



THE SURVEY ON CORES SUPPLIES IN THE SME IN AUTOMOTIVE REMANUFACTURING SECTOR

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ABSTRACT. Background: Remanufacturing of automotive components is a developing sector. The majority of companies in this sector belong to the group of SMEs. The remanufacturing benefits to the circular economy concept. The used products referred as "cores" are in the remanufacturing process bring back to as good as new condition. Supply management of cores faces a number of problems, which are discussed in the literature but there is still a lack of empirical studies in this domain.

Material and methods: The research methodology consists of a literature review, where research papers from the Scopus, Science Direct and Business Source Premier databases were used. On the basis of literature review the problems are identified. The pilot survey was elaborated in order to get in depth knowledge on the organization of the cores' supplies in small and medium-sized enterprises (SMEs).

Results: The survey was conducted among 40 SMEs in automotive remanufacturing sector. The paper presents the characteristics of the respondents and it identifies sources of the cores supplies. Authors discuss also the main problems which appear by organization of these supplies.

Conclusions: A remanufacturing process is more complex than the respective production process. The cores' supply management is crucial for profitability of remanufacturing. This paper provides in depth view on the practical issues in the cores supply management regarding source of cores, quality problems, material matching restriction problems and high variety of cores.

Key words: remanufacturing process, suppliers, cores.

INTRODUCTION

Remanufacturing is an industrial process, which allows to bring back the obsolete or worn out products to "like a new" condition. Sudin [2006] defined "remanufacturing is often a more complex process than manufacturing, due to a higher level of uncertainty in process steps and time, as well as unpredictability of cores' (returned products or their parts) quality and quantity". Ostlin et al. [2009] stated "Remanufacturing is an industrial process whereby used/broken-down products (or components) - referred to as "cores" - are restored to useful life". Remanufacturing

companies especially small and medium-sized face problems to achieve adequate economy of scale of their operations and an operational excellence. One of the problems which appear is the organization of the supplies of the cores of sufficient quality and quantity.

This paper presents the overview of the literature analysis on management of the cores' supplies. The results of the pilot surveys in Polish SMEs, that are involved in automotive part remanufacturing are presented. At the end of this paper are stated conclusions and are described further research steps.

THEORETICAL BACKGROUND - CORES SUPPLIES

In the remanufacturing process the equivalent to the raw materials input are used products (known as cores), which are collected from the consumers and then transformed into recovered products. A core has multiple modules that are materially recycled, reused, refurbished or disposed [Jayaraman 2006]. According to Souza [2008]:

- the input to the remanufacturing process (product returns) is uncertain in quality, quantity and timing of arrival,
- the network for collection might be different than forward distributions channels,
- returns with different quality levels have different lead times, costs and capacity usage,
- some returns are unsuitable for remanufacturing and might be scraped or recycle,

- unsuitable cores might be salvage for spare parts.

Guide [2000] indicated some more problems which are relevant to supply of cores:

- the uncertain timing and quantity of returns,
- the need to balance returns with demands,
- the uncertainty in materials recovered from return items,
- the requirements for a reverse logistics network,
- the complication of material matching restrictions.

An efficient cores management process is the backbone of all remanufacturing [Subramoniam et al. 2010]. For that reason the topic of cores' supplies has attracted in recent years attention of researchers in different countries. The recent research on cores' supplies management can be divided as indicated in Table 1.

Table 1. Research related to supply of cores
 Tabela 1. Powiązane badania dotyczące dostaw rdzeni

Research problem domain	Main tasks	Example of paper
Pricing of cores	Price setting Relation of production planning and pricing Price sensitivity of supply Core acquisition policy	[Liang et al. 2008]; [Qu, & Williams 2008] [Bakal Akcali 2006] [Teunter, & Flapper 2011]
Demand and supply synchronization	Matching demand with supply Take back policies	[Guide 2003] [Gouza 2008]
Supply chain relationship management	Collection management Relation among stakeholders Closed loop supply chain with remanufacturing Recovery network configuration	[Sundin & Dunback 2013] [Lind et al. 2011] [Wikner & Tang 2008] [Golinska & Kawa 2011]
Decision making on recovery strategy	Remake versus buy Strategic decision framework	[Martin et al 2010] [Subramoniam et al 2010]

Source: own elaboration

This paper contributes to the body of literature on cores' collection. Lind et al. [2011] stated that it is one of the main challenges in the remanufacturing to achieve a steady flow of cores.

