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PROPOSITION OF IMPROVING SELECTED LOGISTICS PROCESSES OF PELLET PRODUCTION

Abstract: *The principal objective of this article is to provide the profile of the market of pellet in Poland, and also to develop a design of the production of pellet, taking under a particular consideration the essential activities connected with the entire process of production. This article includes, among others, the analysis of demand for raw materials, and also the analysis of the entire process of production, including the identification of the following processes: technological, transportation, and also the storage ones. This design is intended to be applied by small and medium-sized enterprises conducting their business activity in Eastern and Central Europe which are wishing to optimise and streamline conducting essential processes in which they are involved. This study provides the guidelines to managers and decision makers in pellet industry to optimize the process of the production of pellet in order to develop the sustainable logistic environment.*

Keywords: *Pellet Production; Logistics Processes; Sustainability; Process Improvement; Production engineering.*

1. Introduction

The promotion of sustainable development renders it indispensable for enterprises to look for solutions which may reduce the negative influence exerted by their production activity upon the environment (Zimon et al., 2019; Fonseca et al., 2018). The need to generate thermal and electrical energy, global warming caused by increased emissions of greenhouse gases, rising fossil fuel prices and demand for energy independence, have created a new industry focused on energy production through the use of renewable sources. Among the different options, biomass is the third most important source for obtaining electricity, and is the main source for the production of thermal Energy (Nunes et al., 2014). One of the methods of reducing the emission of greenhouse gases is to use biofuels. Biofuels, in contrast with traditional fuels (such as: petroleum, natural gas or carbon), are produced of biomass, and plants are used in the process of the production of these fuels. This fact means that biofuels are included into the group of clean energy sources, which exert a positive influence upon the environment, and also upon entire economy (Saidur et al., 2011, Zimon, 2020). The production of them may improve the level of the energy security of a country as well. An instance of a biofuel is constituted by pellet, which, in the course of time, is becoming more and more popular both amongst customers being natural persons and amongst the institutional ones (Lysenko-Ryba & Zimon, 2021; Krivokapić & Stefanović, 2020). Using plant biomass for the production of energy (including for the production of pellet), in the aspect of looking for modern solutions rendering it possible to acquire energy from renewable sources, is

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enjoying enormous interest in our times (Magelli et al., 2009). Biomass is a renewable energy source and its importance will increase as national energy policy and strategy focuses more heavily on renewable sources and conservation. Biomass is considered the renewable energy source with the highest potential to contribute to the energy needs of modern society for both the industrialized and developing countries worldwide (Núñez-Retana et al., 2019; Demirbas et al., 2009). Wood waste, which constitutes one of by-products in the plants of the woodworking industry, has become the source of raw materials for the production of pellet. This fact constitutes an additional advantage, and contributes to a constant increase in the popularity of this biofuel (Galik et al., 2009). All of the described aspects exert influence upon an increasing demand for pellet, and intensify a constant interest in the processing of it, not only amongst institutional customers, but, as well, amongst those being natural persons (Ackom et al., 2010).

Wood pellets are currently the preferred form of biomass for effective heating, and demand for them has increased rapidly over the last decade (Lamers et al., 2012). The pelletizing process offers a number of benefits; increases the energy density of the biofuel, reduces handling, storage and transportation costs, and improves overall biomass quality and durability. Demand for wood pellets is anticipated to expand due to government support for renewable sources. For example, the European Commission's Renewable Energy Directive has committed to achieving a 27% share of renewable energy in total energy consumption across its member states by 2030. In addition, it is expected that 42% of renewable energy will be obtained from biomass, such energy being used for heating, cooling and electricity generation decade (Padilla-Rivera et al., 2017).

