

ANALYSIS OF RAW MATERIAL PARTICIPATION IN THE PRODUCTION PROCESS, PART I - INTRODUCTORY CONSIDERATIONS

Przemysław Niewiadomski* and Natalia Pawlak**

* Faculty of Engineering Management, Poznan University of Technology, Poznan, 60-965,
Poland, Email: niewiadomski@zpcz.pl

** Faculty of Engineering Management, Poznan University of Technology, Poznan,
60-965, Poland, Email: natalia.pawlak@put.poznan.pl

Abstract: The purpose of the following publication (consisting of two parts) is to perform a query of literature, which is in direct relation with the research subject of analysis of costs of purchase raw materials used in the production process. Currently, much is being said about a system, which would improve productivity and effectiveness and limitation of production costs connected with general cost minimisation, and broadly understood Lean Manufacturing philosophy. Assuming that the raw material cost amounts to 70% of the total production cost of the final product, the authors decided that it is justified to develop a model strategy, whose implementation will have a tangible effect i.e. the reduction of raw material cost, which will bring distinguishable results in the form of improved value of the production facility.

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1. INTRODUCTION

If a company achieves a competitive advantageⁱ, which allows for effective functioning on the market, this is a result of implementing a better strategy than that of its competitors, which in turn, allows to achieve extraordinary profitability (within its field of operation).

The strategic flexibility i.e. the ability to modify the strategyⁱⁱ and actions in order to adapt to changes in the surrounding world and making the best use of own competences and skills becomes a key factor (Hitt, Ireland & Hoskisson, 2005).

The conditions in which the company functions nowadays are changing. The 21st century brought new economic conditions, which force the companies to select new operational patterns (Skrzypek, 2003) and search for new sources of value. It is the identification and effective management of those factors, which have a decisive impact on building the company's value on the market, in the long term (Domagała-Korona & Herman, 2006).

The idea behind management, which is related to placing the customer in the centre of the company's activities, is to develop an offer adjusted to the needs and expectations of the customer at the strategic level. The basic strategy is therefore the product strategy, which sets the direction for the following strategies. The manufactured product should be plannedⁱⁱⁱ in a way, which provides maximum value to the customer, maximising his satisfaction, which should have an impact on the income that is received by the manufacturer after the product's implementation.

In light of the above I, Rutkowski (2006), companies^{iv}, should develop and engage their competences in the development and introduction of new products into the market. In order to increase the probability of success of the implementation strategy for the new product, the company should also create appropriate conditions, which to a large extent determine the effective management of the process. This is the subject of the following paper, which is the result of theoretical and practical deliberations, which were aimed at creating a model of company that is flexible and adjusts to the needs of the market.

The purpose of the following publication (consisting of two parts) is to perform a query of literature, which is in direct relation with the research subject of analysis of costs of purchase raw materials used in the production process^v. Assuming that the raw material cost amounts to 70% of the total production cost of the final product^{vi}, the authors decided that it is justified to develop a model strategy, whose implementation will have a tangible effect i.e. the reduction of raw material cost, which will bring distinguishable results in the form of improved value of the production facility. The presented model is dominated by the Lean concept, which is a result of research on the production system of the Japanese Toyota company.

2. RAW MATERIAL - A DOMINATING FACTOR IN THE MANUFACTURE OF THE FINAL PRODUCT

The main activity of an industrial company^{vii} is the production process. In its essence (in simplest and general terms) this involves processing the raw material to produce the final product. In case of a particular industrial company, any material (object) that is processed and leaves the plant in a changed form is the "raw material", while any final product used in further processing or use in another company or used directly to meet the customers' needs is the "final product".

The operation of a modern industrial company is a complex matter. The development of science and technology is reflected in the production processes^{viii}, in the technical equipment of manufacturing workshops and results in the increase of quantity and quality of the produced goods, which broadens the available assortment and at the same time results in the use of more diverse and economically effective technological processes^{ix}. In the process, the raw materials are converted into final products in the organisation (Zymonik, Hamrol, & Grudowski, 2013).

This development brings considerable changes in auxiliary and supporting processes associated directly with the manufacture of products.

