



# MODEL MAP OF THE PROCESS OF IMPLEMENTING A NEW PLATINUM RECOVERY TECHNOLOGY FROM USED CAR CATALYSTS ON THE DOMESTIC MARKET

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**ABSTRACT**

The development of industry as well as competition and globalization entail the necessity to use new technologies, which largely affect the competitive advantage of enterprises. Analysis of the implementation process of new or modified technology is difficult to conduct due to the cost of the process, its complexity and the rate of changes on the global market in the field of implemented technological innovations. The paper presents an example map of implementation and organization of platinum recovery from used car catalysts in Poland, taking into account the expectations of participants in various segments of the car recycling network. During the construction of the map, the technical parameters were also taken into consideration, apart from economic and technological parameters. The proposed map consisted of several stages: technology project, market research, technology preparation, acquiring entities that taking over the technology, launch of technology, and sale and distribution of the product. The individual stages have been characterized in the aspect of technology of platinum recovery from used car catalysts. The number of these stages, however, depends on the situation on the market of end-of-life vehicles and interested economic entities forming the structure of the platinum recovery network. The publication is the basis for further discussion on the creation of a platinum recovery network (missing in Poland) from car catalysts.

**KEYWORDS**

new technology, process map, car market, platinum recovery.

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## 1. Introduction

A key determinant of building a competitive advantage is the implementation of new technologies. Changes occurring in the business environment of enterprises, defined as dynamic or permanent, determine the implementation of changes in the technology of manufacturing products and their recycling, as well as in the service of production processes. In the situation of the growing demand for innovative technologies and the broad market of technologies trading, it is of great importance the issue of a thorough analysis of technology, which should replace the one used so far. Full and comprehensive analysis of the implementation project of the new technology is multifaceted, due to the complexity of problems that should be analyzed, e.g. real and potential (predicted) costs in various types of systems, including the purchase of patents, licenses, and investment costs (development or modernization of a fixed asset, workplace costs, labor safety costs, environmental protection costs) [1, 16]. At the stage of analysis, various methods of assessing the implemented

investment project are applied. They are both quantitative and qualitative methods [4]. It should be emphasized that the rate of technological changes in the global market is very fast and therefore a higher investment risk is occurring. Thus, it is necessary to use specific systems and tools, thanks to which investments in research and development, infrastructure and employee qualifications will be adapted to current as well as future market and industrial needs [12, 13]. Various management methods and design tools based on a process approach can be used to implement innovative solutions. One of the tools used in the process approach are maps of processes. They are a graphical presentation of the activities and links between them and the overall model of the selected area of activity [17].

For the purpose of this article, for analysis of the process of implementing new technology in the field of platinum recovery from used car catalysts a mapping process was applied. The above-mentioned technology bases on the washing out the platinum from the catalyst structure using liquid metal as a metal collector.

## 2. Assumptions for working out the map of implementation of platinum recovery technology from catalysts

In the domestic car recycling market, there is no full network structure of entities that would participate in the recovery of platinum from used car catalysts. The network is stripped and formed mainly by entities dealing in the recycling of cars withdrawn from use. Points of car purchase and scrapping run agency of transferring car parts to external entities (most often foreign ones). The car scrapping points themselves do not deal with the recovery of valuable material, which is platinum from used car catalysts. Currently, the processing of used car catalysts in Poland practically not exists, there are only companies dealing in the purchase of used car catalysts and then their export. Attempts are being made to develop a method for their processing in order to run platinum recovery plants in Poland, mainly due to the high price of platinum (1 kg of platinum costs 23,068.17€) [14]. One of such methods is the patented technology of washing out platinum from the catalyst structure using liquid metals as metal collector and magneto-hydro-dynamic (mhd) pump, developed by scientists from the Silesian University of Technology (Patent No. 221118, filed on 19/03/2015) [7].

Process mapping is one of the basic stages of successful implementation of technologies of platinum recovery from car catalysts (using above-mentioned method) in the existing recycling network of cars withdrawn from use. This approach includes specifying the most important aspects of technology implementation, such as:

- description of the market in which the technology will be implemented and entities in this market,
- specification and characteristics of activities related to the launch of new technology,
- assigning appropriate organizations and/or executive positions for realization of individual stages during the technology implementation,
- definition of functional and legal requirements for entities involved in the technology implementation.

