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Engineering of the institutionalization of the circular economy at the level of casting production

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Abstract. This paper is motivated by the necessity of introducing the principles of circular economy at the level of different social – economic activities, and from this point of view one of the fields with a special potential is that of the manufacture of castings. Objective: to connect to the organizing and application of the methodology of the circular economy principles. The proposed method is an innovating one, being connected to the use of institutionalization engineering.
Formulating the subject: The subject formulated to be solved aims at the introduction of new approaches, defined through institutionalization engineering, which proposes to set the correlation of actions between the specifics of the circular economy and the specific elements of the manufacture of castings. Research method: An institutional structuring operation was imposed for the optimization of the research method, in which different versions interact at the following levels: the level of public policies, the level of the regulatory framework, the level of technical solutions and the level of financing solutions and financial instruments. The determination of the optimal solution established in a dynamic context, favorable for the requirements of the different actors present within the process, appeals to the elements of critical thinking, specific for the engineer's actions. Achievement of the research activity: The research activity structures a methodology of quantifying the contributions of each stage of the manufacturing process for castings at the fulfilling of the specific conditions of the circular economy, indicating the critical areas of action for more efficient actions of the circular economy, according to the market economy requirements, where there is a potential of implementing the technical solutions by quantizing the financial solutions and the opportunity of using the financial instruments. The major contribution of the research: The proposed methodology, with examples at the level of castings manufacture, sets the bases of a new field of action of the engineering thinking, namely, that of circular economy institutionalization functioning. Conclusions of the research activity: The proposed methodology represents the bases of establishing a new instrument of action at the level of institutionalized functioning of the circular economy.

1 Introduction

The paper is motivated by the necessity of introducing the principles of the circular economy at the level of the different socio-economic activities, and one of the areas with a great potential in this respect is the production of molded parts. The objective is related to the structure of a methodology for applying the principles of the circular economy, and the proposed method is a novel one, being related to the use of institutionalization engineering. The problem to be solved is to introduce a new approach, defined by the institutionalization engineering, which aims to establish the correlation of the actions between the specifics of the circular economy and the specific elements of the casting production. In the optimization of the methodology of analysis, a structure of institutional functioning has been imposed, in which the following layers interact in different variants: the level of public policies, the level of the regulatory framework, the level of the technical solutions and the level of financing solutions and the financial instruments, the schematic presentation is made in Figure 1.

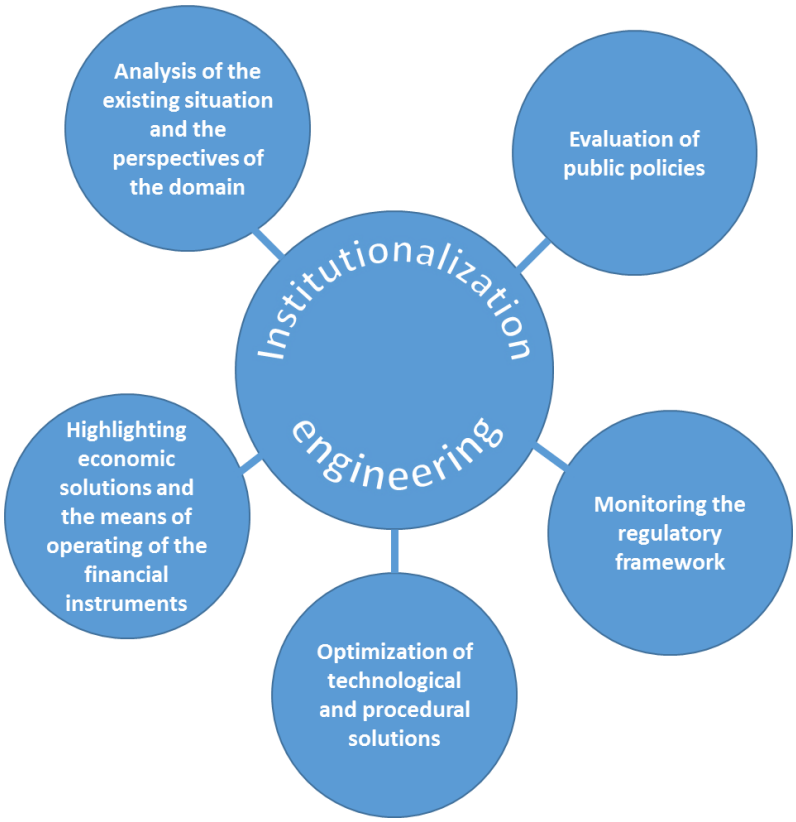

Figure 1. Schematic of the engineering actions of the institutionalization of casting production

The determination of the optimal solution set in a dynamic context, favorable to the requirements of the various actors present in the process, calls for critical thinking elements specific to the engineering actions. The research activity structures a methodology to quantify the contributions of each stage of the casting process in order to meet the conditions specific to the functioning of the circular economy, indicating the critical areas for action to streamline the circular economy in line with the requirements of the market economy where there is potential for implementation. Technical solutions are assessed by quantifying financial solutions and the opportunity to use financial instruments. The proposed methodology, exemplified in the manufacturing of molded parts, sets the basis for a new field of action of engineering thinking, that of the engineering of the institutionalization of the circular economy. The openness offered by the proposed methodology is the basis for the creation of a new instrument of action