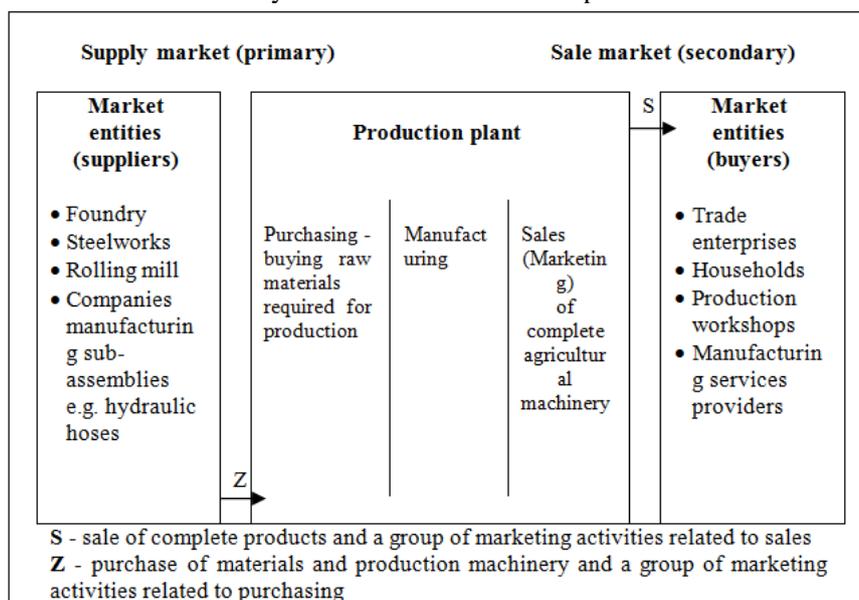


Fig. 1 Market relationships between the production plant and its economic environment. Source: Own materials, based on: Niewiadomski, 2012, p. 126.

In the production goods market^x the major entities, which have an impact on its scale and functioning are manufacturing companies. Those, which supply the production goods also buy them as equipment and materials required in their

production processes See: (Wojciechowski, 2003). Therefore, they participate in the transactions in this market both as buyers and sellers. Even if the manufacture consumer goods^{xi} they always remain buyers of production goods, which are needed for their manufacture and so they also operate on the production goods market although they act only as buyers. The association with the market is twofold, with two separate planes: a market where the production goods^{xii} required for the operations are acquired and a market where the produced goods, manufactured from those production goods or using those goods (e.g. machines, equipment, tools) are sold (Fig. 1).

In summary, companies - production plants, irrespective of the scale of their operations purchase raw materials, material, parts and subassemblies and various services in the market (Skowronek&Sarjusz-Wolski, 2012). The analysis of the purchasing process conducted by the authors in 14 companies operating in the agriculture mechanisation industry^{xiii} allowed generating a list of raw materials, materials and semi-produced materials, which are a basis for the farming equipment parts and subassembly manufacturing process^{xiv}. In context of the above, several groups of items may be distinguished in such companies:

- raw materials and primary materials (general purpose or made to order according to special requirements), which are processed in the production process. Main raw material used in the production process in the companies subject to research is (Fig 2) is cold and hot rolled sheet^{xv} and rolled^{xvi} and drawn^{xvii} bars.
- semi-fabricated cooperative elements in the form of cast iron^{xviii} and cast steel components
- ready products of companies^{xix} (elements, which are impossible or not economically justified to manufacture using own means)
- standardized machine elements (bearings, bolts, seals, protectors etc.)

In this part of the publication, the authors decided to select several product groups, which are subject to purchase and are a basis for the production processes in the given companies. According to Cz. Skowronek and Z. Sarjusz-Wolski (2012), the ongoing specialisation of individual logistic phases resulted in the separation of purchase marketing, which makes its subject the preparation and decision making regarding the purchase of raw materials, materials and semi-fabricated materials. The great importance of the purchasing phase for the company and its competitiveness is emphasised by A. J. Gasser (Krawczyk 2012): "The new sources of income for the company are discovered by managers, persons responsible for marketing, sales research and development, finance, human resources and everyone, who understands that purchasing is not just sending orders, it is a function of strategic importance to the manufacturer". In light of the above the knowledge of raw material, material or semi-fabricated product participation in a given process is indispensable, which confirms the validity of the research conducted by the authors.