The map is a peculiar way of proceeding, enabling the elements at the entrance to the process to be transformed into elements at the exit. The process in this case is the recovery of platinum from used car catalysts by washing out platinum from the catalyst structure using liquid metals and magneto-hydro-dynamic pump. Figure 1 presents a map of this process.

The innovative solution is based on placing the catalyst carrier from the used car catalyst in liquid metal (lead), which is circulating in a closed cycle due to applying magneto-hydro-dynamic pump. As a consequence platinum is washed out from catalyst channels due to the use of a rotating electromagnetic field (see Fig. 2). The continuous flow of metal is essential, it enables to eliminate low efficiency, what happens in case of single washing. Compared to the traditionally used methods of platinum recovery (hydrometal-

lurgical using aqua regia or pyrometallurgical such as metal collector), the proposed solution allows to apply a lower process temperature and leads to an increase in platinum concentration to values that guarantee the profitability of their extraction. Results of laboratory tests indicated that the proposed technology is promising and encourage attempts to develop a network of the treatment of used car catalysts in Poland based on it.

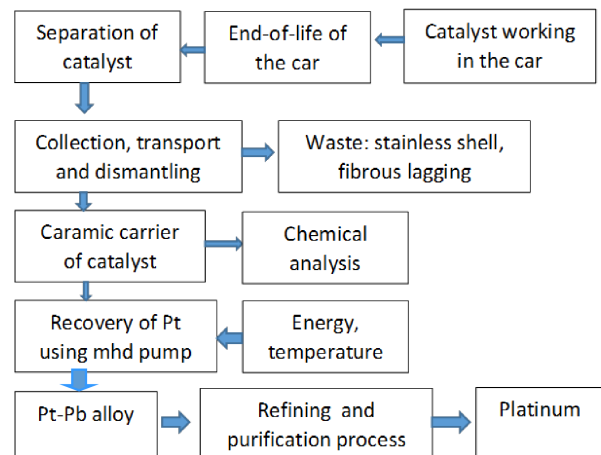


Fig. 1. The map of the recovery of platinum from used car catalysts by washing out platinum from the catalyst structure using liquid metals and mhd pump [6, 22].

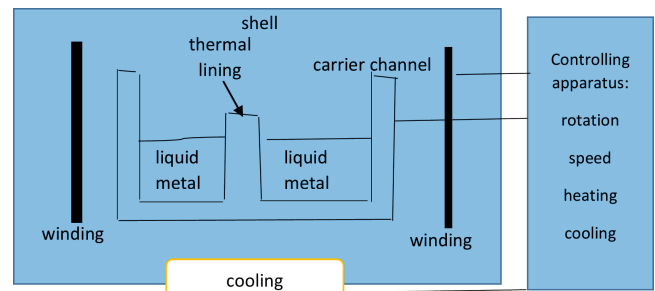


Fig. 2. The scheme of the technology of platinum recovery from used car catalyst basing on modified metal collector method using mhd pump [8, 10].

The implementation of innovative technology (washing out platinum from the carrier of car catalysts using mhd pump) requires the following stages of work to be carried out [2, 21]:

- Activity Definition – determination of research scope (according to client's order) and description of individual stages of implementation of the tested technology, which should be performed within a specified period (it must be realized according to schedule of the investment project).
- Activity Sequencing – establishing and describing the logical relationships between activities in the process of creating a network structure of platinum recovery technologies from used car catalysts.
- Activity Resource Estimating – estimation what resources (employees, equipment, materials) and in what quantities will be necessary in order to carry out determined activities in a technological project.

- Activity Duration Estimating – at this stage information on the scope of work of particular activities, required types of resources and estimated quantities of resources is used.
- Schedule Development – determining the planned start and end dates of activities within a given implementation cycle; it should be also taken into consideration the time schedule and time shifting for certain activities, e.g. during obtaining administrative decisions required by law to conduct a given activity by individual entities.
- Schedule Control with Check Checklist – it is a process of checking the level of work and introducing potential shifts of activities and resources, in order to improve the efficiency of the implementation process.