There are several ways of organization of core collections. The most common sources of cores are:

- a product exchange (at the end of lease period, or after purchase of new product when the dealership collects the returned cores from the end consumer and sends them back).
- core broker relationship,
- remanufacturing contracts when remanufacturer doesn't own the core but just provide service,

- deposit systems, when customer at purchase time is placing a deposit, which is given back when the used produced is returned,
- rejected parts from the production plants,
- scrap yards and dismantling stations.

According to the findings of the literature review, companies usually need to apply multiple sourcing strategy in order to achieve steady flow of cores. The literature review helped us to identify also a number of problems which are connected with cores' supplies. The survey on the cores' supplies is discussed in the next section.

THE SURVEY DESIGN

A questionnaire was used to carry out the survey, because it is the most popular tool for collection of an empirical data. To create an on-line survey form was used Google Docs application located on Google. Ability to integrate and transmit data directly into a spreadsheet greatly facilitates the analysis of collected responses. The advantage of this online tool is that results can be presented as statistical charts, cumulative summary of responses, with the possibility of sharing the results obtained so far from all respondents.

The questionnaire consisted of 20 questions (open, closed, semi-open). The semi-open and open questions were structured depending on the topic as e a single choice, multiple choice and Likert's scale questions. Survey is intended to verify the theoretical findings with the facts observed in the companies. Respondents belong to the group of companies specializing in the remanufacturing of automotive parts. Findings are presented in the form of aggregated statistical charts. The respondents gave the answers anonymously. The questionnaire consisted of 4 main domains:

- part 1 characteristics of respondents: including the location, the time company exists on the market, the size of the company and major groups of products.
- part 2 cores supplies organization: including sources of supply of cores and the relationship between remanufacturer and suppliers, quality of supplies, problems in organization of supplies.

- part 3 issues concerning the characteristics of the remanufacturing process: standard lot size, the average duration of the remanufacturing cycle and workload of various stages of remanufacturing process, the level of recovery of remanufacturing, difficulties of cleaning products with dangerous substances, problems with missing spare parts, inventory management issues.
- part 4 barriers to development of remanufacturing.

This paper discussed mainly results from part 1 and part 2. The analysis of cores' supplies are performed in order to provide more in depth insight into the problems identified in literature by e.g. Ostlin and Ekholm [2007], Hammond et al. [1998] or Rubio and Corominas [2008]. The main problems of remanufacturing in the areas related to cores supplies, are as followed:

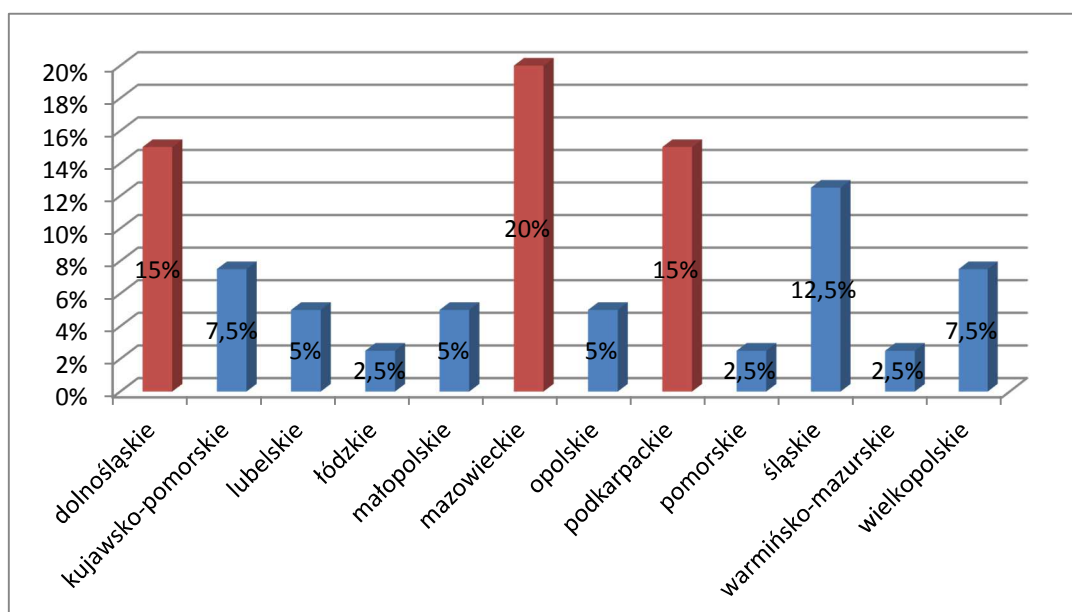
- insufficient availability of the good quality cores,
- high product variability,
- variation of the rate of materials recovered and materials matching problems.

