

# Legacy of Fordism and Product Life Cycle Management in the Modern Economy

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## Abstract

The industrial revolution taking place since the 18<sup>th</sup> century has brought the global economies to the stage of mass production, mass industrialization and spreading ideas connected with its efficiency. The most famous of its kind is Fordism and its modern variations called Post-Fordism or Neo-Fordism. We can still see traditional way of producing things in some parts of the world, and the leading economies are using Ford's ideas or the modifications of the Ford's concepts. But there is a question about the place of these models in the modern economy, especially because mass-production causes mass-waste and modern societies has woken up to the reality of the global pollution, climate change or just the simple fact that the amount of the raw materials is limited. The social mood is slowly changing so there should be a change to the way we produce and consume things as well. There is a question: can we proceed within existing models or should we think outside the box so we can invent more suitable way of looking at efficiency and effectiveness. The objective of this paper is to contribute to the discussion about the future of how are we going to produce things. It is based on the literature review considering Fordism and its variations, Product Life Cycle facing issues like pollution, massive waste and changes in modern economy, as well as on the case study of implementing waste reduction activities in the product' design phase in the industrial plant based in one of the EU countries – Poland.

## Keywords

Fordism, Post-Fordism, Neo-Fordism, mass production, mass waste, Product Life Cycle Management.

## Introduction

The change in the way people produce things has influenced the transformation of the economies and the societies, with their institutions, twice in the last century (Womack et al., 1990). The first transformation is considered as a change from craft production to mass production, whereas the second transformation is the transfer from mass production to flexible production. Fordism refers to the mass production and mass consumption, and it can be characterised as a change from an agricultural to an industrial.

The flexible production refers to Japanese production systems, which have developed during the 1970s–1990s (Thompson, access 2018). According to S. Wood (1993) the Japanese management methods are seen by Post-Fordism' representatives as a prototype of the flexible production, but on the other hand they expose some of the Fordism' problems. However, Fordism is described as the bedrock of the Japanese model that additionally incorporated a lot of improvements. So for that reason it can be called a Neo-Fordism, rather than a Post-Fordism, because it constitutes more of an evolution within Fordism, than it's transformation (Wood, 1993; Parkes, 2017).

The Fordist economy is a subject of constant restructuring, together with the changes of the state (Jessop, 1997) and societies. Macro-economical changes are influencing every aspect of the everyday life but the changes in a lifestyle can also influence the socio-economic conditions. In the contemporary western societies we can notice the new consumer's

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behaviours, a growing awareness of the side effects of the mass – consumption and of the influence the way we produce things has on the environment. The amount of waste in the post-industrial era, pollution of the oceans and the air, or the volume of the single-use items are building up the awareness that it should not continue in that way any longer. Simple examples of disposable everyday items like coffee cups, drink bottles, food packaging, wet wipes etc. are getting way beyond a convenience. The disposable economy – mass production, mass consumption and mass waste of the single – use items and all the other things which are so cheap that is more convenient to dispose of them and buy a new one rather than reuse them, is being questioned. There are more and more people interested in new ways of consuming, as well as producing things, which are more likely to remain in use.

The purpose of this paper is to contribute to the discussion about the future of how we are going to produce things. Are we going to succeed working around Fordism, Neo-Fordism, Post-Fordism or its variations or should we look even beyond the existing concepts. The western societies are recently being confronted with mass information about the extent of the pollution and the amount of waste we are producing globally every single day. The weather change is the closest effect we can experience in our everyday life. It is not a new phenomenon but growing mass media's focus on these issues contributes to the change in social attitudes.

This paper is based on literature review and the case study. The literature review includes Fordism and its evolution, as well as some of the side effects of mass production and consumption like pollution or mass generation of waste. Then the Product Life Cycle Management and chosen aspects of modern economy are analysed. The literature review has been combined with the analysis of secondary data including EU circular economy strategy. The case study is an example of introducing waste reduction activities in the product' design phase in the industrial plant based in one of the EU countries – Poland. The activities include Lean Manufacturing implementation in the company representing the armaments industry. These concepts can be linked with Post-Fordism or Neo-Fordism and its implementation can be an example of the possible improvements in any Product Life Cycle Management, in any area of industry as well. The Post-Fordism or Neo-Fordism models offer a lot of solutions towards waste management, so they could be used parallel to seeking for the new solutions.