As part of activities related to the implementation of the new platinum recovery technology and the creation of a network structure of cooperating economic entities it should be identified segments of the market (see Fig. 3), to which this technology will be addressed. Market segmentation means the division of potential users of technology and network participants, thus they are business entities that have similar needs and probably similar business goals [15, 18]. In the process of platinum recovery from used catalyst, the participants of the process are:

- entities dealing with the recycling of vehicles, i.e. collection of end-of-life vehicles and then transferring them to the dismantling station,
- vehicle dismantling stations, which start the process of processing end-of-life vehicles in the following tasks:
  - drying the vehicle,
  - dismantling dangerous elements,
  - dismantling parts and sub-assemblies suitable for further use – recycling of car parts,
  - recovery of materials suitable for further use – recycling of materials;

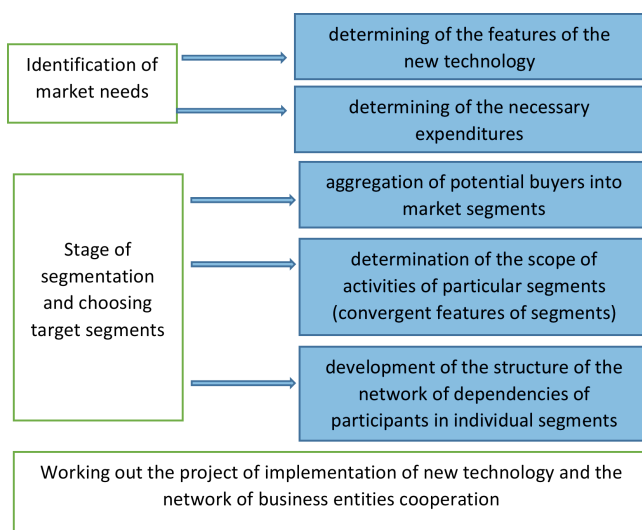


Fig. 3. The process and stages of market segmentation – general approach [15, 22].

- transfer of recovered parts and materials to entities dealing with their re-use or further processing, e.g. to plants carrying out the process of shredding car wrecks and obtaining ferrous metal fraction, non-ferrous metals, light fractions, which are later subjected to segregation and re-use or sales on the market of secondary raw materials.

In developing a map of the platinum recovery process from used catalyst, it could be also taken into account car manufacturers and manufacturers of car parts because their role is to prepare the vehicle and its components for the recycling process already at the design stage, they can also be recipients of parts and materials from secondary recycling. Identification of customer segment of the platinum recovered from car catalysts requires to show the technology features to potential network participants. For this purpose, a QFD (Quality Function Deployment) test was performed. The QFD method means transferring customer requirements to technology concepts. This is achieved by showing the relationship between the design requirements being the input data and the technical requirements of the designed technology [3, 11]. In this method it is important to choose appropriately the team of specialists who know the issues from various areas (both technical and marketing and management). An interdisciplinary team, preferably consisting of 6 to 8 members, should represent key functional groups of the organization in terms of process from the innovation phase to recycling stage [23]. The applied method allowed to combine quality aspects – requirements of customers with technical requirements, conditioning the implementation of a new technology of platinum recovery from used catalysts. During the research, the following aspects and requirements of the implementation of the new technology were taken into account:

- requirements of customers: administrative processes in the scope of obtaining permits to conduct the activity, compatibility between the current infrastructure and the new technological line, small construction costs of the technological line, short period of project implementation, financial assistance of external institutions, access to the market of used catalysts, high process efficiency, small amount of waste, high level of platinum recovery, compliance with environmental standards, sales from platinum alloy,
- technical parameters: e.g. the size of technological line, cost of electric energy, required source of energy and mediums, cost of materials, amount of workers, the level of technological readiness, time of unit working, the daily amount of obtained platinum alloy, amount of metal used to wash out the catalyst carriers, amount of produced waste, health and safety procedures, number of alloy recipient, daily number of catalyst treatment [22].

Then, the correlation of the impact of customer requirements on the processing parameters of the platinum recovery was established. As a result, a corre-

lation matrix was obtained, based on which critical processes (the most important) and then subprocesses and side tasks were identified and they were used to modify the model map including customer satisfaction criterion [22].

### 3. Stages of implementation of platinum recovery technologies from used catalysts – a map of process

The implementation of platinum recovery technology by washing it out from the catalyst carrier using mhd pump is a multi-step process. Figure 4 presents the main activities that should be taken to implement that technology.