The company for the pilot study were selected based on Internet search with key word: remanufacturing, automotive parts, regeneration. Among companies specializing in remanufacturing of automotive parts, randomly was selected group of 70 companies. Finally 40 of them replied in the framework of the questionnaire. The original method of research was supposed to be the electronic survey, which was sent on given by the respondent (during a brief phone call) email inbox. Because the respond rate was not satisfactory (approx. 4,5 %), the companies were contacted again. In the second round the most of the surveys were conducted as telephone survey (92.5% of the sample) based on the same electronic form which was previously received by the companies. The research team was entering the answers on behalf of the respondents to on-line form during phone conversation. The results of the study are resented in the next section.

SURVEY RESULTS

In the survey was included responds from 40 enterprises specializing in remanufacturing of automotive parts. The survey was addressed to the companies located in all Polish regions. The received responses were from 11 Polish provinces (Figure 1). Most of the surveyed

companies, have their headquarters in Mazowieckie Voivodeship (8 companies), Dolnoslaskie and Podkarpackie (6 companies). None of the respondents is located in the administrative district: Świętokrzyskie, Podlaskie, Lubuskie and Zachodniopomorskie Voivodeship (see figure 1).



Source: own elaboration

Fig. 1. Geographical dispersion of the respondents

Rys. 1. Rozmieszczenie firm ankietowanych na terenie Polski

Table 2. Age of companies and the employment - crossed table
 Tabela 2. Tabela krzyżowa czasu działania firm na rynku oraz wielkości przedsiębiorstw

	Less than 5 years		5-10 years		More than 10 years	
Small enterprise (up to 49 employees)	0	0%	1	12,5%	3	11%
Micro enterprise (up to 9 employees)	4	100%	7	87,5%	25	89%

Source: own elaboration

Respondents are mainly companies with over 10 years of experience (28 companies) in remanufacturing of automotive parts. The size of companies was as follows: 89% are micro-enterprises employing up to 9 persons, rest of the companies were declaring that their employment is below 49 people.

The analyzed companies specialized in remanufacturing of turbochargers (16 companies), steering gear (9 companies) and cylinder heads (7 companies). Among these can be distinguished companies that specialize

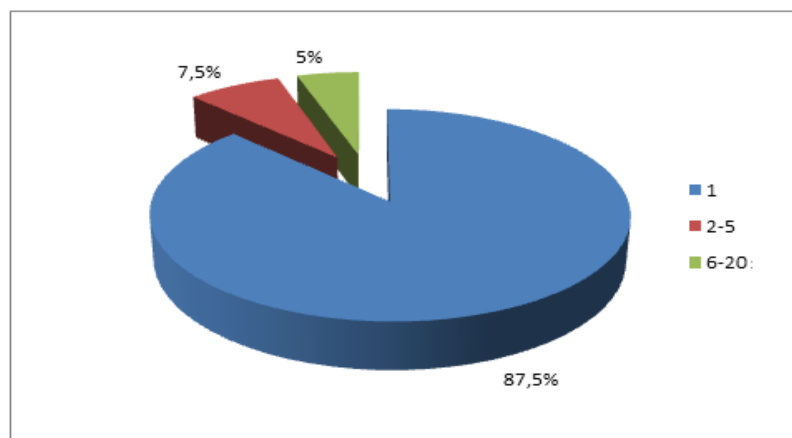
in one type of products' group, or those whose activity is enhanced by additional products. The most typical lot size (87.5% of the sample) is single product's group. The main reasons which the companies gave in order to explain a strong focus on single products' group were, as followed:

- different types of products from different car models whose dismantling instructions are different,
- each core having different worn components,

- the degree of consumption of individual elements is different for each cores.