The production of wood pellet experienced a revival in the 1990s, and it has been developing since then. Certain countries have been encouraging the use of wood pellet within the frameworks of their energy environmental policy (by means of enacting an environmental tax, supporting the implementation of machines powered with the use of biomass, education and so on, and so forth). The implementation of fuels produced of biomass has also been one of the important measures taken to counteract global warming, which were to improve the level of local energy security and counteract the effects of increase in the prices of petroleum (Mobini et al., 2013). In the year 2016, the market of wood pellet experienced the surplus of production capacities, which brought about decrease in its prices, whereas in the year 2017 another phenomenon was observable, namely, that of a substantial demand dynamic. The worldwide demand for this raw material increased year-to-year by 13%, and that means by 3.7 million tonnes (Olkuski & Stala-Szlugaj, 2018).

AEBIOM, which stands for the European Biomass Association, in the year 2015 included the following countries into the group of the largest producers of pellet: Germany (approximately 2.0 million tonnes), Sweden (approximately 1.7 million tonnes), Latvia (approximately 1.5 million tonnes), Estonia (approximately 1.3 million tonnes), Austria (approximately 10 million tonnes), and also France (little fewer than 1 million tonnes). The countries with lower positions in this ranking were: Poland (approximately 900 thousand tonnes) and Portugal (fewer than 500 thousand tonnes). It is important that, in the years since 2000 until 2010, the use of this fuel increased seven times in Europe (www.pelet.info.pl).

The market in Poland is becoming more and more popular as well. The number of the producers and distributors of this biofuel is increasing. Into the well-known brands in this group, Barlinek, IKEA, Pellet Stelmet, Pellet Energy, Biomass Partner, PelletPol, and SYLVA wood, to name but a few, are included.

Regardless of that fact, in accordance with the data provided by the Baltic Energy

Conservation Agency Ltd., only one-third of the domestically-produced biomass is used in Polish boiler rooms. The remaining part is exported, principally to Germany and to Austria. The legal provisions forbidding the use of obsolete boilers enacted by the Polish government may, nevertheless, change quite a lot. In accordance with forecasts, the legal regulations in question will bring about, within the next few years, a substantial increase in demand for biofuels, which will, in turn, bring about increase in the production of pellet, and also in the production of modern boilers.

In order to reach the largest number of customers, enterprises are already developing platforms where it is possible to find a supplier from the immediate vicinity of a customer, and also perform cost calculation.

An instance of a map of the producers and suppliers of pellet is presented in Fig. 1.

Figure 1. Map of Polish producers

Green is used to mark producers and distributors, and blue to mark the suppliers of technologies used for granulation and of packaging. In turn, grey is used to mark institutions involved in research, and in the certification of pellet. Finally, red is used to mark the producers and distributors of boilers powered with the use of pellet.

Key parameters of industrial sustainability include economic, social, and environmental benefits. Development of the wood pellet industry has resulted in job creation along the value chain from feedstock sourcing to pelletization and shipping, which in turn delivers both economic benefits (new revenue streams) and social benefits (job creation). The introduction of wood pellets has successfully led to effective utilization of sawmill residues which 16 years ago were mainly landfilled or burnt in beehive burners without any energy reclamation. From an environmental perspective, this is clearly an improvement—the use of wood pellets in a furnace or boiler system allows highly efficient energy recovery, offsetting the need for fossil fuels (Ackom et al., 2010). The worldwide tendencies indicate that, within the next few years, the European market of pellet will be developing, which ought to constitute a significant premise for increasing the production capacities of potential producers and exporters from Poland. According to studies by Laschi et al. (2016), Murphy et al. (2010) and Ackom et al. (2010) companies producing pellets should especially take care of the effective implementation of production and logistic processes because they consume the largest amount of energy during their implementation. Therefore, the appropriate organization of production processes in enterprises becomes crucial not only for economic but also ecological reasons. Thiffault et al. (2019) emphasizes that the quality of the bioenergy end-product can be significantly improved, and production costs reduced, by close integration of production lines of conventional forest products (such as flooring) and bioenergy products. Developing more formal relationships between the type of process that generates residues (e.g., planning, trimming, sawing), and the physical and chemical properties of residues hence generated (which can then be used to predict pellet quality), would greatly contribute to the optimization of pellet production by reducing uncertainty associated with the "trial-and-error" method too often used in current pellet production (Kong et al., 2012). In turn, Rentizelas et al. (2009) emphasizes that the larger fraction of cost in biomass energy generation originates from the logistics operations. A major issue concerning biomass logistics is its storage, especially when it is characterized by seasonal availability.