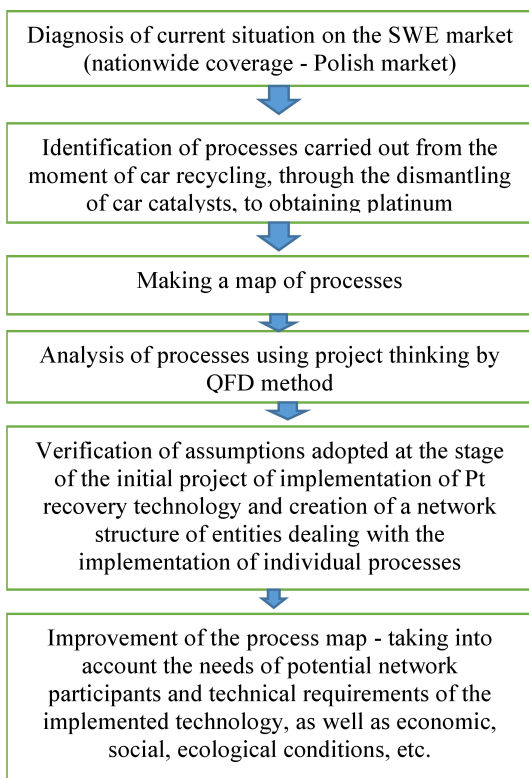


Fig. 4. The stages of implementation of platinum recovery technology by washing it out from the catalyst carrier using mhd pump [22].

The project of platinum recovery from used car catalysts based on the mentioned technology was carried out at the Faculty of Materials Engineering and Metallurgy of the Silesian University of Technology. Work began in 2007 with a project [19] concerning the research about obtaining cements for platinum group metals alloys using metals from treatment of used auto catalyst and was continued in another project [20], whose subject matter was the use of magneto-hydro-dynamic pump for platinum recovery from used car catalysts. As a result, the technology obtained a patent in 2015 and was approved for use. Documentation of the new platinum recovery technology from used catalysts has contributed to further research [6, 22]. As part of further

work, the market was identified, i.e. the identification of economic entities – potential users of new technology. Figure 5 presents a full map of the processes of implementing a new platinum recovery technology from car catalysts.