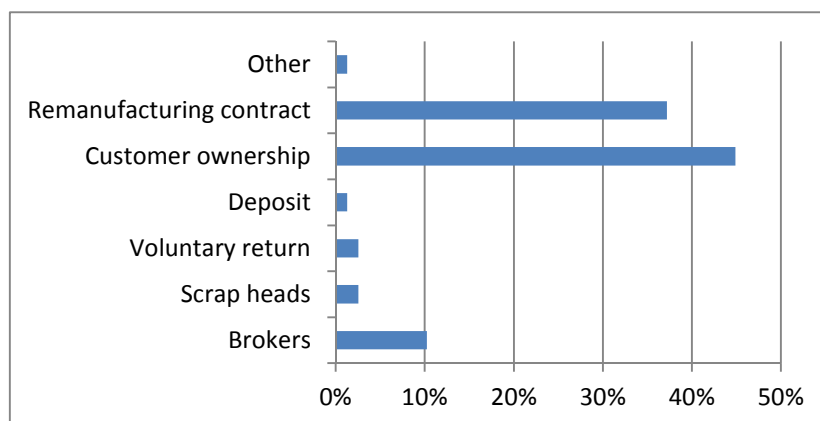
The answers obtained from companies confirmed the theoretical statement that in remanufacturing there is a very high variety of products models (products proliferation). The respondents explained that despite remanufacturing of single products' group (e.g. turbochargers) they still have to deal with hundreds of different variants of products, which belonged to different products' generation.

In order to additionally verify the problem of products proliferation, the companies were asked about the standard size of lot size in their remanufacturing process. As presented in Figure 2, majority of respondents (87,5%) remanufactured mainly one-piece orders. Only 5% of respondents are able to achieve the lot sizes of 6-20 pieces. Such situation influences organization of the cores because companies have to deal with high variety and complexity. This remark is consistent with the results of previous research.



Source: own elaboration

Fig. 2. Typical lot size in analyzed remanufacturing companies
Rys. 2. Najbardziej typowe wielkości partii poddawane regeneracji fabrycznej



Source: own elaboration

Fig. 3. Sources of cores
Rys. 3. Źródła pozyskiwania rdzeni

The respondents gave answers to various questions relating to the way in which they acquire cores for the remanufacturing, the countries from which they came from, and the barriers they encounter when obtaining cores.

The companies were also asked about the frequency of orders, standard delivery time, as well as problems with the quality of the supplied cores.

Figure 3 presents the sources of cores' deliveries. This question was a multiple choice from the available suggestions, which were identified, based on the literature review and were defined as followed:

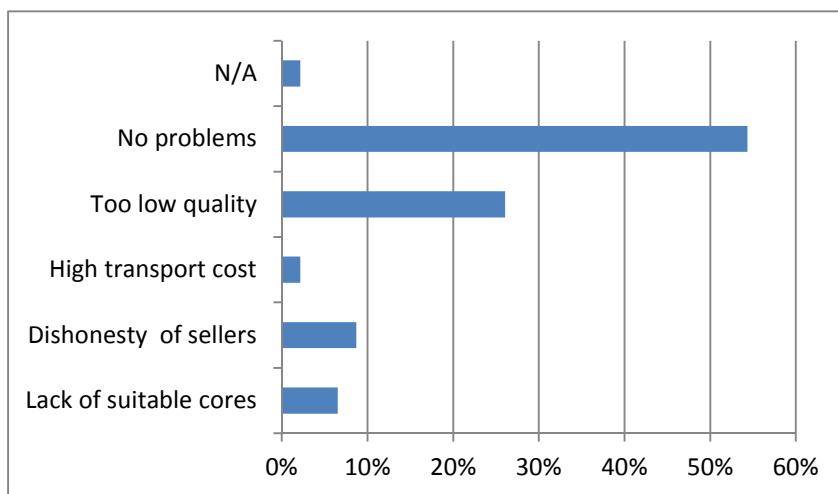
- purchase from core broker (B),
- purchase from scrap yard or dismantling station,
- voluntary free of charge return by user,
- deposit agreement,
- remanufacturing service for individual customer (customer ownership (C)),
- remanufacturing contract for services for another company (client provides cores (RS)),
- other.