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## Methodology

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The case study was part of the project related to implementation of the Lean Manufacturing concept over the years 2012–2016 in one of the Polish companies representing the armaments industry. The company is a part of a group of more than 60 different plants and businesses, employing over 17,500 persons, and recording annual revenues of more than PLN 4.5 billion.

The case study was conducted as a part of a more extensive Lean Manufacturing project implemented in this enterprise. It comprised a sub-project entitled “Operational improvement programme for the Engineering and the Technological Department” covering the following items: improvement of the Engineering Department's operations and improvement of the Technological Department's operations.

The Group and its individual companies deploy modern production and management concepts, including Lean Manufacturing and Management. This is associated with the Group's short-, medium- and long-term operating goals. Some of the most important of these goals are: consolidation of the domestic defence industry involving both state-owned and privately owned companies, as well as implementation of business operations to guarantee rapid growth and modernisation of the Group, and increasing its competitiveness in the international armaments market.

One of the ways to pursue these goals is through implementation of the aforementioned Lean concepts in selected representative businesses of the Group. The company chosen for purposes of the research was one, which could be considered as representative of other entities in the Group on account of the manufacturing processes it had deployed as well as its size (being classified as a part of the SME sector). The Lean Manufacturing concept is essentially based on an assumption that various forms of waste are identified and eliminated from processes. Once defined (in this case – according to the procedural criteria of waste assessment), the waste forms are analysed and adequately assessed. Different methods applied to eliminate or minimise waste are established. One is to determine where teams must interfere in order to eliminate the waste and how to measure the outcomes attained in the given process.

The analysis was conducted using techniques of value stream mapping and problem solving methods such as the Waterfall chart or the 5Why+1How analysis. According to the analyses performed in the enterprise, ca. 40% of the errors made at the production and assembly lines was caused by imperfections in the

design documentation of respective parts. It was the main reason why investigations of this problem had been initiated in the first place, as described further on in the case study. The process of preparing the structural drawings of parts was analysed on the following basis:

- Process mapping according to Value Stream Mapping principles
- Interviews with the Engineering Department's personnel and management
- Review of the Department's documentation, including engineers' work sheets
- Analysis of data from the in-house controlling system.

The research confirmed the following thesis:

1. Lean Manufacturing is a method which enables the Group, including the companies representative of the Group, to pursue its operating goals;
2. In order to fulfil these goals one should start implementing the Lean concept from design-related activities performed while developing engineering and technological processes whenever they determine the efficiency of the follow-up production processes, especially in their initial phase;
3. Implementation of Lean in this particular case will reduce the time of activities which do not generate value added to design-related operations;
4. It is significantly easier to implement the Lean Manufacturing concept and to attain positive outcomes of this endeavour when Group Technology is being deployed simultaneously to Lean.

## Fordism, Post-Fordism, Neo-Fordism or...?

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Fordism is such an important subject not only because it has changed the economies in the 20<sup>th</sup> century but because it still exists and shapes the life of modern societies. As we can see, it has been restructured and modified but whatever prefix we will use to describe its modern variations, the original ideas are still there. It is so potent that there is high possibility that it will still shape the majority of economies worldwide, but at the same time we are at a point that should lead to a change. The side effects of mass production should not only be dealt with when they appear but at the point where they arise.

Fordism is characterised in the narrower or broader sense. It is widely described as the 20<sup>th</sup> century system of mass production, pioneered by the Ford Motor Company and firstly popularized by Henry Ford. In a broader sense it is seen as (1) "industrial paradigm", (2) "national accumulation (or growth)

regime", (3) "mode of regulation", and (4) "form of social life". This broad spectrum underline that the system involves not only mass production or mass consumption, but can be "characterized by mass media, mass transport, and mass politics" (Jessop, 2016). According to B. Jessop (1995) Fordism as an industrial paradigm involves mass production, based on the moving assembly – line, run by semi-skilled workers. When considered as a regime of accumulation, it involves macroeconomic growth through mass production productivity, economy of scale, or raising mass demand. Fordism as a mode of social and economic regulation is linked to Taylorism in the field of separation of ownership and control, and can also involve monopoly pricing, union recognition, etc., and as a pattern of social organisation involves, inter alia, mass consumption (Nordick, 2016).

Ford's system is characterised as using some of the solutions created within the Taylorism or scientific management, but at the same time there are differences pointed out between these two concepts (Ćwiklicki, 2011). Taylor's organisation of work allowed mass production and consumption to be developed. Fordist model is described as based on the concept of mass production or division of intellectual and manual work, which is a clear link to Taylorism (Souza, access 2018). Taylorism is characterised as more wider approach, whereas Fordism as a mass production system (Degan, 2011). Taylor is described as the inventor of industrial engineering (Dennis, 2002) and the one not only having influence on Henry Ford's assembly line, but a much wider impact as well (Kanigel, 2005).