Enterprises producing pellet ought to, therefore, look for solutions optimising the processes of production and logistics. It is a major challenge for Polish organisations that they need to implement innovative solutions, and also to design the processes of production in the best possible manner.

Taking under consideration what is stated hereinabove, it has been a presumption of the authors that a design of the production of pellet which may assist in the appropriate organisation of the logistics and production aspects of managing an enterprise ought to be developed. This design is intended to be applied by small and medium-sized enterprises conducting their business activity in Eastern and Central Europe which are wishing to optimise and streamline conducting essential processes in which they are involved.

In the further part of this article, the properties of pellet and the principal stages of the process of production are described, and also an original design is presented. The final part of this article is constituted by conclusions, and also by implications for management

2. Profile of pellet

Pellet is a fuel which is efficient, environmentally-friendly and renewable. It is marketed in a form of cylindrical granules, the diameter of which may amount to 6-8 mm, and the length of which may reach 2-3 cm (Kwaśniewski, 2008).The granules are formed by means of exposing a raw material to a high pressure, and, which is important, without the application of chemical adhesive substances; the only adhesive in use is the resin being an ingredient of sawdust. It is important that, in the course of applying pressure, the level of moisture is reduced in the raw material. In connection with that, it is characterised by a very low value of the coefficient of moisture, which brings about an increased calorific value (www.pelet.onfo.pl).

The raw materials used for the production of pellet are, first and foremost:

- wood biomass in the following forms: waste from sawmills, wood processing plants, or wood waste of forest origin (sawdust, chips and wood shavings),
- straw and hay, cane, the leaves and litter from coniferous trees, the barns of corns, rapeseed cakes, the peels of sunflower, and also the peels of coffee beans.

Pellet constitutes a fuel which may be used both in the heating systems of particular buildings and in district heating. It proves useful both for small heating installations (boiler rooms and fireplaces in one-family houses) and in the large ones (offices, schools, hospitals, bakeries, restaurants, sport facilities and housing co-operatives).

The following may be seen as the principal advantages of using pellet:

- it is a high-energy biofuel,
- it is an environmentally-friendly product, produced solely of natural and renewable raw materials,
- the emission of carbon dioxide in the course of combusting pellet amounts to 0%,
- it does not contain harmful substances,
- it does not emit unpleasant smells,
- its ash may be used as a fertiliser for lawns,
- in comparison with carbon dust, wood dust is much easier to dispose of.

As any other product, pellet has also certain drawbacks; the most important of them are:

- the high costs of fuel,
- it being indispensable to replace an installation if heating with pellet was not taken under consideration when a building was being designed,
- the necessity of the purchase of an appropriate furnace,
- it being indispensable to clean a furnace frequently,

- ensuring the appropriate conditions of the storage of fuel (in the conditions of low moisture, it is rapidly ignited, and, apart from that, it has a high level of heating efficiency),
- costs connected with servicing a boiler.

3. Quality classes of pellet

International pellet quality standards were developed by the International Organization for Standardization (ISO). In particular, standards for the use of pellets as biofuel include EN ISO 17225-1 for general quality requirements, EN ISO 17225-2 for graded wood pellets for industrial and domestic use, and EN ISO 17225-6 for graded non-woody pellets. According to this standard, the best quality class is A1, which represents virgin woods and chemically untreated wood residue that are low in ash and nitrogen. Pellets with a slightly higher ash content and nitrogen content are described as A2. Finally, there is property class B. This class includes chemically treated industrial wood by-products and residue (Picchio et al., 2020).