Most companies remanufacture products which are owned by customers (35 replies) or they remanufacture for companies with whom they have agreements for services (29 replies). Those who take the challenge to acquire cores from intermediaries usually decided to

cooperate with so-called. brokers cores (8 replies) or they buy products, e.g. through the website. Most of the companies apply mixed approach to the cores purchase and they use more than one source of supplies.

Most of the respondents obtained cores exclusively from Poland (30 companies). Several companies (22.5% of the sample) apply mix sourcing and they obtain cores from Polish and from an import. Only one company declares that the cores come exclusively from the import. Respondents indicated the countries from which most imported cores are coming from, which are: Germany and the United Kingdom (each gets 6 replies), and France (4 replies). In case of countries from outside the European Union dominates Ukraine (3 replies).

The next question focused on the problems with obtaining cores from Poland. The results are presented in Figure 4.



Source: own elaboration

Fig. 4. Problems by cores' supplies from Poland
Rys. 4. Problemy podczas pozyskiwania rdzeni z Polski

Barriers encountered when acquiring cores to remanufacturing from the territory of Poland are not big (Fig. 4). Mainly it's too low quality of obtained cores. A small group of companies complain about dishonesty of sellers (4 respondents). Most companies believe that the difficulties in getting the cores from the territory of Poland do not exist. The opinions of the respondents are mainly influenced by the fact that most of them provide mainly remanufacturing services for individual

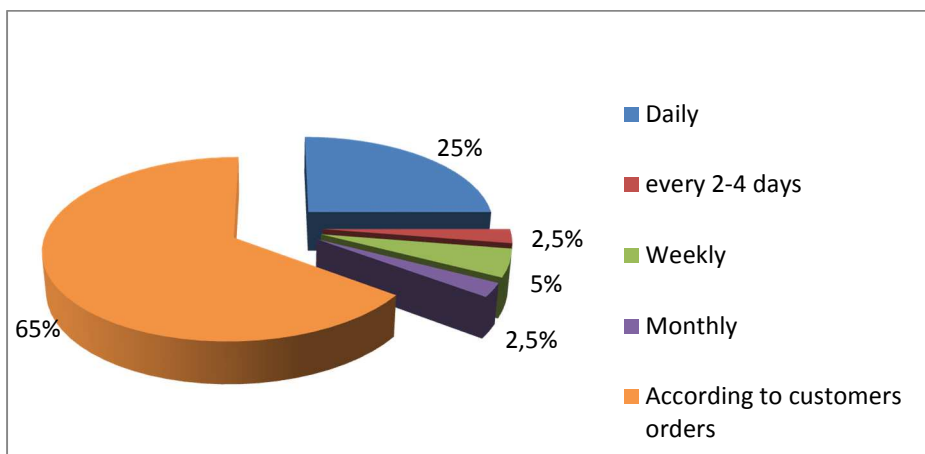
customers and other companies, so they don't need to buy cores.

Analogical question was stated in order to identify problems which might appear by import of cores but due to the fact that very few respondents are importing the cores the results are not analyzed in this paper.