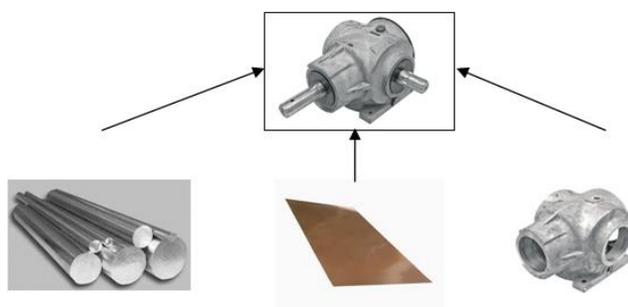


Fig. 2 Raw materials used for production in the machine industry. Source: Author's research

The authors are aware of the fact that the problems of selecting the raw material are a very important matter, which is widely discussed in literature. However due to the limitations (text length), many issues may not be discussed in this article. They will, however, be subject to other, following articles^{xx}.

3. COST REDUCTION AS AN ATTRIBUTE OF A MODERN ORGANISATION

The recent years brought a considerable development of modern market tendencies, which have a major impact on the methods used in managing companies (Knosala et al., 2007).

According to B. Nogalski, the use of new tendencies in company management appearing around the world by Polish companies and their implementation as changes provides them with a great opportunity to become competitors of established companies and in a broad perspective, to survive and develop, which is a new paradigm^{xxi} (Nogalski, 2004).

In light of the above, numerous companies now endorse a business model based on knowledge, where a "lean company" is the point of reference. This is the subject of the following article, which is the aftermath of theoretical deliberations and practical actions taken to create a business model, which would react to the changes in demand and growing customer expectations in a flexible and continuous way, providing the ability for further development, which according to the authors, is a desirable feature of any organisation.

What is a lean company, then? On what principles is the operation of such company based?

The need to maintain the compact size of this publication implies the need to synthetically present the arguments, therefore the questions related to lean companies are presented in a very simplified manner.

The lean company approach drastically changes the present view of the company (Nogalski & Niewiadomski, 2013). In such company, the stock is maintained at minimum level or there is no stock at all. A company reacts quickly to the demands of the customer. Materials and raw materials are supplied directly from suppliers to the locations at which they will be used using the Kanban^{xxii} system. In addition, all processes in the entire company are improved by project groups - Kaizen^{xxiii}. High visualisation of the work positions - 5S^{xxiv} makes the employees more engaged in the change and improvement process. Time for changing tools in machines are minimised (SMED)^{xxv}, so there is no need to manufacture large batches. Maintenance is based on the TPM^{xxvi} rules, which means preventing any failures. All areas of the company's activity are subject to measurement processes. The measurement results are used as basis for making decisions regarding the condition of the company (Niewiadomski & Pawlak, 2012).

In summary, lean manufacturing is an example of approaches to managing a modern organisation. Production process, which is made Lean in a reasonable manner^{xxvii}, allows making more, better, and cheaper products, at the same time allowing meeting the goal of supplying the customers with exactly what they need. The principle of the lean company concept is to remove any signs of wastage, which improves the economical factors of operations as the company uses less resources to reach the same goals. This principle is most often used in companies with large production capabilities, providing the with independence in reaching their goals. The lean production/manufacturing/enterprise may be considered a company management philosophy, company organisation or a system of concepts and management methods (Trzeciński, 2011).

On the other hand, J. Czerska specifies that the lean concept should be understood as a group of actions, influencing the reduction of tasks, which do not add any value to the product and allowing to achieve results, which qualify the company as lean. It might be said that lean is a concept of actions, which result in the reduction of costs of company operation thanks to engaging minimum resources in the production process that also use the ongoing behaviour of the company directly adapting to the changing requirements (Czerska, 2001).

4. STRATEGIC MODEL - REDUCING RAW MATERIAL COSTS

In order to respond to the changes in its economic environment the company is required to adapt, synchronise and adjust the actions of various employees to meet the encountered situation (Ćwiklicki & Obora, 2011). The development of new management concepts is related to the need to solve problems, which occurred at

a given moment in a given economical space (Kosieradzka, Kąkol & Krupa, 2011). Solving those problems is based on the ability to look at the problem from a new, different perspective and liberating oneself from conventional methods of thinking, which breaks the existing paradigm and creates a new one. An expression of such approach is the authors' three-phase strategy model based on the raw material vs. costs relation (Fig. 2).

Managing costs is an important element of any business activity, especially under the conditions of economic crisis. Employees, business people and organisations strive to achieve the highest possible effectiveness. One of the ways of achieving it is limiting and even eliminating wastage, which will be discussed further in the following paper.