Currently, in the market, there are three principal quality classes of pellet (www.kb.pl):

- **Class 1 pellet (A1)** – it is the wood pellet of the highest quality. The raw material used for the production of it are tree trunks, and also other wood residues (from coniferous and deciduous trees), which have not been subjected to chemical processing. This kind of biomass fulfills all the requirements set forth in the European EN Plus A1 standard. Purchasing a class A1 pellet guarantees the best parameters: the highest quality, efficiency and calorific value, and also the smallest quantity of ash generated in the course of combusting. The diameter of this pellet amounts to between 5 and 7 mm. The properties of it include a light colour, as well as a low coefficient of moisture, the value of which may not exceed 10 %. A class 1 pellet is intended to be used in fully-automatic boilers. Even though its prices are higher in comparison with those of biomasses inferior in the aspect of quality, nevertheless, the calorific values may compensate for the costs to be incurred. Detailed characteristics are presented in table 1.
- **Class 2 pellet (A2)** – this is the second-best pellet as far as quality is concerned. It is produced of bark, boughs and branches, and also of wood waste, which have not been subjected to chemical processing. The calorific value of it is, as a general rule, lower in comparison with that of a class 1 fuel. A class 2 pellet has a higher level of ash generated as a result of combusting as well. The price per a single tonne of this fuel is lower as well. In connection with the specific features of it, class 2 wood pellet is found valuable in the case of using high-power machines. The features of class A2 pellet, which are in accordance with the requirements set forth in the EN plus A2 standard, are presented in table 2.
- **Class B pellet** – and that means a so-called industrial pellet is the one representing the lowest quality of this fuel. It is principally produced of wood waste, by-products and residue from the woodworking industry. Its calorific value is lower than those of the other two classes. In turn, the prices of this pellet will be the most reasonable of all. Heating with the use of this biofuel is connected with generating the largest quantity of ash as well, and this pellet is not appropriate for heating in ordinary automatic

boilers. Heating with the use of class B pellet may be considered only in the industry or in the case of backfill boilers. Combusting it at home conditions may bring about polluting the air, and also cause damage to a heating unit.

Table 1. Features of a class A1 pellet

Value	Requirements relevant to EN plus A1	Parameters
Diameter	6 mm +/- 1 mm	6 mm +/- 1 mm
Length	3.15<L<40 mm	3.15<L<40 mm
Moisture	≤10%	≤10%
Ash contents	≤0.6%	≤0.7%
Bulk density	600≤BD≤750 kg/square meters	600≤BD≤750 kg/square meters
Calorific value	18.17 MJ/kg (0.5 kWh/kg)	≥4.6 MJ/kg (0.5 kWh/kg)

Table 2. Features of a class A2 pellet

Value	Requirements relevant to EN plus A1	Parameters
Diameter	6 mm +/- 1 mm	6 mm +/- 1 mm
Length	3.15<L<40 mm	3.15<L<40 mm
Moisture	≤10%	≤10%
Ash contents	≤1.2%	≤1.2%
Bulk density	600≤BD≤750 kg/square meters	600≤BD≤750 kg/square meters
Calorific value	4.6 kWh/kg	≥4.6 kWh/kg

4. Profile of the process of the production of pellet

For the production of pellet, both the wood from deciduous and coniferous trees may be used. In the majority of cases, the wood from coniferous trees constitutes, approximately, 70% of the used raw material, whereas that from deciduous trees is the remaining part. If different species of trees are used, it is important that they are mixed with one another thoroughly. Thanks to that procedure, cellucotton is spread evenly, which is extremely significant in connection with the fact that cellucotton is responsible for bonding pellet into a single entirety (and, in connection with the properties of it, the diverse species of trees differ in the aspect of its contents). Trees representing hardwood species such as beech, to name but one, have lower contents of cellucotton than the soft ones, to which, among others, spruce, to name but one, is included. Therefore, it is important that the mixture of waste constitutes the most homogeneous structure possible. A raw material which does not fulfill these requirements may bring about problems in the course of the process of production.

Depending upon the applied technological machines and solutions, the process of the production of pellet may differ. Regardless of that fact, it can be found that this process is composed of several principal stages:

- purifying,
- drying,
- milling,
- granulation,
- pressing,
- cooling.