Both – Taylorism and Fordism – are considered to be responsible for the success of American motor vehicle companies up to mid 50s (Degan, 2011). But the crisis of Fordism that emerged in the mid-1970s has provoked discussions not only about the weak points of Fordism itself, but "whether Fordist stability was a parenthesis in an otherwise disorderly, crisis-prone capitalist system" (Jessop, 2016). The development of computer – based systems, flexible manufacturing, rising raw material prices or consumers demand for differentiated quality, etc. led to the rethinking of the Ford's concept (Souza, access 2018). As the consumers started demanding better quality and performance, the production techniques had to focus on added value or flexibility, including the workforce (Morley and Crowley, 1997). In the global competition the Japanese auto industries' ideas were winning with those of North America or Europe, where the techniques were little changed from Ford's mass production system (Womack et al., 1990). The reason for an interest in Japanese way of making things was the efficiency, the productivity and winning the global com-

petition. Despite borrowings from Ford and Taylor, the Japanese production techniques or the Japanese way to do things were different from the American way. Moreover, the differences can be rooted in the cultural level and influenced by different economical and social demands (Parkes, 2017).

In the mid 20<sup>th</sup> century the Japanese saw Taylor's ideas as essential part of the economic growth (Kanigel, 2005). There are lots of indications of F. W. Taylor's and H. Ford's influences on the Toyota Production System (Liker, 2005; Dennis, 2002; Ohno, 1988), but there were major differences as well. For example, according to T. Ohno (1988), Ford mass production system (automobile production system or automation system) was based on specifically directed workflow, production of "large lots of a single part" or "lots of inventory". Whereas Toyota (autonomation) system was based on "small lot sizes and quick set-ups", elimination of overproduction or kanban system "in which a later process goes to an earlier process to withdraw parts needed just in time", etc. (Ohno, 1988; Jakonis, 2012; Parkes, 2015; 2017). The techniques developed in Toyota allowed production of small batches which led to lowering the costs by decreasing large inventories, waste and parts with defects and increasing the quality of produced goods. But there were another crucial changes implemented like: life – time employment, awarding the seniority or a team approach (Deegan, 2011), and much wider differences like the way to finance the industry (Womack et al., 1990).

According to P.S. Adler (1992), Toyota production system and its variations, could be characterised as different from Taylor's model so for that reason the term "post-Taylorism" has been used, even though they implied strong references to Taylor's thoughts (Ćwiklicki, 2011). P.S. Adler presented an example of successful and innovative implementation of "Taylor/s time-and-motion regimentation", which provides quality and efficiency in routine operations and appeared to encourage continuous improvement, and at the same time to be able to become a learning-orientated, humanised bureaucracy, that was one of the ways to overcome some of the disadvantages of traditional Taylorism like de-skilling worker's tasks, leading to alienation or rigidity (Adler, 1993). P.S. Adler is using the term "post-Taylorism" in his previous work (Adler, 1992), but at the same time it looks like the flexible systems could be actually analysed as an examples of a neo-Taylorism because the original concepts have been more reformulated than abandoned. The examples of manifestations of neotaylorism in contemporary workplaces are: selection of employees by employing only the best candidates, innovation and development in the work' methods,

quick feedback about completed work or standardisation and scientific measurements (Ćwiklicki, 2011).

The post-Taylorism could be used as a term to describe the answer to the crisis of Taylorist organisation of work, which included increasing work' intensification, deskilling, monotony or alienation. But, according to Hirsch (1991), this crisis is seen as a part of a wider crisis of the Fordist model, which additionally includes critical points of the corporatist welfare and interventionist state, consumption model, ecology or a Fordist model of accumulation (Souza, access 2018). Thus, the term Post-Fordism is used to characterise the regime focused on: new technologies, post-industrial production, flexibility of machines, systems and workforce, economy of scope, etc. (Jessop, 2016). Post-Fordism should be applied not only to the changes in organisation of the production, but according to Hall (1994), to the wider social changes, like the increase in pluralism, new identities connected with raising work flexibility or individualisation (Souza, access 2018). Another point of view is to use the prefix "neo" while describing flexible production systems, like "the Neo-Fordism school of Japanese management" (Morley and Crowley, 1997).