at the level of the institutionalized functioning of the circular economy. From the examination of the specialized literature we can see the existence of some concerns in the field of reporting the production of molded parts to the requirements of the circular economy. It is worth noting, in this context, the methodology for assessing the tendencies in the manufacturing of molded parts from the perspective of the circular economy [1]. At the same time, at the level of the practical actions, the report of studies and researches on the consolidation of the circular economy through projects of increased exploitation of the industrial products by the participation of six Centers Techniques Industriels from France, which reminds that starting within the year 1997, started the incorporation of the spent foundry mixture into building materials [2]. Institutionally, there is a tendency to materialize procedures for determining the material cycle in an economy [3]. Examples of economic and social structures are presented at the level of the trajectories of enterprises in achieving the objectives of the circular economy [4]. An institutional synthesis of the institutional developments for the promotion of the circular economy highlights the constituent elements of the circular economy that have the vocation to be directly integrated into government actions [5]. Also, the circular economy institutionalization is characterized by the annual report of the circular economy in the competition for resources [6] and the typological construction of the regional programs of the circular economy for mobilizing resources and minimizing the losses through the innovative regional economy [7]. Historically, given the authors' concerns and concerns, we want to present two Romanian landmarks related to certain stages of the economy. Thus, in the "Wire Industry Survey SA" published in 1938, it is formulated in a modem manner for those times, comparable to those present at present, “If iron and steel have gained more and more utilization, facilitating light and solid constructions, while the spread of known warehouses to date is limited. The need for iron and steel increases to a greater extent than the reuse of old iron can help us. Other means of saving have been sought, being found in: suitable methods for executing a thing with minimal material expense; Constructive forms appropriate to the demands and qualities of the materials; Raising steel by adding other metals to increase its strength; Protection against acids and humidity. ... The exhibition (Dusseldorf Exhibition of 1937) aims to show that old things have an appreciable economic value, and they can serve to manufacture new objects, and thus have a raw material character. ... Thus, in the case of scrap iron, it shows how to sort, cut large pieces, press in packs, which are then taken to the high furnace where they are mixed with iron ore to be rebuilt in cast iron or sent to the Martin or Electric steel for the production of steel, saving up to 80 % of the ore. The process is also applied for a long time and in our country (Romania), with the electric furnace in operation at the Turda Plain plant, it brings its contribution, using all those scrap iron that remain after the lamination of the wires and its other sections." [8]. At theoretical level [9] This prefigures smartly and realistically "the need to establish the institutional framework given by the defined convergences of public policies, juristic regulations, technical solutions and economic and financial ones in the sense of ensuring sustainable development.” [10].

2 General considerations regarding the institutionalization of the circular economy.

Below are some elements of Professor Vasile Soporan's synthesis on the institutionalization of the circular economy [11]. It presents the following elements of the analysis made for the institutionalization of the circular economy: triggering mechanisms for the development of the circular economy; Motivation for "circular economy institutionalization"; The values at which the circular economy is reported; The conditionalities envisaged from the perspective of the circular economy; The concept of circular economy; The fields of action of the circular economy; Specific approaches to "circular economy institutionalization"; The questions necessary to substantiate the "engineering of the circular economy institutionalization".

The triggering of the mechanisms for the development of the circular economy took into account the following: institutional reporting to the continuity of the three states: the past, the present and the future; The existence or perception of discontinuities by their emphasis by Marc Halevy [12] presents the following forms: ecological discontinuities, informational discontinuities, organizational discontinuities, economic discontinuities and discontinuities of the meaning of life; Individual

awareness of needs and development materializes in the community space, in its specific forms, at the philosophical, theological-religious, political, economic level, from the perspective of the rejection of the order of nature triggered by the political order, the social order, the religious order and the military order, Some economic-social structure, trying to optimize the balance of division and hierarchy between the close and the enemy.

The motivation for "circular economy institutionalization" is based on the functioning of the whole by the synergistic cumulation of actions designed and developed cumulatively at the level of actions of four levels already mentioned in the presentation.

Circular economy reporting takes into account that the material, product or service has an expression at the following values: the functional value; material value, energy value, environmental value and social value. Correct assessment should take into account the considerations considered in the design of a shaped material, product or service: conditionalities of functionality, safety conditions, machining conditions, environmental conditioning, durability conditioning and conditioning disposal at the end of the life cycle.

The concept of circular economy used is based on Vincez Aurez et Laurent Georgeault's wording: "The circular economy is a principle of economic organization that aims at systematically reducing the amount of raw materials and energy on the whole of a product or service life cycle and at all levels of organization of a society, in order to ensure the protection of biodiversity and the proper development of individuals. At an institutional level, the circular economy consists of three areas of action with seven orientation axes: D1 - waste management (A11 - waste recycling axis); D2 - economic supply field (A21 - sustainable provisioning axis, A22 – eco-concept axis, A23 - industrial and territorial ecology axis, A24 - functional economy axis); D3 - the daily consumption area (A31 - the length of service life, A32 - the responsible consumption generation axis) "[13].

The specific approaches to the "engineering of the circular economy institutionalization" are proposed to be carried out as follows: addressing the issue (specific status and issues, state of the public policies, regulatory framework, technical and procedural solutions, financial solutions and financial instruments); Institutionalization of processes (defining the actors of institutionally regulated processes, institutions, institutionalized instruments, institutional actions, taxation and institutionalized financing); The technical solution of the problem; Financial settlement of the problem.