The other aspect which was analyzed was frequency of cores supplies. Figure 5 presents

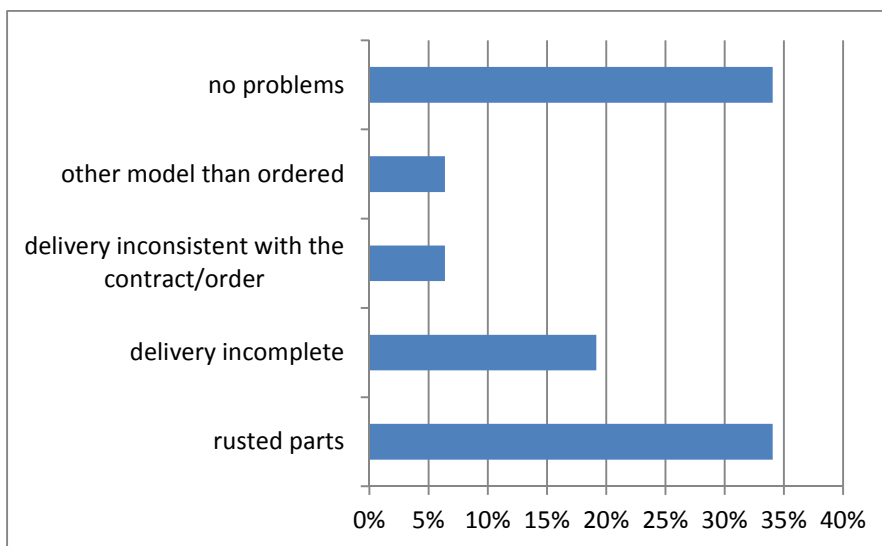
the results. The frequency of placing orders for cores was very difficult to define. Most of the companies (65% respondents) have stated that they don't monitor order placing frequency because it is unpredictable and it depends solemnly on customer demand, which varies seasonally. Hence the conclusion is that the lack of order, results in the lack of a specific

delivery date for cores, and so it is impossible to specify the length of the delivery lead time. The next group of companies (25% of the sample) admits that customers provide the cores to every day, therefore it can be concluded that by them the order takes place with such frequency.



Source: own elaboration

Fig. 5. Frequency of placing orders
 Rys. 5. Częstotliwość składania zamówień na rdzenie



Source: own elaboration

Fig. 6. Quality problems in cores' delivery
 Rys. 6. Pojawiające się problemy, z jakością rdzeni

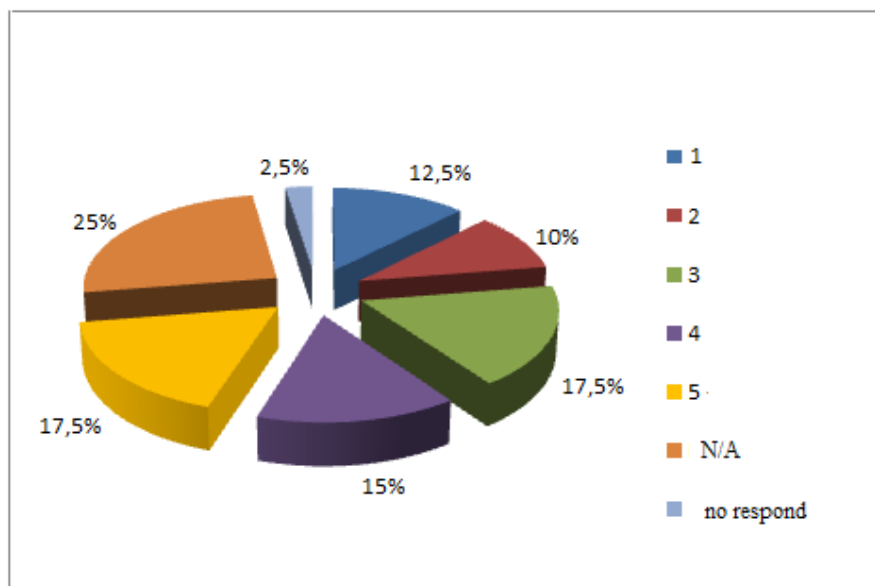
The next problem which is addressed in the survey is quality of cores (see Fig 6). The interviewers suggested several typical difficulties described in literature (multiple choice question):

- rusted parts,

- delivery incomplete,
- delivery inconsistent with the contract/order,
- other model than ordered,
- no problems with quality.