However, there are opinions that no real change occurred. Neither post-Fordism replaced the Fordism model, nor it could be considered as an evolution. The productive process is still focused on increase in productivity, profitability, etc., so Taylorism-Fordism production' organizational methods are still intact, and to many the "post-Fordism is like Fordism" (Souza, access 2018).

Furthermore, these concepts are still vital to the global economy. In some industries, like automobile mass production, more democratic form of Taylorism was forecasted to have a future (Adler, 1992). The mass production or Tayloristic model could be replaced by Japanese methods, based on flexibility or semi – autonomous teams. But at the same time, Taylorism could be still in use in automobile final assembly' sector (Adler, 1992). Nowadays we can see the essence of Taylorism for example in a new participatory management schemes or assembly line tasks and services that are timed to seconds, standardization of the consumer' goods or the modern life itself (Kanigel, 2005). The Regulation Approach is often criticised as too simplistically pointing the transition from Fordism to a post-Fordism, whereas later research pointed to complex and different models of development (Jessop, 1997). Some theorists propose alternatives to Post-Fordism, like "Toyotism, Fujitsuumism, Sonyism, Gatesism, informational capitalism, the knowledge-based economy" or "the network economy" (Jessop, 2016).

## Product Life Cycle in modern economy

Summarising the development of Ford's concepts, they can still be vital, especially in the developing countries that are going under heavy and quick industrialization. The developed western economies are partially still using traditional ways of producing "things", but the one who wanted to win the competitive markets were trying modifications like post-fordism' flexible management techniques or neo-fordisms' modifications and the nowadays innovations. But there are changes on the horizon and they appear to be so significant that the existing ways of organising human's economic activity may not be enough. The mass-production and mass-consumption causes mass waste and is connected with a high level of pollution of the environment. The changes that are predicted to happen according to climate change or the limited amount of raw materials are one of the factors that make people think about the way the things are made and consumed.

The pollution and a growing amount of waste is not a new phenomenon but recently the discussion about it is being made one of the mainstream topics in western media. There are issues like waste management or the amount of plastic floating in the water all around the world. According to the research (2015) led by Erik van Sebille at Imperial College London the amount of plastic particles in the world's oceans was estimated between 15 and 51 trillions. One of the problem is the amount of non- biodegradable single-use plastic, so it is advised that the waste hierarchy should be focused more on reduction and reusing than recycling (Evans-Pughe, 2018). The awareness of the amount of generated waste and the need to prevent it leads to new social phenomena. One of them is "zero-waste lifestyle" which manifests itself in actions like: choosing packaging-free food, reusing containers and the things we bought, reduction in consumption or avoiding all plastic (Loeb, 2017–2018).

Another phenomenon we can notice in the modern economy itself is its quick evolution in the direction which is going to bring significant changes not only to the way we produce "things" but to the way we consume, work, or live. The important change to the modern economy began in the 18<sup>th</sup> century with an industrial revolution. Today, we divide this phenomenon into four phases. The First Industrial Revolution (IR) was based on the iron, coal and textiles, whereas during the Second IR (late 19<sup>th</sup> and 20<sup>th</sup> centuries) the industry started to exploit the synthetic materials like plastics (Encyclopedia Britannica, 2018). It has applied the science to mass production and manufactur-

ing as well. The Third Industrial Revolution or Digital Revolution has been focused on electronics and IT systems, whereas the Fourth IR – on new technologies which combine digital, biological and physical innovations like AI, genome editing or robotics (Schwab, 2018). We can say that Fordism and automation can be linked with 1<sup>st</sup> and 2<sup>nd</sup> Industrial Revolutions, whereas Post – Fordism or Neo-Fordism as well as Japanese automation can be connected with the Third Industrial Revolution. But the latest innovations, like stated above cyber-physical systems, can be linked with a wider social change. The modern economy has been described by different names: Global, Knowledge based, Green, Virtual Economy, etc., that are emphasizing the areas that have been developed or need to be focused on. But at the same time there are new emerging issues, like "zero-marginal-cost economy" (where technological revolution might bring the marginal costs to near zero), that is connected with such phenomenon as the Internet of Things or "sharing economy" based on a "shared access rather than private ownership" (Rifkin, 2014). According to J. Rifkin, as a result of bringing the costs down by the dynamism of competitive markets, "many goods and services are becoming nearly free, abundant, and no longer subject to market forces" (Rifkin, 2014). The Fourth Industrial Revolution, with the concepts like: disruptive technology, machine learning, robotics, artificial intelligence or Big Data, is anticipated to change the existing industry as well: its core workings, jobs on offer, desirable skills, or a social class structure (Feest, 2017–2018). These changes affect economic behaviours as well, as we can see on the above example of a "sharing economy" stated by J. Rifkin, when consumers prefer sharing to possessing. And that lead to the question about the volume and product life cycle in the economy today.