The first and essential presumption in the course of the production of pellet is an appropriately purified raw material. The sources of pollution may be: nails, and also other metal and non-metal parts, sand, gravel, stone, ground, glass, and occasionally also plastics. It is extremely important to remove all impurities. Foreign matters exert a negative influence not only upon the properties of a granulated product being manufactured, but, as well, upon the wear and tear of production machines. In connection with that, it may be found that the appropriate preparation of the raw material improves the effectiveness and efficiency of production, and purifying it brings about extending the life of a production line (Pirraglia et al., 2010).

For purifying the raw material, both mechanical machines and the pneumatic ones are used. In turn, metal impurities may be removed with the use of magnetizers, the effectiveness of which reaches even as much as 99%. Another important presumption is that the moisture of a raw material may not exceed 10%. To achieve this objective, a material is subjected to drying which is continued until the required result is achieved (www.ehw-maschinen.com). In the further course, a dry material is transported from a drying room to a mill (for instance, a beater mill), where it is disintegrated into a fraction homogeneous in the aspect of its size.

The next stage of the process of production is constituted by granulation. It consists in supplying 1-2% of the water, in the form of steam, to the wood raw material. This way, biomass reaches the temperature of approximately 70°C. This process brings about the release of cellucotton, thanks to which the fractions are bound and the final product is cohesive. Cellucotton, softened in this manner, and wood dust are then subjected to granulation. In granulators, disintegrated biomass material is charged on a die forging press. In connection with exerting a high pressure, a raw material is pressed through narrow holes in a die (Chau et al., 2019). The pressed material, the form of which resembles thin 'pencils', is subjected to the process of cutting with the application of a special knife. This way, a cut-off granulated product is transported to a collection sector. In connection with that, pressed pellet reaches the temperature even as high as of 100°C, and is subjected to the process of cooling. This objective is attained by using a special refrigerator. Dust in pellet may exert a very big influence upon the quality of formed elements (Mahapatra et al., 2007). In connection with that, the final stage of production is constituted by the process of dust extraction from a material.

5. Objectives of research

The principal objective of this article has been to conduct the analysis of the production of pellet taking under a particular consideration all the processes of production. In order to achieve the said principal objective of this article, the following were performed:

- Analysis of the useful area of a building being by means of separating it into: administrative premises, a deliveries warehouse, a final product warehouse, and also the entire area of a production zone, taking under consideration indispensable machines, and also human resources;
- Analysis of the needs of the enterprise in the aspect of materials;
- Analysis of the entire process of production, including the identification of the following processes: technological, transportation and storage, and also the quality assurance of a final product.

6. Proposition of a design

The specific profile of the process of the production of pellet renders it possible to conduct it in a single-store production zone and storage space, the light walls of which may be constructed of steel and provided with a light roof. By means of ensuring such parameters, the enterprise will avoid substantial construction expenditure, and may also reduce the time of construction works. In addition to that, the buildings of this type are durable, and also boast a long life. Materials to construct them are easily available as well. An extremely important feature as well is the fact that such buildings are easy to construct because it renders it possible to employ a smaller number of ordinary employees and specialists to construct them. Another advantage of constructing a single-store production zone is that it will be lit evenly.

In addition to that, the enterprise will receive an additional building, namely a final product warehouse, constructed of the materials identical with those used in a production zone.

In Figure 2, and also in Figure 3, the area of an entire enterprise (lateral view and view from the top) is presented. The entire space of the premises amounts to 3,010 square meters (43 meters x 70 meters).

Figure 2. Premises of the enterprise (lateral view)

Figure 3. Premises of the enterprise (view from the top)

6.1. Determining the area of a deliveries warehouse

Here, it is worth indicating that the design does not take under consideration a typical deliveries warehouse. All raw materials indispensable for production are in containers, which, in turn, occuppy an empty space on the premises of the enterprise.

This situation is very good for the enterprise because it renders it possible to avoid the costs connected with constructing a building of a raw material warehouse, and also with the use and the maintenance of it.