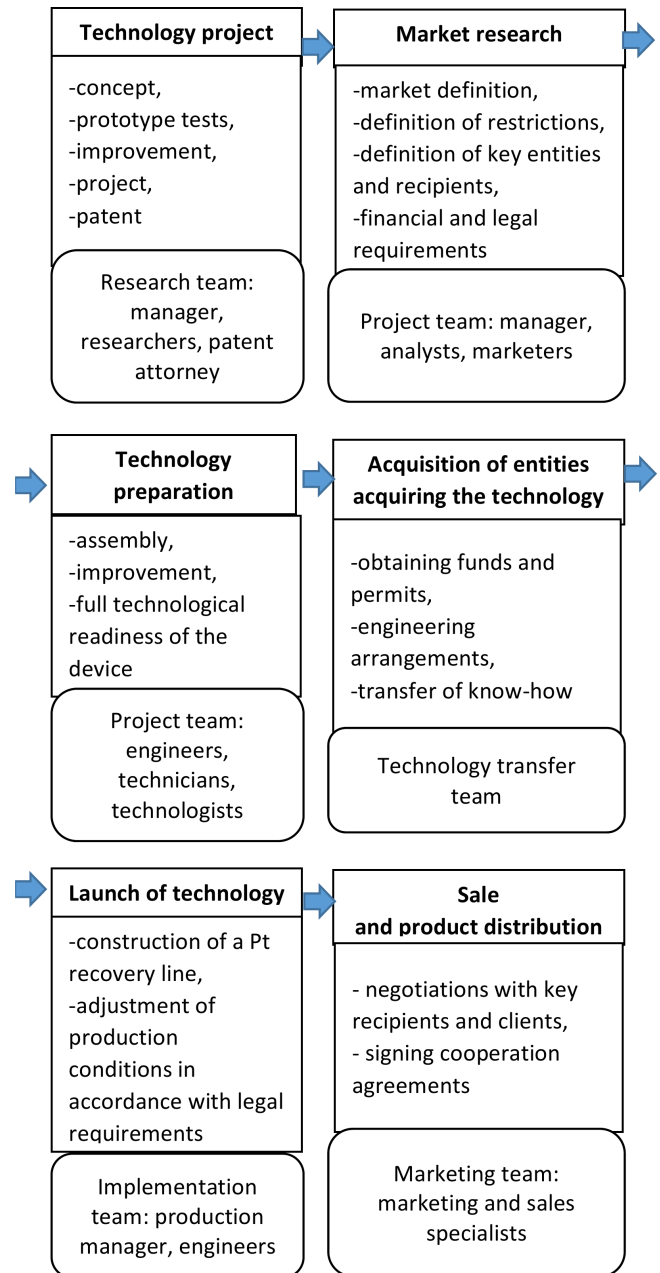


Fig. 5. The map of the implementation process of platinum recovery technologies from car catalysts.

As part of the market reconnaissance, it was constructed a structure of a network of entities participating in the material recycling (platinum recovered from car catalysts). This structure consists of three main segments:

- collection points of used car and car catalysts,
- plants recovered platinum from used catalysts,
- recipients of the recovered material (platinum) who use it for the re-production of car catalysts or sell it to other entities.

The arrangement of these three segments is presented in the form of a supply chain in Fig. 6.

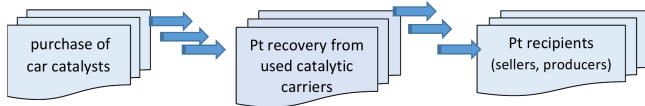


Fig. 6. Segments of the platinum recovery network from used car catalyts.

The implementation of the new technology must be in accordance with the applicable regulations. The scope of legal acts has been established in relation to entities and their business activity on the market of end-of-life vehicles. The basic legislative documents include:

- Directive 2000/53/EC, 18.09.2000 about end-of-life vehicles,
- Directive 2008/98/EC, 19.11.2008 concerning waste and repealing certain directives,
- Act of 27.05.2015 amending the act on recycling of end-of-life vehicles and some other acts.

These acts regulate the rights and obligations of such entities as: state administration, car and its parts makers, individual importers, vehicle owners, owners of dismantling stations and vehicle collection points. From 1.01.2016, the amended provisions of the Act on recycling of end-of-life vehicles entered into force (Dz.U. 2015, item. 933). Among the most important changes was the introduction of an obligation to provide a collection network by the introducer over 1,000 vehicles per year to the country. According to this duty in each voivodship at least three dismantling stations or collection points are to be run, which will ensure the car owners ability to return the end-of-life vehicle free of charge.

Next, a level of critical processes was created, consisting of processes related to technical parameters which were indicated by means of the QFD method as critical for customer satisfaction. These are: obtaining the required permits, meeting environmental standards, meeting the plant's area requirements, minimizing material costs, optimizing the level of technological readiness, obtaining financing for implementation processes, preparing catalyts for processes, replacing metal used to wash out catalyts, optimizing the number of catalyts charged per one working period to the device, maximization of the platinum alloy obtained, re-use of technological waste, maximization of the rate of platinum transfer to the alloy, optimization of the daily number of catalyts processing.

While constructing a map of implementation of platinum recovery technology from used car catalyts, the entities responsible for the implementation of particular stages of work were also indicated:

- a research team with a manager and patent attorney at the stage of developing a technology project,
- project team (marketing) at the stage of market research and determining the structure of participants of the market of cars withdrawn from use and their

expectations regarding the implementation of technology,

- team of technicians and technologists (project team) at the stage of building a prototype of the platinum recovery line for washing out platinum from the catalyts structure using mhd pump,
- specialists in the field of technology transfer (including employees of Business Incubators, organizations of producers) at the stage of developing the concept of technology transfer,
- entities dealing with platinum recovery – potential users of technology, including: production managers, major technologists, designers who will build the discussed line in the plant,
- marketing and sales specialists at the stage of promoting the implemented technology and building a competitive advantage of entities using it.