At present, the discussion on eliminating wastage is dominated by the Lean concept, which is a result of research on the production system of the Japanese Toyota company. Numerous companies use the experience of the Japanese company related to organisation methods and production and supply chain management, as well as design and product and customer service, which has been collected in the 1990s and helped create the concept of lean manufacturing. This was also the method applied by the authors of this article, who based their model on thorough elimination of losses understood as "actions causing the consumption of resources, which do not result in creating any value for the customer" (Niewiadomski & Nogalski, 2012).

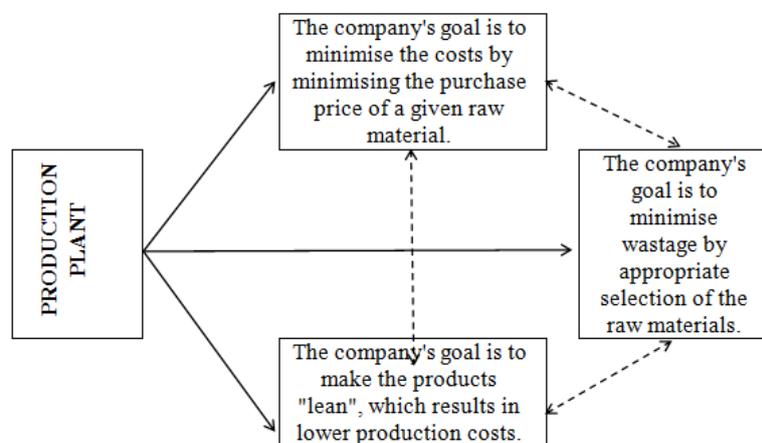


Fig. 3 Strategic model reducing raw material costs^{xxviii} Source: Authors' materials

This strategic model assumes the tendency to make the costs leaner in the raw material area, which is possible by using the listed approaches (together or separately).

For the purposes of this article the authors suggest using their own system, which, similarly to the systems introduced in all companies using the said approach, is based on a set of tools originating at Toyota. The most important

sources of loss have been indicated in the system, which provide the ability to achieve savings in industrial companies.

Assuming the tendency to create unconventional, slightly modified ore existing company management tools, especially in conditions of economic slowdown in the industrial product market, it seems justified to propose a concept based on reducing the "volume" of the product, while maintaining its price.

High quality product or its "lean" variant? In many cases this is not an easy choice. It is worth to note, that the decision of the company to produce low or high quality product is a matter of marketing strategy. The manufacturer may offer a lower quality, cheaper product or a high quality product which produces lower margins. In the first case the manufacturer produces a lot of units and sells them cheap, hoping to achieve high profit as a result of the experience effect^{xxix}. In the second case the production volume is in most cases smaller.

Which route to create and select? This article points out that it is the: lean", high-margin products, which bring considerable profits on sales may be, and in fact are, a stimulant in the development of the company and result in relatively quick improvement of its value.

Wastage in the production process may be eliminated by using common sense and taking actions directed at reducing costs. The second symptom of resource wastage - covered by the authors' observations - is wastage resulting from less than optimal usage of a given raw material.

Based on the observations and conclusions, the authors feel able to formulated this thesis: the optimisation of raw material selection and the percentage of its usage have an effect on the manufacture costs of a given product. This thesis seems to be confirmed by the research of B. Nogalski & P. Niewiadomski (2013), who, based on the production process of agricultural machinery parts, in particular on the cutting of metal sheets, have shown how considerable savings may be brought by the optimum selection and cutting of the raw material.

5. CONCLUSIONS

The authors of this article believe that the presented questions do not reflect the full complexity of the presented matter as it is impossible to fully present the complexity of the encountered approaches and potential deliberations related to this matter. The limited volume of this article imposed the need to select, introduce a hierarchy and systematise the questions related to organisational strategy, which was aimed at enhancing the practical aspects of the article. The objective inability to develop all aspects of the discussed, complicated problem does not lift the authors' responsibility for the presented views.

The matters discussed in the text should be considered contextual, affecting the broader and better understanding of the subject matter discussed in the second part

of this article. The following article is a first part of the discussion on raw material cost analysis in the production process. The next part will present the results of research, which was conducted based on a selected group of products, confirming the correctness of the strategy model developed by the authors.