This leads us to the conclusion, which applies to the Product Life Cycle (PLC). And it is so interesting how the possible redefinition of the PLC management can be connected to the wider social phenomenon like desire to extend not only human' life expectancy but its quality as well. The contemporary social discourse in western media is about not only living longer but also staying young and fit, finding new ways to redefine and express oneself in the latest stages of life. That can be linked with growing population and life's expectancy, and when adding other factors like economic growth of developing countries, we can see that mass production and mass consumption are going nowhere. Moreover, western economies are looking more closely at the new ways of consuming which could sustain economic growth but at the same time meet the needs of the environment and the social expectations.



An example of the new ways of consumption is: buying second-hand items, reselling, exchanging, sharing and reducing the amount of possessions or at least the consumption of single-use items. Furthermore, there are more and more companies focusing on the products that are “design to last” (Fryer, 2017–2018). An example of these can be an automotive company, whose business model is to offer a car “under a mobility contract”, so in company’s interest is to focus on longevity of the product rather than its obsolescence (Fryer, 2017–2018).

The classic stages of the product life cycle include market’: development – growth – maturity – decline. The process is described as bringing new product to the market, dealing with increasing demand, the market’ saturation phase and the decreasing of demand and sales (Levitt, 1965). Propositions of extending product life cycle included focus on the current users – by promoting more frequent or more varied product’ usage or on creating new users – for example by expanding the market (Levitt, 1965). The classic Product Life Cycle Management, even though it has been criticised or modified, is still valid and focusing on extending the life of the product. Nowadays, the circle of a product life is being characterised for example as: Concept – Design – Manufacturing – Distribution – Customer – End of Life, but there are voices that Product Life Cycle Management rarely includes all stages of product’ life (Fryer, 2017–2018). And it is suggested that the focus should be placed on the full circle, with a specific interest in design and development in which there will be indications what can be done to the product to extend its life and at the end of its existence (Fryer, 2017–2018).

Some of the reasons for not planning the end of product’s life in the designing phase could be the character of the product or restricted ways of recycling it. However, there is still a lot of improvements that can lead to efficiency’ increase and the reduction of the waste generated in the process itself, which can be demonstrated by the case study in Polish industry.

## Case study – results and conclusions

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We can state that a complete product life cycle actually consists of four cycles that may be described as follows:

- Preliminary cycle, where having taken customers’ opinions, marketing conditions, profit and demand into consideration, one produces a product, runs its tests (Crovling et al., 2003) and analyses the technological aspects of its design. The cycle ends when the product is introduced into the market,

- Growth cycle – a period when the manufacturer’s sales and profit typically grow. It is in this period that product promotion expenses increase,
- Maturity cycle – the sales reach peak values in this period. In the maturity period, one typically performs implementations aimed to upgrade and improve the product design as well as the relevant production technology,
- Decline cycle – the sales keep declining until the product is finally withdrawn from the market.

From the product life cycle perspective, the legacy of Fordism is particularly related to post-Fordism, i.e. implementation of production systems characterized by flexible specialization which can be attained by differentiating the products offered in the market, manufactured in shorter batches. Diversification and flexible specialization is being limited to producing sets of products that are very much alike in terms of geometry and technology. Such similarity is defined on the basis of what is referred to as Group Technology. Flexible specialization also requires optimization of all processes implemented by businesses. Optimization means that processes should be relieved of all waste, namely actions which do not generate any value added. This involves process management by deploying and following the principles of Lean Manufacturing. The enterprise addressed in the case study has implemented all four phases of product life cycle. Their pursuit of flexible specialization, as well as identification and elimination of waste have enabled them to diversify their market offering. Once focused on production for the local market, this enterprise has started to export their merchandise. The case study describes selected activities conducted in the preliminary cycle of one of products manufactured in the chosen arms industry facility referred to as Factory X (Bednarek and Buczacki, 2015). Factory X is a manufacturer and supplier of arms purchased by the Armed Forces of the Republic of Poland and the Ministry of the Interior as well as exported and sold in the civilian market. The range of the Company’s operations comprises production of arms, sporting weapons and training sets. The Company uses the experience and competencies of its personnel as well as technologically advanced and diversified machinery and equipment. They have established contacts and collaboration with technical universities and research institutions as well as directly with users of their products, while the positive outcomes of the resulting exchange of experience enable them to upgrade and improve their products on a regular basis.