Companies have confirmed that frequently appearing problem is corrosion of parts and the incomplete deliveries. A significant proportion of respondents declared that there is "no problems". In addition to rusted parts, it is the most common answer among respondents. This finding might result in the fact that when providing remanufacturing services and dealing with one piece lot size companies are used to remanufacture any core disregarding its quality.

The last factor that strongly affects remanufacturing process is the lack of spare parts used for re-assembly stage. The problem is related to the time of launching the product on the market. Among the available models of cores are both old and new models. They have a limited number of spare parts, as partially or completely withdrawn them from the market already (old products) or have not yet been introduced to the market (new products).



Source: own elaboration

Fig. 7. Problems with matching parts in cores

Rys. 7. Trudność z brakującymi elementami zamiennymi do powtórnego montażu

We have examined the importance of this issue. The respondents have assessed this problem on Likert scale where: 1 means low importance of this problem, and 5 means very high importance of this problem. The results are presented in Figure 7. Majority of companies confirm that the matching parts problem is important regarding cores' management (answers on Likert scale from 3 to 5). Very few of the respondents (2,5%) denied to answer this question. A big group of companies (25%) stated that this problem is not applicable (25%) to them. That finding might result from the fact that remanufacturing companies, which provide remanufacturing services try to fulfill any order they received and try to make in-house missing components.

CONCLUSIONS

The paper presents the summary of the literature study on cores' supply organization. The theoretical findings were then empirically verified in the pilot study, which was conducted in SMEs in automotive remanufacturing sector. The respondents provide the empirical data in domains:

- identification of cores supply,
- problems by cores' supply,
- products proliferation,
- quality of cores,
- material matching problems.

Authors in the survey try to receive in depth inside in cores' supply organization regarding the problems described in the literature, such as:

- insufficient availability of the good quality cores,
- high product variability,
- variation of the rate of materials recovered because of materials matching problems.

Most of the respondents remanufacture one piece lot sizes. The variety of products is very high. About 50% of companies confirm that material matching restrictions are an important problem (assessment 3-5 in Figure 7). Regarding quality problems companies mainly have to deal with rusted parts and incomplete deliveries. Significant group of companies declare that quality of cores problem is not relevant to their case. During phone survey they explain that such statement is based on the fact that they don't own the cores. The further research step will include the extension of the respondents group and continuation of the pilot study with focus on medium size companies.

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BADANIE ORGANIZACJI DOSTAW "RDZENI" W MŚP ZAJMUJĄCYCH SIĘ REGENERACJĄ CZĘŚCI SAMOCHODOWYCH

STRESZCZENIE. Wstęp: Regeneracja części samochodowych jest rozwijającym się sektorem w Polsce. Większość firm w tym sektorze należy do grupy małych i średnich przedsiębiorstw (MŚP). Regeneracji pozwala osiągnąć korzyści wynikające z zamykania pętli przepływów materiałowych w łańcuchu dostaw. Używane produkty określone jako "rdzenie" są w procesie regeneracji przywracane do stanu pierwotnego. Zarządzanie dostawami rdzeni jest kluczowe dla opłacalności procesu regeneracji jednak napotyka na szereg problemów, które zostały omówione w literaturze, ale nadal brakuje badań empirycznych w tym obszarze.

Metody: Przeprowadzono badania literaturowe, w tym celu przeszukano bazy Scopus, Science Direct and Business Source Premier dla kryterium "remanufacturing" i "cores". Na podstawie przeglądu literatury zostały zidentyfikowane problemy w obszarze organizacji dostaw rdzeni. Następnie zostały zrealizowane pilotażowe badania w celu uzyskania dogłębnej wiedzy na temat organizacji rdzeni dostaw w małych i średnich przedsiębiorstwach (MŚP).

Wyniki: Badanie zostało przeprowadzone wśród 40 przedsiębiorstw z branży zajmującej się regeneracją części samochodowych. Artykuł prezentuje charakterystykę respondentów oraz identyfikuje podstawowe źródła dostaw rdzeni w analizowanych przedsiębiorstwach. Autorzy również omawiają główne problemy, które pojawiają się przy organizacji dostaw rdzeni. Artykuł prezentuje analizę odpowiedzi respondentów w zakresie identyfikacji źródeł dostaw rdzeni, problemów związanych z jakością rdzeni oraz z czasami dostaw.