3 Particularities of the production of molded parts from the perspective of the circular economy

From the perspective of the circular economy, the particularities of casting production concern the following aspects, presented in the seminar "Situation of the production of molded parts in Romania and the needs for structuring the vocational training" [14]: the evolution of production of castings at global level (2000-2015); The structure of the production of molded parts, with specifications in the year 2015; The economic status of casting producers; The specific investment made by molded cast makers, exemplifying the situation in 2015; The average production of industrial establishments, with examples at the level of the first 10 producers of castings and Romania; The share of the casting production in the specific technologies for putting into operation the material for machine building; Global institutional conclusions on the issues faced by molded cast producers; The motivation for the sustainable production of molded parts from the perspective of circular economy; The conditionality of the research activities at the manufacturing stage of castings.

Evolution of casting production is presented using the World Casting Production annual reports published by WFO and published in December of each year in Modern Casting [15] and a cumulative synthetic report of WFO [17].

From the analysis of the mentioned WFO reports, the global institutional conclusions on the issues faced by the producers of castings in the last half century show: the transition from the "linear economy" to the "circular economy"; The emergence of conditions for the use of material resources; Conditions for the use of energy resources; Imposing conditioning on health and the environment; The need for intelligent use of complex computerized processes or adaptation to the requirements of the "digital

agenda"; The influence of sophisticated complex processes at the global market (instability by de-globalization); Diversification of use areas for castings made by casting; Increasing characteristics and requirements in operation; Increasing competition from materials and manufacturing technologies for shaped products.

The motivation for the sustainable production of castings from the perspective of the cyclical economy is determined by the quantitative importance of molded parts, which exceeded 100 million tons, the significant consumption of resources needed for their production, the impact processes generate on the environment and the fact that hazardous substances are used to a significant extent, and generated waste also falls into this category. From the perspective of the presented ones, it is clear that this branch of industry is suitable for analysis from the perspective of the circular economy. The position is supported by the fact that the serviced fields are of a special complexity, aiming at a deployment from the automotive industry to nuclear power. Therefore, the European document "Towards a Circular Economy: zero waste program for Europe" [15] finds an appropriate field of application in the casting industry, at least through the design and innovation approaches for a circular economy: "Reducing the amount of material needed to perform a particular service (easy load); Extending product life (sustainability); Reducing the use of energy and materials in the production and use phases (efficiency); Reducing the use of hazardous materials or difficult to recycle in products and production processes (substitution); The creation of outlets for secondary (recycled) raw materials (based on standard, public procurement, etc.); Designing products that are easier to maintain, repair, upgrade, re-fabricate or recycle (eco-design); The development of services that consumers need in this regard (maintenance / repair services etc); Stimulating and supporting waste reduction and quality separation activities by consumers; Stimulating separation and collection systems that minimize the costs of recycling and reuse; Facilitating the grouping of activities to prevent the transformation of by-products (industrial symbiosis) into waste and encouraging the extension and improvement of the consumer choice through rental, loan or exchange of services as an alternative to the holding of products, At the same time, the interests of consumers in terms of costs, protection, information, contractual clauses, insurance aspects etc. "[16].

It is therefore appreciated that the research activities at the manufacturing of casting parts also concern the issue of the development of the circular economy through the conditions that impinge upon it. Thus, the field of casting production, even if it is one of the oldest technological processes for putting metal materials in their functional form, and not only them, requires a permanent connection to the conditions of the socio-economic activities. The major needs of innovation in this area can be grouped into two levels: the level of technical and technological innovation and the level of change in the way markets are approached. From a pragmatic point of view, at the level of actors present in the production of cast pieces, the rules of survival and development make for the substantial collaborative dynamics between the information and the actions carried out.

Starting from the objective of the paper and in view of the activities carried out within the Technical University of Cluj-Napoca, in the last years, from a multidisciplinary perspective, we consider the following topics addressed in the context of the eco-responsibility needs: research on the design and functioning of “Collaborative Entrepreneurial Platform” in casting industry as a virtual action tool; production of molded parts in terms of digital communication requirements in the virtual space; research on the development of the methodology for assessing the tendencies in the production of castings from the perspective of the circular economy; contributions to the determination of the “unnecessary part” generated in the manufacturing processes of the molded parts and determination of the solutions for increasing its usefulness from the perspective of the circular economy; research on the optimization and digitization of institutional waste audit procedures under the conditions of casting production; research on the use of "Life Cycle Analysis - ACV" in the hierarchy of manufacturing processes of molded parts at the level of provision of conditions related to the provision of sustainable development; researches on the use of "critical thinking" in the manufacturing of molded parts; optimization of engineering training systems in the manufacturing of molded parts through an AHP (Analytical Hierarchy Process) hierarchy at the level of transversal and professional skills; rewriting casting manufacturing processes from the perspective of using fast prototyping and 3D printing capabilities. Grouped in one major theme, the

issue mentioned at the research level could be titled: "Engineering of the Institutionalization of the Economy in the Manufacturing of Molded Pieces".

4 Considerations on the Model Approach for the Manufacturing of Castings from the Circular Economy perspective

Following the analysis of the casting approach variants, a method has been used that is structured on the schematic representations of Figure 1.

The criteria for evaluating public policies and the regulatory framework from a cyclical economy perspective take into account the incidents that can be created at the economic, environmental, social and administrative levels. The economic incidence is based on the following criteria: the financial viability of measures to promote the circular economy; the possibility of economic development; the possibility of partnering. Impacts related to environmental protection are assessed in terms of the following criteria: the possibility of reducing the environmental impact; the possibility of waste reduction at source; creating a global environmental advantage. Social incidents are appreciated by the following criteria: acceptance of solutions offered to the public and stakeholders; the absence of risks with negative side-effects other than those related to environmental protection. Administrative impacts are measurable according to the following criteria: conformity assurance; ease of office; ease of administration; the measurable character of the processes through administrative formulas.