The case study was conducted as a part of Lean Manufacturing project implemented in this enterprise. As stated in Methodology, according to the analy-

ses performed in the enterprise, ca. 40% of the errors made at the production and assembly lines was caused by imperfections in the design documentation of respective parts. For that reason the process of preparing the structural drawings of parts was analysed.

Results of the observations have been provided in Table 1 and collated in Table 2.

Table 1  
Process of preparing structural drawings of parts

Action	% of duration time
Allocating parts	1
Geometry analysis	5
Chains of dimensions	5
Drawing preparation	8
Correlating drawings of different products parts	10
Review of drawings	5
Completing drawings	15
Analysis of technological aspects of design	5
Acceptance and analysis across different levels of management	46

In order to optimise the process of preparing structural drawings of parts and to improve its quality, the following was arbitrary recommended by the team of engineering design experts:

- all activities correlating drawings of different products parts are value added
- all activities correlating acceptance and analysis across different levels of management are non-value added.

Only 7 among 9 actions comprising the process create value added. One of the non-value-added-creating actions, i.e. acceptance and analysis, accounts for as much as 46% of the total process time.

In order to optimise the process of preparing structural drawings of parts and to improve its quality, the following was recommended: Time of acceptance and analysis related actions should be reduced and time of drawing review actions should be increased. With the above objectives in mind, a pilot implementation was conducted on the basis of the following arbitrary assumptions:

- Acceptance and analysis time should be reduced by a half, i.e. to 23% of the total process duration time.
- Drawing review time should be increased to 25% of the total process duration time.

Table 2  
Analysis of the process of preparing structural drawings of parts

Item	Parameter	Parameter value	% share in process duration time
1	Number of actions per process	9	100%
2	Action duration	116 hours	100%
3	Waiting time	70.76 hours	61%
4	Most time-consuming engineering actions	<ul style="list-style-type: none"> <li>• correlating drawings of different products parts (11.6 hours)</li> <li>• analysis of technological aspects of design (5.8 hours)</li> <li>• drawing preparation (9.3 hours)</li> </ul>	39%
5	Most time-consuming in-waiting actions	<ul style="list-style-type: none"> <li>• acceptance and analysis (53.36 hours)</li> <li>• completing drawings (17.4 hours)</li> </ul>	61%

- The share of the actions comprising the analysis of the design’s technological aspects in the total process time should remain unaltered.

In order to reduce the share of non-value-added-creating actions in the total duration time of the process in question, it was decided that the Technology of Groups and particularly the principles of classification and codification of the parts manufactured by the enterprise would be applied in the engineering activities (Bednarek, 2015). The foregoing has been illustrated in Figure 1.

The classification and codification system was implemented in the following steps:

- a random set of parts manufactured by the enterprise was established,
- the set of parts was subject to routine acceptance and analysis (compare Table 1),
- the time required to complete these actions was measured,
- the set was divided into groups of similar parts in accordance with the principles of classification (compare Figure 1),
- a representative of each group of similar parts was defined (the most geometrically complex part),