Wnioski: Proces remanufacturingu jest znacznie bardziej skomplikowany niż proces produkcji pierwotnej dla analogicznego produktu. Zarządzanie dostawami rdzeni ma kluczowe znaczenie dla rentowności regeneracji. Ten artykuł prezentuje próbę analizy zagadnień dotyczących: źródła pochodzenia rdzeni, problemów z ich jakością, trudności związanych z doborem brakujących elementów w rdzeniach, różnorodność rdzeni.

Słowa kluczowe: proces remanufacturingu, rdzenie, dostawcy

UNTERSUCHUNG DER ORGANISATION VON ANLIEFERUNGEN DER "KERNE" IN KLEIN- UND MITTELSTÄNDISCHEN UNTERNEHMEN, DIE SICH MIT REGENERATION VON AUTOERSATZTEILEN BESCHÄFTIGEN

ZUSAMMENFASSUNG. Einleitung: Die Regeneration von Autoersatzteilen stellt einen sich sehr gut in Polen entwickelnden Sektor dar. Die meisten Firmen in diesem Segment gehören zur Gruppe klein- und mittelständischer Unternehmen (KMS). Die Regeneration erlaubt es, die aus der abschliessenden Abrundung von Materialfluss-Zirkulationsschleifen in der Lieferkette resultierenden Vorteile zu erzielen. Die angewendeten, als "Kerne" bezeichneten Produkte werden im Prozeß der Wiederaufbereitung bis auf ihren Primärzustand zurückgewonnen. Das Management von Anlieferungen der Kerne ist ausschlaggebend für die Rentabilität des Wiederaufbereitungsprozesses. In der Praxis stößt er aber auf eine Reihe von Problemen, die zwar in der Gegenstandliteratur behandelt wurden, wobei immer noch empirische Untersuchungen in diesem Bereich ausbleiben.

Methoden: Es wurde eine gezielte Literaturrecherche vorgenommen. Zu diesem Zweck hat man die Basen: Scopus, Science Direct und Business Source Premier für die Kriterien: "remanufacturing" und "cores" (Regeneration und Kerne) in Anspruch genommen. Auf Grund der Literaturrecherche wurden die im Bereich der Organisation bei der Anlieferung der Kerne auftretenden Probleme identifiziert. Demzufolge wurden die einleitenden Untersuchungen zwecks Ermittlung eines Fachwissens zum Thema der Anlieferungen der Kerne in den klein- und mittelständischen Unternehmen (KMS) in Angriff genommen.

Ergebnisse: Die Untersuchungen wurden in 40 Unternehmen aus der Branche der Wiederaufbereitung der Autoersatzteile durchgeführt. Der Artikel stellt eine Charakteristik der betreffenden Respondenten dar und ermittelt die Haupt-Bezugsquellen für die Kerne innerhalb der analysierten Unternehmen. Die Autoren gehen auf die wesentlichen Probleme, die bei der Organisation der Kerne-Lieferungen auftauchen, ein. Darüber hinaus pojjiziert der Beitrag die Analyse der Antworten seitens der Respondenten bezüglich der Identifikation der Bezugsquellen für die Kerne, ferner der mit der Qualität der Kerne zusammenhängenden Probleme sowie bezüglich der betreffenden Lieferzeiten zuletzt.

Fazit: Der Wiederaufbereitungsprozeß ist viel mehr komplizierter als der Prozeß primärer Herstellung des analogischen Produktes. Das Management der Lieferketten bei der Anlieferung der Kerne hat daher eine grundlegende Bedeutung für die Rentabilität des Regenerationsprozesses. Der Artikel präsentiert Versuche einer Beantwortung der folgenden Fragen, die auf die Analyse der Bezugsquellen für die Kerne, auf die Analyse der die Qualität anbetreffenden Probleme, ferner der mit der Auswahl von fehlenden Elementen und Baugruppen zusammenhängenden Schwierigkeiten sowie auf die Vielfalt der Kerne zurückgehen..

Codewörter: Wiederaufbereitungsprozeß, Kerne, Lieferanten

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