REFERENCES

- Czerska J., (2001), Usprawnianie przedsiębiorstwa produkcyjnego zgodnie z koncepcją Lean, *Ekonomia* nr 40, *Zeszyty Naukowe Politechniki Gdańskiej*.
- Ćwiklicki M., & Obora H., (2011), Hoshin kanri. Japońska metoda strategicznego zarządzania jakością w Polsce, PWE, Warszawa.
- Domagała-Korona B., & Herman A., (2006), *Współczesne źródła wartości przedsiębiorstwa*, Difin, Warszawa.
- Duda J., & Samek A., (1998), „Sformalizowany opis metod projektowania procesów technologicznych”, *Materiały konferencji naukowo – technicznej, Projektowanie procesów technologicznych TTP '98, Sekcja Podstaw Technologii KBN PAN, Poznań – Czarniejewo*.
- Gierszewska G., (2011), *Zarządzanie wiedzą w przedsiębiorstwie*, Oficyna Wyd. Politechniki Warszawskiej, Warszawa.
- Hitt A. M., Ireland D. R., & Hoskisson E. R., (2005), *Strategic Management – Competitiveness and Globalization*, Thomson South-Western Int.
- Kosieradzka A. Kąkol U. & Krupa A., (2011), „Przełomy organizacyjne w zarządzaniu produkcją”, *Przełomy w zarządzaniu. Zarządzanie procesowe*, R. Borowiecki, L. Kiełtyka (eds.), TNOiK „Dom Organizatora, Toruń.
- Knosala R i zespół, (2007), *Komputerowe wspomaganie zarządzania przedsiębiorstwem*, PWE, Warszawa.
- Krawczyk S. (red.), (2011), *Logistyka. Teoria i praktyka*, Difin, Warszawa.
- Łunarski J, (2008), *Zarządzanie jakością*, Wydawnictwa Naukowo-Techniczne, Warszawa.
- Niewiadomski P., (2012), „Jakość czy cena? – czynniki determinujące decyzje zakupu produktu na rynku maszyn rolniczych. Część I: Rozważania systematyzujące”, *Journal of Research and Applications in Agricultural Engineering* 2, Poznań.
- Niewiadomski P., & Nogalski B., (2012), „Szczupłe wytwarzanie – paradygmat lidera kosztowego w przedsiębiorstwie wiedzy”, *Przegląd Organizacji* 8, TNOiK, Warszawa.
- Niewiadomski P., & Sterna K., (2011), *Nowe podejście do ochrony środowiska wykorzystujące elementy Lean management*. *Technika Rolnicza-Ogrodnicza-Leśna* nr 6, Wyd. Przemysłowego Instytutu Maszyn Rolniczych w Poznaniu, Poznań.
- Nogalski B., (2004), *Wybór paradygmatów zarządzania przedsiębiorstwem przyszłości, Przedsiębiorstwo przyszłości. Fikcja i rzeczywistość*, I. K. Hejduk (ed.), Orgmasz , Warszawa.
- Nogalski B. & Niewiadomski P., (2013), “The problem of waste minimization during raw material cutting in a flexible manufacturing plant – practical dimension”, *Enterprise management. The customer perspective and internal processes management*, J. Kałkowska, E. Pawłowski, H. Włodarkiewicz-Klimek (eds.), Publishing House of Poznan University of Technology, Poznan, pp. 78-96.
- Michłowicz E., (2002), *Podstawy logistyki przemysłowej*, AGH, Kraków.