#### 4. Stages of further actions on the implementation of the discussed technology

The implementation of technology in enterprises (economic entities dealing with platinum recovery using the current collector metal technology or hydrometallurgical route and a new modified collector metal method by flushing out platinum using mhd pump) includes the following steps [9]:

- initiation of the technology implementation (all activities carried out in the earlier stages, which allowed to obtain technology and prepare appropriate documentation),
- planning of the technology implementation, including the creation of an implementation team, planning the organization and communication of the team with other employees, planning the scope of activities together with preparation of the schedule for implementation of individual works, planning and providing resources for technology implementation, investment risk assessment),
- initial implementation basing on providing the necessary infrastructure, personal resources, physical resources and financial resources (entrepreneur's capital and/or loans or bonds),
- proper implementation – platinum recovery by means of modified metal collector method with mhd pump together with control and monitoring activities of the launched technological line,
- secondary implementation (modification of technologies and processes – improvement and modification activities),
- completion of implementation – standardization of activities, service.

Each innovation, which is implemented into the enterprise, requires the costs, such as the purchase of a license, a patent. Search for the technology described above can be done using the individual university website; also by following the publications of the employ-

ees of the Silesian University of Technology, in which the description of innovations is included. An important source is the database of the Patent Office of the Republic of Poland, on which the technology and research profile of the reporting unit (based on a list of patents) can be found and then the need for technology or sponsored research can be reported. The entrepreneur may also go to a research center and commission a so-called sponsored research. In the case of successful cooperation, the necessary technology will be created, and then through the implementation and production process it will be implemented into the economy, and thus technology transfer will take place. At the enterprise level, relevant information about new technology mainly applies to:

- conditions for obtaining technology and the specificity of the market for end-of-life vehicles, on which the entity intends to operate,
- requirements in terms of infrastructure and resources needed to implement technology, including financial commitment and the opportunity to benefit from preferences for entities implementing innovations (e.g. lower taxes),
- legal and administrative requirements, including: environmental and documentary permits (a set of documents needed to run operations based on the implemented technology).

The entities that decide to conduct the process of platinum recovery must obtain the necessary administrative permits required at the stage of technology use, as well as elaborate a report on the impact of technology on the environment (EIA – assessment of the impact on the environment).

An entity acceding to the implementation of a new technology must have resources, including own funds (owner's capital) and external resources (loans or issued bonds) for the construction of a platinum recovery line. Investments are always associated with investment expenditures and operational expenses (e.g. payments for employees' remuneration, purchase of materials, purchase of services) [5]. Investment expenditures include, among others: expenditure on the purchase of mhd pumps, control and measurement equipment, equipment for pollution capture. The financial analysis of the project may be based on a simple analysis of return on investment (ROI) or more complex analysis of the internal rate of return. Financial analysis can help in measuring some quantitative effects of the implemented technology and risk assessment. Financial profit is the basic criterion for assessing the profitability of operations and is a basic measure of the acceptability of the implemented technology.

The entity or entities involved in the recovery of platinum from used car catalysts should carry out complex negotiations with car dismantling stations, e.g. in the scope of trade negotiations on issues such as: quantity and range of catalysts or range of services: frequency of deliveries, form of deliveries, price of catalysts, method and date of payment. The issue of the num-

ber of catalysts provided by car dismantling stations has obtained a high index in the analysis matrix of research results under QFD. Ensuring continuity of supplies should be subject to further research as part of the business risk assessment (investment risk). Taking into account the supply chain, the final platinum recipients are located at the exit. Platinum is used, among others for re-use in car catalysts. Calculation of profitability of production should be the basis for the business plan of the entity implementing the new technology of platinum recovery from used car catalysts.

## 5. Conclusions

The increase of the requirements for recycling of waste from end-of-life vehicles on the domestic market and the growing demand for raw materials, exceeding their supply from natural geological deposits, have pointed to the need of transfer the innovative technology of platinum metal recovery. Due to the lack of processing of car catalysts, the purpose of platinum recovery on the domestic market was perceived as a threat from foreign companies to take over this function. The implemented technology (Patent No. 221118) can solve the problem of the lack of business entities dealing with this type of activity. The proposed map of processes realized at the stage of technology implementation can be a facilitation for potential business entities in the construction of a business plan.