The evaluation of economic instruments that promote the circular economy at the manufacturing stage of castings is based on a set of indicators of appreciation of the effect of production on the environment: energy efficiency; the content of recycled materials at the process level; recyclability of the product at the end of its life cycle; water resource economy; conserving resources through process deployment; GHG emission at production level; measures to prevent waste in the manufacturing process; the percentage of renewable materials used in manufacturing; the negative effects of the manufacturing process on workers, animals, plants, air, water and soil; the content of toxic material in the casting process; the quantities of packaging used in the manufacturing process; transport distances carried out in the manufacturing and dispatching of cast parts; facilitating repairs and refurbishment of castings; managing the castings at the end of the life cycle. From the perspective of the significance of the indicators presented, the economic instruments used for the promotion of the circular economy have the following expression: green (ecological) supply; additional usage fees for the resources used; consignment systems for technological infrastructure usable in manufacturing processes; waste management incentive systems for the production of molded parts from a circular economy perspective; recycling of the solid waste generated; application of the principle the user pays; obtaining credits for greenhouse gas reduction situations; application of the wider producer responsibility.

The analysis of the technological and procedural processes used from the perspective of the circular economy and the functioning of the economic instruments for the promotion of the circular economy represent the most important area in the evaluation of the resources that can be used to achieve the objectives of the circular economy. The stages of the manufacturing process under consideration are: the analysis of the specific information that influences the field (market analysis, the analysis of the regulations influencing the production of castings, the analysis of the processes evolution and of the technological infrastructure); analysis of production preparation from the point of view of the available technologies and technological infrastructure (analysis of constructive design, analysis of technological design, analysis of the technological manufacturing preparation); analysis of the casting process (analysis of direct activities, analysis of indirect activities); analysis of the results of the manufacturing process (the stage of the analysis of the useful part of the manufacturing process - the cast parts delivered to the unproductive parts resulting from the manufacturing process, the unpleasant parts resulting from the manufacturing process); life cycle exploitation and disposal (re-use of molded parts, recycling of waste parts, waste management); analysis of other phases that contribute to casting (analysis of the production and distribution of utilities, analysis of other phases of the process); process analysis at the level of the whole from the perspective of compliance with environmental conditions and sustainable development (pollution intensity, quantification of specific energy consumption per unit of product,

other consumption per product unit, waste generated per unit of unit, consumption of recycled material introduced on the production process at the product unit, consumption of recycled material introduced into the production process on the product stream, energy consumption recovered in the casting process). Within this activity, the stages of the manufacturing process of casting together with the measures envisaged to achieve the objectives of the circular economy are presented in Table 1.

Table 1. The stages of the casting process and the measures projected to achieve the circular economy (selection of points in the analysis carried out).

No.	Step or stage of the technological process	Specific measures projected in terms of circular economy
1	1. Analysis of influencing specific information field; 1.1. Market analysis and influencing factors; 1.1.1. Analyze developments beneficiaries castings	Quantification main user industry castings and competing technological procedures, such as mechanical construction welded or processed commodity plastics.
2	1. Analysis of influencing specific information field; 1.3. Analysis of the evolution of processes and technological infrastructure; 1.3.1. Making process analysis and modification	Reducing energy consumption and materials in the process of developing specific product unit. Increasing the use of recycled materials specific process for obtaining the castings. Avoiding placing in the batch composition of the elements that hinder the recycling process of castings at the end of their life cycle. Avoiding substances that generate hazardous waste generated at the level that causes a reduction in the possible use specific circular economy.
3	1. Analysis of influencing specific information field; 1.3. Analysis of the evolution of processes and technological infrastructure;1.3.3. Analysis of the casting process	Loss of material and energy decrease occurring during the casting process through the use of technology and infrastructure. Organization of the technological process by developing opportunities for recovery and reintroduction technological flow generated losses.
4	2. Analysis of manufacturing preparation in terms of technology and technological infrastructure available; 2.1. constructive concept analysis; 2.1.1. Management tools for computer aided design	Development information tools that generate constructive forms-based functional and management of databases on constructive changes made in technological contexts data.
5	2. Analysis of manufacturing preparation in terms of technology and technological infrastructure available; 2.2. Analysis of technological design; 2.2.1. Solidification by correlation analysis and optimization feeder system, the cooling of constructive typologies designed	Development of software for computer aided design of solidification process, which, based on models created to perform a specific consumption optimization in the construction of the assembly molding technology.
6	2. Analysis of manufacturing preparation in terms of technology and technological infrastructure available; 2.2. Analysis of technological design; 2.2.2. Analysis of the cooling process and design optimization from the point of view of stresses which are formed in the casting pieces	Development of software for computer aided design of castings cooling process, which, based on models created to achieve constructive forms of optimization in order to reduce the destructive effects of stress that develops in the alloy mass.
7	2. Analysis of manufacturing preparation in terms of technology and technological infrastructure available; 2.2. Analysis of technological design; 2.2.3. Optimization of the technological constructivism alloy	Development of operational design software, computer aided process for obtaining castings, usable in the offices of study and analysis technology with current practice in the analyze domain

