analysis we find that the subjects of doctoral theses in the field of castings manufacturing have dealt more with the problems of the alloys from the point of view of the elaboration and casting, their specific phenomena, the modeling and the use of the IT tools at the level of the technological elements.

Unfortunately, there aren’t any doctoral theses that cover the casting in terms of the functionalities, the characteristics that it possesses, through the properties embedded in the cast alloy, auxiliary operations, means of investigation of quality, technological infrastructure and activities related to the preparation of the manufacturing.

By following the tendencies at the level of the manufacturing, which mostly coincide with the fields not covered by the PhD thesis, it is found that the problems approached were most often chosen randomly among the tendencies of the moment, it did not coincide with the solving of the major theme, which brings about development and modernization by using the new tools of the general technologies of the moment.

9. References
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