## References

- [1] Białoń L., *Zarządzanie działalnością innowacyjną*, Placet, Warszawa, 2010.
- [2] Brandenburg H., *Zarządzanie projektami*, Wyd. Akademii Ekonomicznej, Katowice, 2002.
- [3] Day R.G., *Quality Function Deployment: Linking a Company with Its Customers*, ASQC Quality Press, Milwaukee, WI, 1993.
- [4] Ejdyś J., Ustinovicus L., Stankeviciene J., *Innovative application of contemporary management methods in a knowledge-based economy – interdisciplinary in science*, J. of Business Economics and Management, 16, 1, 261–274, 2015.
- [5] Felis P., *Metody i procedury oceny efektywności inwestycji rzeczowych przedsiębiorstw*, Wydawnictwo WSE-I, Warszawa, 2005.
- [6] Fornalczyk A., *Analiza możliwości wykorzystania magneto hydrodynamiki do intensyfikacji odzysku platyny ze zużytych katalizatorów samochodowych*, Wyd. Politechniki Śląskiej, Gliwice, 2016.
- [7] Fornalczyk A., Przyłucki R., Saternus M., Golak S., Kadzimirz R., Sikora B., Kężel Z., Chruślicki W., *Sposób odzyskiwania platynowców ze zużytych katalizatorów samochodowych*, Patent 221118 udz. dn. 19.03.2015.

- [8] Fornalczyk A., Saternus M., Willner J., *The influence of platinum washing-out time on its recovery from used auto catalytic converters*, *Metalurgia*, 53, 349–352, 2014.
- [9] Fraś J., *Zarządzanie procesem wdrażania innowacji w przedsiębiorstwie*, *Studia i Prace Wydziału Nauk Ekonomicznych i Zarządzania* 34, 175–186, 2013.
- [10] Gil S., Bialik W., Saternus M., Fornalczyk A., *Thermal balance of the magneto-hydrodynamic pump for recovery of platinum group metals from spent auto catalysts*, *Archives of Metallurgy and Materials*, 61, 253–256, 2016.
- [11] Govers C.P.M., *What and how about quality function deployment (QFD)*, *International Journal of Production Economics*, 46–47, 575–585, 1996.
- [12] Halicka K., *Zarządzanie technologiami z wykorzystaniem metody technology roadmapping*, *Zeszyty Naukowe Politechniki Śląskiej, Organizacja i Zarządzanie*, 73, 211–223, 2014.
- [13] Halicka K., *Prospektywna analiza technologii* [w:] Knosala R. [Red.]: *Innowacje w zarządzaniu i inżynierii produkcji*, t. 2, Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole, 2014.
- [14] <https://www.bullionbypost.co.uk/platinum-price/year/kilograms/EUR/>, 2.10.2018.
- [15] Kotler P., *Marketing. Analiza, planowanie, wdrażanie i kontrola*, Gebethner i S-ka, Warszawa 1994.
- [16] Łunarski J., *Zarządzenie technologiami. Ocena i doskonalenie*, Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów, 2009.
- [17] Phaal R., Farrukhand C.J.P., Probert D.R., *Technology roadmapping – a planning framework for evolution and revolution*, *Technological Forecasting and Social Change*, 71, 1–2, 5–26, 2004.
- [18] Przybyłowski K., Hartley S.W., Kerin R.A., Rudelios W., *Marketing*, Dom Wydawniczy ABC, Warszawa 1998.
- [19] Research project No N N508 381133, *Research about obtaining cements for platinum group metals alloys using metals from treatment of spent auto catalytic converters*, NCN, 2007–2010.
- [20] Research project No N N508 625540, *Application of magneto-hydro-dynamic pump for recovery platinum from spent auto catalytic converters*, NCN, 2011–2013.
- [21] Świeczak W., *Inbound marketing jako forma marketingu internetowego*, *Marketing instytucji naukowych i badawczych*, Prace Instytutu Lotnictwa nr 222, Wydawnictwa Naukowe Instytutu Lotnictwa, Warszawa 2012.
- [22] Święcicka Z., *Implementacja nowej technologii w sieci odzysku platynowców ze zużytych katalizatorów samochodowych*, PhD Thesis, Katowice, 2018.
- [23] Wolniak R., *Metoda QFD w projektowaniu jakości, Teoria i praktyka*, Wyd. Politechniki Śląskiej, Gliwice, 2016.