	composition, the casting characteristics of the shape and conditions of casting	
8	2. Analysis of manufacturing preparation in terms of technology and technological infrastructure available; 2.3. Technological preparation of production analysis; 2.3.1. Selection, analysis and optimization of process flow steps	Developing technological analyzes aimed at enhancing technology flows, whole, and in terms of aspects related to the context of developing circular economy, instead of the dominant linear development lately. The analysis in this respect, it is necessary to achieve each stage of the technological process. The analysis of development in the context of circular economy are essential.
9	2. Analysis of manufacturing preparation in terms of technology and technological infrastructure available; 2.3. Technological preparation of production analysis; 2.3.2. Choice or imposition technological infrastructure needed for the process flow steps	Development and analysis of infrastructure technologies used in terms of capacity development to protect the environment, conditions of employment and sustainable development. In this context, the quantification of the effects on the development of circular economy.
10	5. Analysis of exploitation and disposal at end of life; 5.1. Reuse of casting pieces; 5.1.1. Management components with the potential to be recycled	Organizing recycling flows in the castings at end of life on typology and alloys constituting, aiming to avoid the inclusion of parts which by their composition affects the ability to reintroduce the productive flows, especially in the materials increased sensitivity to compositional and structural changes.
11	5. Analysis of exploitation and disposal at end of life; 5.1. Reuse of casting pieces; 5.1.1. Management components with the potential to be recycled	Organizing recycling flows in the castings at end of life on typology and alloys constituting, aiming to avoid the inclusion of parts which by their composition affects the ability to reintroduce the productive flows, especially in the materials increased sensitivity to compositional and structural changes.
12	5. Analysis of exploitation and disposal at end of life; 5.1. Reuse of casting pieces; 5.1.2. Developing technologies reconditioning castings	Development of recycling technologies massive and complex parts to increase their lifespan.
13	5. Analysis of exploitation and disposal at end of life; 5.1. Reuse of casting pieces; 5.1.3. Development alloys typing parts and castings to ensure interchangeability and linking overall constructive on this criterion	Conducting an active database on typing and alloy parts to ensure their interchangeability conditions at constructive solutions used.
14	5. Analysis of exploitation and disposal at end of life; 5.2. Recycling of worn parts; 5.2.1. Establishment of collection systems based on flow assurance criteria ensuring recycling	The development of circular economy principles collection systems for the purposes of efficient use of resources with potential for use in the production of castings.
15	5. Analysis of exploitation and disposal at end of life; 5.2. Recycling of worn parts; 5.2.2. The development of circular economy principles collection systems for the purposes of efficient use of resources with potential for use in the production of castings.	Develop training techniques recycled materials production of castings, especially for sorting, crushing and quality assurance charging materials and establishment of training centers castings materials industry.
16	5. Analysis of exploitation and disposal at end of life; 5.2. Recycling of worn parts; 5.2.3. Market promotion of recycled materials for competitive production of castings	Using institutional regulations and financial instruments to stimulate the market for recycled materials used or generated castings industry.
17	5. Analysis of exploitation and disposal at end of life; 5.3. Waste management; .3.1. Charging heredity material management;	Development activities quantify the impact that it may have to introduce new elements in the alloy

		formation, in addition to improving the assessment characteristics.
18	5. Analysis of exploitation and disposal at end of life; 5.3. Waste management; 5.3.2. Application of the principles of extended producer responsibility in relation castings	Using the principles of extended producer responsibility in the global management of production processes castings, meaning thinking from the very beginning of their elimination at the end of their life cycle.
19	5. Analysis of exploitation and disposal at end of life; 5.3. Waste management; 5.3.3. Management of historical industrial dumps and landfills specific manufacturing processes tuned parts	Development of material recovery potential of industrial dumps and new landfills generated in manufacturing of castings.
20	6. Analysis of other phases contributing to the cast pieces; 6.1. Analyze production and distribution utilities; 6.1.1. Analysis of water resources	Managing the environmental principles of circular economy and water resources used.
21	6. Analysis of other phases contributing to the cast pieces; 6.1. Analyze production and distribution utilities; 6.1.2. Analysis of energy	Managing the environmental principles of circular economy and energy resources to increase their efficiency.
22	6. Analysis of other phases contributing to the cast pieces; 6.1. Analyze production and distribution utilities; 6.1.3. Analysis of production and distribution of compressed air	Managing the environmental principles of circular economy and the activities of production and distribution of compressed air.

5 The need to design the collaborative entrepreneurial platform for the durable manufacture of "PAC – FDPT" castings

Given the complexity of the issues that arise in the transition of the manufacture of castings from the linear economy to the objectives of the circular economy, the fundamental proposal that has been developed since 2013 [17] is related to the construction of an entrepreneurial platform to solve the issue proposed and set forth.

The entrepreneurial approach of global factors of influence to the requirements of the manufacturing castings from the perspective of small-sized companies and the conditions imposed by an increasingly globalised market. The platform is a portal that can bring together the well-defined partners of a community, but also the outsiders, who try out the private offers and requests for information, advice, design, processing, services, promotion, sales, etc. within a virtual space, in a given social and economic context, aiming at concluding some transactions.