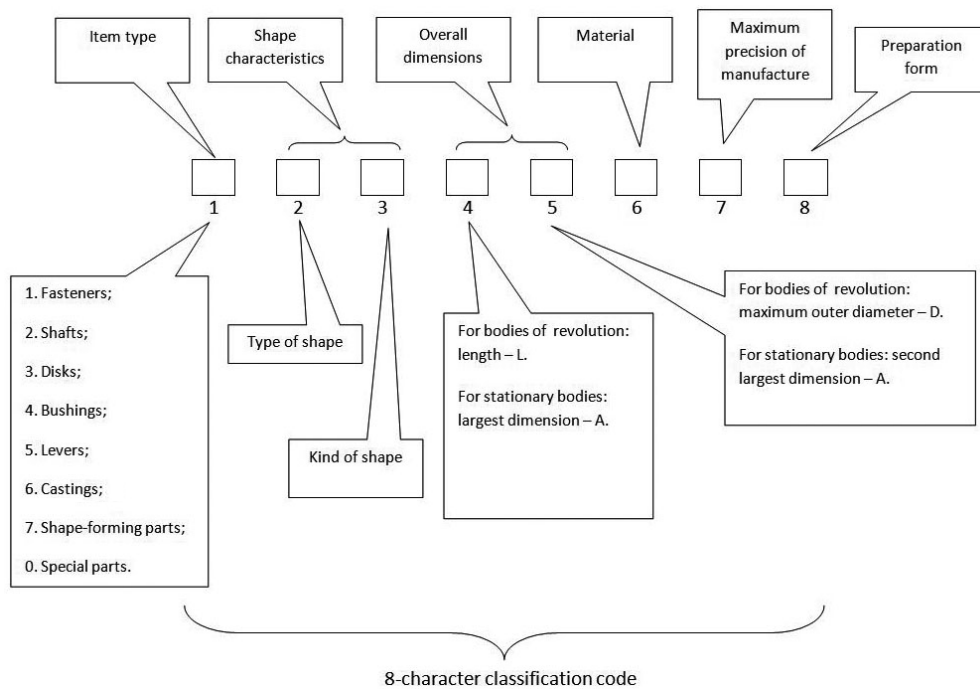


Fig. 1. Classification and codification of parts manufactured by the enterprise (Bednarek and Rybak, 2014)

- the acceptance and analysis actions were repeated with reference to the representative parts,
- the acceptance and analysis time was reduced from 53.36 to 32 hours (27% of the total process duration time),
- 19% more time was allocated to the review actions, consequently leading to a 40% reduction in the number of geometrical and dimensional errors revealed in the drawings of parts.

Suggestions:

1. Reasons for numerous costly errors made in production may be found in the processes involved in preparation of structural drawings of parts.
2. They are responsible for prolongation of the preliminary cycle and delays in introducing new products into the market.
3. However, conducting adequate analyses as well as implementing the principles of the Technology of Groups in engineering processes make it possible to reduce the number of errors in designing and building of the product, consequently shortening the preliminary cycle time in the total PLC.

### PLCM – further expectations

As we can see on the example of above case study, there are improvements which are being made during the design' phase of a new product.

Nowadays, PLC Management faces even more expectations. The designing products that last longer and can be repurposed or recycled, can help to reduce the amount of waste, cut down the amount of natural resources used or change the ways of consumption. There will be standards to help to implement the European Union's Circular Economy Package, with PLM techniques, including guidelines for designers and covering issues connected with product longevity or "ability to repair, re-use and remanufacture" (Fryer, 2017–2018). The circular economy' goal is "to maintain the value of products, materials and resources for as long as possible by returning them into the product cycle at the end of their use, while minimising the generation of waste" (ec.europa.eu). To monitor the framework on the European Union circular economy there are 10 indicators grouped in 4 areas: 1) production and consumption, 2) waste management, 3) secondary raw materials, 4) competitiveness and innovation. The progress of the selected indicators (from each group) is presented in the Table 3.

One of the above indicators – the circular material use rate – measures the share of material that was recovered and fed back into the economy. It is "defined as the ratio of the circular use of materials to the overall material use" (the higher rate the more secondary materials substitute for extracted primary raw materials) (ec.europa.eu). It is one of the crucial elements of the circular economy, which seeks to turn



Table 3  
Selected EU Circular Economy indicators ([ec.europa.eu](http://ec.europa.eu))

	2006	2009	2012	2015	2016
1. Generation of municipal waste per capita [kg per capita]	522	511	486	481	483
2. Recycling rate of municipal waste (and recycling rate of plastic packaging) [percentage]	– (26.4)	37.3 (31.9)	41.1 (35)	44.6 (39.9)	45.3 (42.4)
3. Contribution of recycled materials to raw materials demand – Circular material use rate [percentage]	9.3	10.8	11.2	11.4	11.7
4. Gross investment in tangible goods in the circular economy sectors (recycling sector, repair and reuse and rental and leasing sector) [percentage of GDP at current prices]	–	–	–	0.12	0.12

the waste into valuable resource. The other indicators, presented in the Table 3, as the measures of developing circular economy, show that there is some progress in reducing the amount of waste, increase in recycling, or circular material use rate, but there are areas with no growth like gross investments in tangible goods. There is a question about the sufficiency of the growth of the rest of the indicators. For example, analysing the Eurostat data, the EU plastic packaging' recycle rate grew over a period of 2006–2016 on average 1.6% a year. With this average growth the rate in 2030 will be nearly 65%. Even if we assume that the rate growth will be faster, for example between 2015 and 2016 it increased by 2.5%, this level of growth will deliver over 77% rate in 2030. Whereas the EU "vision for Europe's new plastic economy" is stating, inter alia, that "by 2030 all plastics packaging placed on the EU market is either reusable or can be recycled in a cost-effective manner" (European Strategy). With the rate increase on the current level, around one third of the

plastic packaging will not be recycled. So, it must be reusable or the rate must increase, otherwise this vision will be difficult to turn into reality.