- Pacholski L., Malinowski B., Niedźwiedz Sz., (2011), Procesowe, strukturalne kooperacyjne aspekty innowacyjności organizacyjnej przedsiębiorstw, Wyd. Politechniki Poznańskiej, Poznań.
- Rutkowski I., (2006), Metodyczne i kompetencyjne uwarunkowania rozwoju nowego produktu w przedsiębiorstwach przemysłowych, Wyd. Akademii Ekonomicznej w Poznaniu, Poznań.
- Skowronek Cz., & Sarjusz-Wolski Z., (2012), Logistyka w przedsiębiorstwie, PWE, Warszawa.
- Skrzypek E., (2003), Miejsce zasobów niematerialnych w kształtowaniu wartości przedsiębiorstwa, Wpływ zasobów niematerialnych na wartość firmy, E. Skrzypek (ed.), UMCS. Lublin.
- Stolarek W., (1971), Podstawy organizacji produkcji, WNT, Warszawa, p. 23.
- Szymonik A. (ed.), (2012), Logistyka produkcji. Procesy, Systemy, Organizacja, Difin, Warszawa.
- Trzcieliński S., (2011), Przedsiębiorstwo zwinne, Wyd. Politechniki Poznańskiej, Poznań.
- Trzcieliński S., Pawłowski E., & Pawłowski K., (2010), Metody i narzędzia Lean Manufacturing. Poznań, Wyd. Politechniki Poznańskiej, Poznań.
- Witkowski J., (2002), Logistyka z zarządzaniu przedsiębiorstwem, Wyd. Akademii Ekonomicznej im. Oskara Langego we Wrocławiu, Wrocław.
- Wojciechowski T., (2003), Marketing na rynku środków produkcji, PWE, Warszawa.
- Zymonik Z., Hamrol A. & Grudowski P., (2011), Zarządzanie jakością i bezpieczeństwem, PWE, Warszawa.

BIOGRAPHICAL NOTES

Przemysław Niewiadomski – engineer, Ph.D. in economic sciences (organisation and management). Author of about 80 scientific publications. His research interests include: strategical management, development of industrial companies, flexibility of production facilities, knowledge management. Member of numerous organisations and societies such as the Polish Production Management Society or the Polish Economical Society.

Natalia Pawlak – assistant lecturer at the Poznań University of Technology - Faculty of Engineering Management. A logistics specialist by education. Author of about 40 publications. Her research interests include manufacturing, lean methods, logistics and transport. She is one of the founders of the Student's Process Development Group, who performed an analysis of production and organisational conditions in a company in Kruszwica and the analysis of spring production process in a company in Gniezno. In 2007 and 2008 she conducted training on lean methods for medium level managers.

i. One of the main paradigms of customer orientation in management is assuming that the requirements and needs of the company's customers have a major impact on its actions. The implementation of this concept results in the company's adjustment to those needs.

- ii. A bad choice of every strategy be it the organisation's strategy or the functional strategy, may have many negative consequences for the ongoing functioning of the company and its future. In: (Gierszewska, 2011).
- iii. Knowledge of buyers, which is gathered in proper customer relations and marketing research are indispensable when planning a production strategy.
- iv. In the following paper the terms company, plant and organisations are used as synonyms.
- v. This is one of the most important functions of the production system, understood as a purposefully designed material, energetic and information system operated by people in order to create goods required to meet the various demands of the customers. In: (Michlowicz, 2002). See also: (Szymonik, 2012).
- vi. This matter will be a subject of separate research implemented in the second part of this publication.
- vii. In the following publication, the terms production company and production facility are used interchangeably.
- viii. The production process is an ordered set of actions resulting in the manufacture of a product. In a factory this includes taking the material, performing a set of technological, transport and control procedures etc. and supplying the final product to the warehouse. See (Stolarek, 1971).
- ix. The technological process is a deliberate and ordered sequence of discreet actions, which are taken in the production system in relation to the product. J. Duda and A. Samek believe that a production system is a collection of elements whose function is the technological process. Within this process the state of the object changes from initial to final and changes based on connection of elements into the final product occur. See (Duda J., Samek A., 1998).
- x. Manufacturing goods are material objects required in the production process: work materials: (raw materials, materials, semi-manufactured products), means of labour (factories, plants, land, mines, machines, tools).
- xi. Consumer goods include goods and services produced for use of the final consumer, for personal or household applications.
- xii. In case of companies manufacturing agricultural machinery the production goods include, among others iron castings, steel castings, bars (rolled or drawn), sheet metal, used to manufacture semi-finished products (parts), which in turn, are used to build complete machines.
- xiii. The agriculture mechanisation industry is a process of replacing manual labour with use of machines and technical devices, which aims at reducing the labour requirement, improving labour effectiveness, relative reduction of production costs and providing the required crop and quality of the final product. In: (Nogalski & Niewiadomski, 2013).
- xiv. Materials and components of the final product obtained from outside often constitute up to 50-70% of the value of a given product (Łunarski 2008). This view is shared by the authors of this paper, emphasising that their quality and cost influence the final features and competitiveness of the product.
- xv. Sheet metal - metal product with thickness much smaller than the width and length. The thickness of sheet metal ranges from decimal parts of millimetre to several millimetres. The companies subject to this research most frequently use hot rolled sheet with a thickness from 1 to 5 mm, in the so called commercial sizes (sheet: 1000x2000 mm, 1250x2500 mm and 1500x3000 mm), grade S 235 JR.
- xvi. The companies subject to research declared the use of smooth rolled bars with a cross section of 35, 52, 55, 60, 90,100,110, 120 mm, grade C45 or S 235 JR.
- xvii. Bar – metal product with cross section much smaller than its length. The ratio between the cross section and length ranges from 0.001 to 0.35. Bars are characterised by high rigidity and large forces and specialist tools are required to deform them. Rods are made by rolling or drawing.
- xviii. According to the current standard cast iron is defined as a material, with iron as its main component, and where the content of carbon exceeds 2% (presence of large concentrations of carbide forming components may affect the specified carbon content) In: Norma PN-EN 10052:1999. *Glossary of heat treatment of ferrous alloys*. 1999-09-24.