The "PAC – FDPT" missions are expressed as follows: direct virtual business relationship between the members of the platform; strengthening the presence of small-sized companies on the global market; supporting a strategic concept such as the development of a specific market of materials and the economic development of a particular geographical area; serving an extended and associative economic entity among several economic stakeholders organised into clusters, development centres or agencies; analysing the offers and requests of the participants and the economic stakeholders; ensuring their structuring on different criteria: formal qualification, competence, specific activity, medium-term development intent; demand and supply consolidation, which involves: aggregating data on the demand and supply of internal markets of organisations, assessing the critical level from which they are relevant, aggregating the relevant supply and demand by material / symbolic relationships between the participants who generated it; participation in the virtual economy, meaning that once consolidated, the demand and supply are exposed to the global virtual marketplace with a view to concluding transactions with external partners; business intermediation for the benefit of its members and partners; mediating demand and supply, by ensuring interconnection with the participants within the virtual pole established; operation according to the "business incubator" principle by starting up businesses (start-ups) through assistance, advice, training; supporting the launch of innovative projects and their development with the

help of the virtual environment; managing the creative potential and the science of making it available at the level of the social network created, at the level of mentors, trainers and trainees; developing a stronger demand and offer for a much stronger global market presence; achieving an effective platform to support the Romanian inclusion and consolidation markets and their alignment with the requirements of global markets.

The "PAC – FPT" architecture features the following elements: "PAC - FPT – PS" static platform and "PAC - FPT – PD" dynamic platform. The attributes of the static platform "PAC-FPT-PS" are shown in Figure 2, and the components of the dynamic "PAC-FPT-PD" platform in Figure 3.

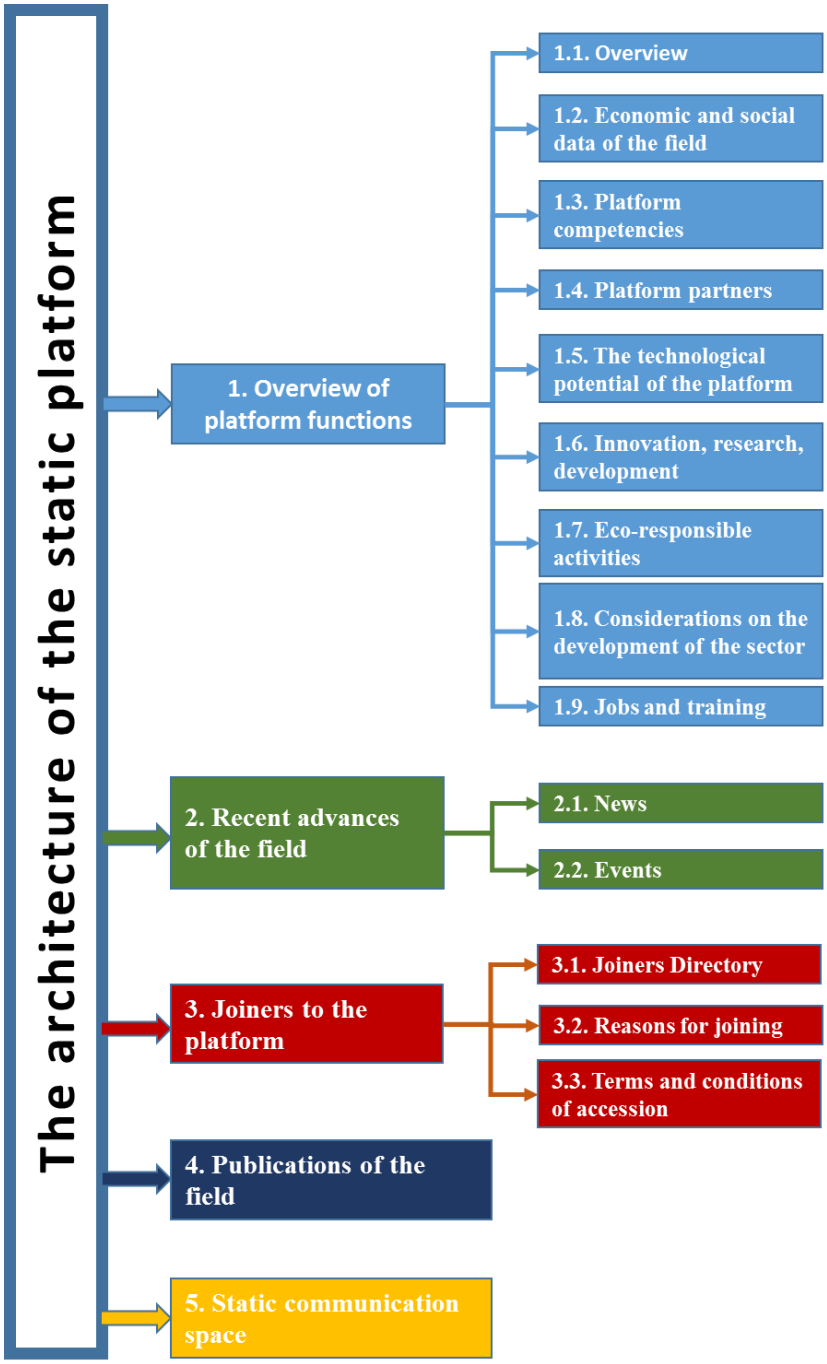

Figure 2. Schematic of static platform attributes "PAC-FPT-PS"