## Discussion

The issues stated above suggest that today's mass production and mass consumption models have such a significant impact on the whole ecosystem, that we can't ignore it any longer. The change is required; even so it could be difficult to transform the systems, consumer's behaviours, etc. However, there is always a possibility for improvements that could be focused at least on some areas.

That is why, Product Life Cycle Management can be a platform for improvement, furthermore it involves the designers', producers' and consumers' combined effort, and so we can avoid placing responsibility only on the one group. Product Life Cycle according to a Fordism model can still be focused on extending the product' life by promoting more varied product' usage or finding new uses for the product, as suggested by Levitt (1965). The need to reuse involves even more focus on extending product's life, on its longevity (Fryer, 2017–2018) and ability to evolve. There is already an increased focus on the latest stages of product life. Today's PLC could look more like: development – growth – maturity – decline – reuse/repair/remanufacture/recycle/dispose, so "the end of life" phase can be pushed as far away as possible or can be linked with another product' development stage. But the reason behind it can't only be connected with profitability, but with other urgent issues like reduction in raw materials use and waste generation.

It looks like this is the issue that goes beyond social responsibility. The conclusion that "less is more" is the new demand in even more an environmental than market sense, but there is quite a simple fact that there will not be any market without the environment. Consumerism could possibly reach the point that there are not a lot of things, which an average consumer really "needs". There could be still a lot of things that the consumer "desires" but high accessibility and low prices or a charitable giving of consumer goods in developed economies could lead to the point of saturation of basic needs. Furthermore, there are other areas for the social and market responsibility than consumption, for example focusing on the groups deprived by poverty or alienated by homelessness, and there is a high demand for social responsibility and maturity in production and consumption, in every sector of the economy.

Moreover, the change does not have to be painful, neither for producers nor consumers. There can still be a high level of consumption but of a different kind. And it can be linked with Product Life Cycle Management, for example by increasing “post-purchase” satisfaction. This can be achieved for example by increasing services, warranties and other activities connected with the sale which can generate profit instead of manufacturing and selling more volume. Including the post-purchase services in the price would justify holding or increasing the price instead of introducing discounts and credits and it could build long lasting relationship with the customer. It could be more beneficial to help maintaining client’s loyalty and building long-lasting satisfaction and responsibility instead of such phenomena like for example accidental and short gratifications connected with impulsive buying.

Post-purchase services can be linked with investing in people and creating new work places. For example: call centres, blogging, online customer service are already there, they should be more client-friendly, focused on talking with customer rather than speaking to customer and on building a relationship. The services can provide information about updating the product or give customers updates of the ways of re-purposing the product. Redirecting promotion towards public relations instead of sales promotion can be linked with it as well.

The increase in online shopping and e-services has already been connected to the importance of post-purchase services, but there is also focus on the pre-purchase and transactional services that improve customer experience. So, while developing websites, companies should focus on including the customer services in the design, the services that start before finalising the transaction (Küster et al., 2016). And that can be developed and extended not only to increase companies’ profitability, but also to shift customers’ satisfaction beyond just the act of purchase. Replacing high level of consumption of physical goods by consumption of services connected with the purchasing process could help to reduce waste generation without decreasing companies’ profitability.

Fordism’ ideas like mass production, or its modern variations: Post-Fordism or Neo-Fordism with flexible production systems are still vital globally. Mass production, standardisation, assembly line, outsourcing, mass consumption, etc. are the “old” Fordist existing concepts in the developed and in the developing economies. As well as 20<sup>th</sup> century’s innovations: quality and elimination of defective products, flexibility, differentiation of products, embracing craft production and individualisation, etc. But at the base of it we can place the profitability and consumerism, which

is hard to sustain with its side effects like waste or pollution. The consumers are more and more aware of the issues highlighted in this paper, but they cannot be the only ones made responsible for resolving them. Every sector involved in Product Life Cycle has to take these issues into consideration and look into other possibilities of adding the value. There are possibilities of improvements to be made within existing models, but there could be new ideas, like the sharing economy or consuming more services than physical products. The thing to remember while creating new systems is the basic consequences of the developments and considering all the stages of the products’ life cycles.

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