- xix. In the production processes subject to research, the companies use spheroidal iron (grey cast iron, where graphite is present in the form of spheroidal concentrations. It is obtained by modifying cast iron with a tendency to solidify as grey but with very low concentrations of sulphur and phosphorus)
- xx. It should be noted that any decisions whether to produce the elements or cooperate with other companies, should be made early in the development phase of the product.
- xxi. The authors have in mind the material need planning based on the ABC method, which differentiates the material assortments in the company based on their participation in the consumption ratio and the Kraljic material analysis, which is a starting point for discussing supply strategy and shaping relationships with suppliers. The Kraljic classification of products specifies, among others a group of products, which are called "levers". These are materials or services, which have a strong influence on the company's financial results but are associated with low risk related to supplies. Such products often includes raw materials, which are subject to little processing. Failure to use the capabilities resulting from using the character of those "levers" is one of the biggest errors made in the purchasing practice. This is an area, which may use the principles of competitive market. The "lever" products present an ability to quickly lower the costs by using tools such as tenders or electronic bidding. The right classification and use of the possibilities related to those products should be part of sourcing strategies. See: (Krawczyk, 2008).
- xxii. According to the authors, the term paradigm denotes a model used to understand some aspects of reality.
- xxiii. In order to reduce the scope of work in progress, the kanban system is employed – an information system for controlling the flow of production based on the just in time principle. It calls for starting production in every phase of the cycle just as it is needed and to produce what is needed. See: (Trzcieliński, 2011).
- xxiv. As noted by L. Pacholski and his team, kaizen is both a philosophy and a method for continuous development. The kaizen approach calls for making all employees, irrespective of their position, part of improving all areas of the organisation. See: (Pacholski, Malinowski, & Niedźwiedź, 2011).
- xxv. S. Trzcieliński et al. Assumes that the 5S tool is a condition required to create a work culture allowing for quick recognition and control of work process elements by observation, without the use of computers or help from other employees. See: (Trzcieliński, Pawłowski E. & Pawłowski K., 2010).
- xxvi. As noted by P. Niewiadomski and K. Sterna SMED – i.e. quick replacement of tools allows for designing a production process where only the required amount of raw materials is used and at the same time the actions required from employees are limited (Niewiadomski, & Sterna, 2011).
- xxvii. It is a tool/method of lean manufacturing used to obtain a failure and defect free production. See: (Trzcieliński, Pawłowski E., Pawłowski K., 2010). According to L. Pacholski, Ł. Malinowski and Sz. Niedźwiedź, thanks to the improved approach to quality management and considerable improvement of production capabilities a reduction of maintenance cost and all operating costs is obtained. See: (Pacholski, Malinowski, & Niedźwiedź, 2011).
- xxviii. Care must be taken to reduce the costs only in cases where it is justified. Unfortunately it has been observed by the authors that numerous entrepreneurs, who do not fully understand the principles of the given concept and wishing to keep up with the latest fashion tend to reduce costs in areas where the costs should be increased. The remuneration of employees should not be limited as it has a negative influence on their motivation - which many seem to forget. A system must be created, which guarantees the increase of remuneration for the benefit of the employee and the company.
- xxix. The solid line denotes the ability to use a given option to make the process lean, while the broken line indicates the ability to combine the options.
- xxx. The experience effect theory states that the total unit cost of the product decreases by a constant percentage every time the accumulated value of production is doubled.