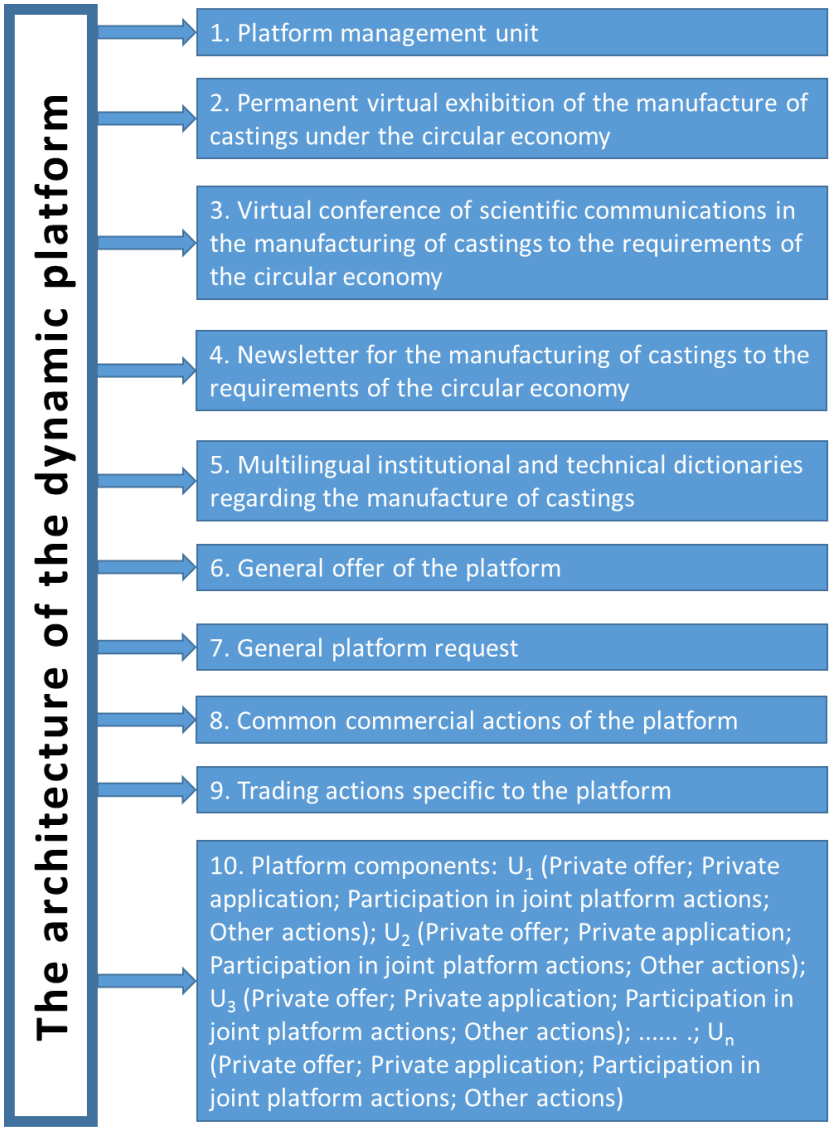

Figure 3. Schematic of dynamic platform components

The "PAC - FPT – PS" instruments aim the following aspects: 1. Theoretical aspects regarding the manufacturing of castings under the circular economy; 2. The current situation of the manufacturing of castings with respect to the observance of the rules of the circular economy; 3. Mechanisms of functioning of the castings market in terms of circular economy; 4. Circular economy tools adapted to the manufacture of castings; 5. Public policies regarding the manufacture of castings under the circular economy; 6. Regulatory framework for the manufacture of castings under the circular economy; 7. Technical and technological solutions for ensuring the manufacture of castings under the circular economy; 8. Funding solutions and financial instruments for ensuring the manufacture of castings under the circular economy; 9. Examples of good practice and branches for the manufacture of castings under the cyclical economy; 10. The stakeholders of the manufacturing process of castings under the circular economy (level of action: local, regional, national, European and global): 10.1. Castings manufacturers: 10.1.1. Ferrous alloys: 10.1.1.1. Cast iron (a. Grey and alloy cast iron; b. Nodular graphite cast iron; c. Malleable cast iron; d. Special cast iron and other types of cast iron); 10.1.1.2. Steels (Carbon steels; Alloyed steels; Special steels and other types of steels); 10.1.2. Non-ferrous alloys: 10.1.2.1. Copper-

based alloys; 10.1.2.2. Aluminium alloys; 10.1.2.3. Magnesium alloys; 10.1.2.4. Zinc alloys; 10.1.2.5. Other types of non-ferrous alloys); 10.2. Suppliers: 10.2.1. Suppliers of raw materials for the casting industry; 10.2.2. Suppliers of equipment for the casting industry; 10.2.3. Providers of service and computer products for the casting industry; 10.2.4. Consultancy and technical and managerial assistance service providers for the manufacture of castings; 10.2.5. Service providers specific to the circular economy; 10.2.6. Providers of educational and training services; 10.2.7. Intermediary service providers in the manufacture of castings; 10.2.8. Media, advertising and virtual media service providers; 10.3. Units of scientific and technological research in the manufacture of castings adapted to the requirements of the circular economy; 10.4. Socio-professional and scientific associations; 10.5. Public regulation, implementation and monitoring authorities; 10.6. Banking units and investment funds for the manufacture of castings under the circular economy; 10.7. Units for managing institutional funds (local, national, European) that relate to the manufacture of castings under the circular economy; 10.8. Beneficiaries of castings manufacturing; 11. Events in the manufacturing of castings with respect to the requirements of the circular economy: 11.1. Fairs and exhibitions relating to the manufacture of castings; 11.2. Congresses and conferences; 11.3. Seminars; 11.4. Other events; 12. The issue of the manufacture of castings from the perspective of the circular economy; 13. Publications on the manufacture of castings from the perspective of the circular economy: 13.1. Specialty books; 13.2. Specialty magazines; 13.3. Doctoral theses; 13.4. Institutional reports; 13.5. Product catalogues; 13.6. Collection of public policies and regulations; 13.7. Virtual media for information dissemination.

6 Conclusions

The present paper emphasizes the importance of the transition process of the castings manufacturing from the modalities of carrying out the transition from ”linear economy” to the ”circular economy”. At the same time, this paper, which aims to continue the work presented in recent years, presents a methodology of ensuring that processes are carried out at the level of the objectives of the circular economy. Within this framework, from the perspective of the circular economy, the following stages are followed (the process is generalized, with the potential to develop in other productive domains as well): analysis of the domain specific information according to the principles of economic intelligence; analysis of manufacturing preparation in terms of technology and technological infrastructure available; analysis of the castings manufacturing process; analysis of the results of the manufacturing process; analysis of the exploitation of castings and their elimination at the end of the life cycle; analysis of the other phases that contribute to casting; process analysis at general level from the perspective of compliance with environmental conditions and sustainable development. Considering the complexity of the productive field, related to the market requirements from the perspective of the circular economy, the importance of the position of the actors present in the process is emphasized: the uses of castings, the beneficiary of castings, their producer and the supplier of the materials and the energy resources used. The method of analysis regarding the achievement of the objectives of the circular economy included encompassing and quantifying the effects of the process from the perspective of sustainable development and environmental protection through the evaluation indicators: consumption of material per unit of product, energy consumption per unit of product; the effects on the product unit created on the environment; generation of by-products per unit of product; generation of by-products on the total unused portion produced; generation of waste per unit of product; generation of recycled materials per unit of product and on the generated unused part; the share of recycled materials on the life cycle of castings with direct use on the life cycle of cast parts with direct use on the casting stream; the share of recycled materials on other technological flows; the share of recycled materials generated by other technological fluxes used in the casting process; the share of energy recovered at the level of the technological flow with direct use; the share of recovered energy delivered to other beneficiaries; the social and environmental effects that they create. Regarding the perspective of the procedures and indicators, the importance of introducing digitization at the level of casting manufacturing through the collaborative entrepreneurial platform is emphasized.

7 References

[1] Soporan V F, Crișan M, Lehene T and Pop A L, 2016 *IOP Conf. Ser.: Mater. Sci. Eng.* **133** 012063
[2] Petitpain M 2014 *Economie circulaire: Projet valorification croisees de co-produits industriels* (Epernon: Cerib. Etudes et Recherches)
[3] Ghewy X, Paquier J L, Gregoire P, Gicquiaux C and Louis H 2013 *Le cycle des matieres dans l'economie francais* (Paris: Commissariat general au developpement durable Service de l'observation et des statistique)
[4] AFEP 2017 *Trajectoires economie circulaire. 33 entreprises se mobilisent avec 100 engagements* (Paris : Association francaise des entreprises privees – afep)
[5] Perret B 2014 *L'economie circulaire, etat des lieux et perspectives. Raport n° 009548-06* (Paris: CGEDD – Conseil General de l'Environnement et du Developrpement Durable)
[6] Valerian F 2014 *L'economie circulaire, ou la competition pour les ressources. Etude annuelle 2014* (Paris: Conseil General de l'Economie, Ministere de l'Economie de l'Industrie et du Numerique)
[7] be circular be.brussels 2016 Programme regional en economie circulaire 2016-2020. Mobiliser les ressources et minimiser les richesses perdue: pour une economie regionale inivante. Be circular be.brussels, Mars 2016.
[8] Diamant I 1938 *Buletinul de studii Industria Sârmei S.A. octombrie 1938* (Cluj: Industria Sarmei SA)
[9] Georgescu-Roegen N 1995 *Le decroissance. Entropie – Ecologie – Economie* (Paris: Edition sang de la terre)
[10] Soporan VF 2015 *Universitatea, ecoantreprenoriatul și dezvoltarea comunităților* (Cluj-Napoca: Pro Ecologic Concept 188-189)
[11] Soporan V F 2016 *Ingineria instituționalizării economiei circulare – notițe de curs* (Cluj-Napoca: Univeristatea Tehnică din Cluj-Napoca)
[12] Halevy M 2015 *Les grandes mutations économiques: comment s'y adapter* (Bordeaux: Centre Entreprise et Communication Avancee Université Hommes-Entreprises Sens et Croissance 5-10)
[13] Aurez V and Georgeault L 2016 *Economie circulaire. Systeme economique et finitude de ressources* (Louvain-la- Neuve: De Boeck Superieur 115)
[14] Soporan V F 2017 *Situația fabricației pieselor turnate și instituționalizarea formării profesionale în România și la nivel global* (Cluj-Napoca: Universitatea Tehnică din Cluj-Napoca Seminarul "Situația fabricației pieselor turnate în România și nevoile de structurare a formării profesionale")
[15] Comisia Europeană 2014 *Comunicare a Comisiei către Parlamentul European, Consiliu, Comitetul Economic și Social și Comitetul regiunilor: Spre o economie circulară: un program "deșeuri zero" pentru Europa"*, (Bruxelles: COM(2014) 398 final/2)
[16] Comisia Europeană 2014 *Comunicare a Comisiei către Parlamentul European, Consiliu, Comitetul Economic și Social și Comitetul regiunilor: Spre o economie circulară: un program "deșeuri zero" pentru Europa"* (Bruxelles: COM(2014) 398 final/2 4-5)
[17] Vescan M M 2016 *Studii și cercetări cu privire la comunicarea virtuală specifică fabricației pieselor turnate din perspectiva economiei circulare* (Cluj-Napoca: Universitatea Tehnicdin Cluj-Napoca Referat teză de doctorat)