Entire space dedicated to containers with raw material: 77 square metres

Dimensions of a single container with raw material: 6.18 metres x 2.6 metres x 2.36 metres = 16,068 square metres

Number of containers: 4 pieces.

Capacity of a single container: 30.14 cubic metres = 30 cubic metres

Maximum level of the stock of raw materials: 120 cubic metres

6.2. Determining the area of the production zone

The area of the production zone has been determined with the use of the following formula:

Area of the production zone = (area occupied by the production line) x 1.30 (useful area extension rate)

Dimension of the production zone = (22.8 metres x 11.3 metres) x 1.3 = 334.93 square meters. In Figure 4, the cross-section of the production zone is presented.

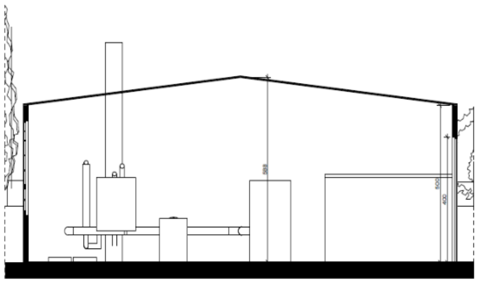

Figure 4. Production zone (cross-section)

6.3. The entire area of the production zone

The design assumes constructing the separate deliveries warehouse, and also the final product warehouse. In connection with that, the areas of these two have not been taken under consideration in the course of calculating the entire area of the production zone.

Entire area = (area of the administrative premises + area of the production zone) x 1.30 (useful area extension rate)

Entire area of the production zone = [(16.46 metres x 5 metres) + 334.93 square meters] x 1.3 = (82.3 square meters + 334.93 square meters) x 1.3 = 417.23 square meters x 1.3 = 542.39 square metres

In Figure 5, the view of the production zone from the top is presented. In turn, in Figure 6 the view of the administrative premises from the top is presented.

Figure 5. Production zone (lateral view)

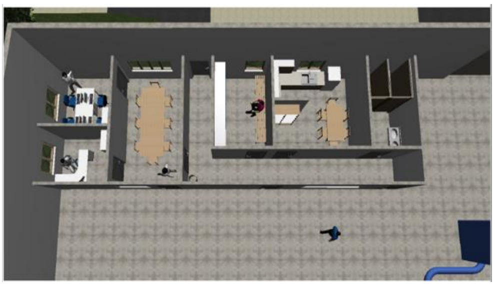

Figure 6. Administrative premises (view from the top)

6.4. Determining the area of the final product warehouse

The area of the final product warehouse has been calculated upon the basis of the following parameters:

Area of the warehouse = length of the warehouse multiplied by the width of it

Length of the warehouse = 17 metres

Width of the warehouse = 12 metres

Area of the warehouse = 204 square metres

Height of the warehouse (the maximum level to which the material may be stacked) – 3.5 metres

Capacity of the warehouse – 17 metres x 12 metres x 3.5 metres – 714 cubic metres (not taking under consideration the area required for the movement of a trolley)

Area required for the movement of a trolley (next to the gate) – 5 metres x 3.5 metres – 17.5 square meters Capacity of the area required for the movement of a trolley – 5 metres x 3.5 metres x 3.5 metres – 61.25 cubic metres

2 x 61.25 cubic metres (2 areas required for the movement of a trolley next to the gates) = 122.5 cubic metres

714 cubic metres – 122.5 cubic metres = 591.5 cubic metres

Dimensions of a pallet: 1.2 metres x 0.8 metres x 1.7 metres with free space for maneuvering] – 1.3 metres x 0.9 metres x 1.7 metres = 1.98 cubic metres

Capacity of a pallet loading unit – 1.63 cubic metres

Capacity of a pallet loading unit taking under consideration free space for maneuvering – 1.98 cubic metres

591.5 cubic metres/1.63 cubic metres = 362 pallets

591.5 cubic metres/1.98 cubic metres = 298 pallets

Maximum level of the stock of the final product: 298 cubic metres

In Figure 7, the cross-section of the final product warehouse is presented.

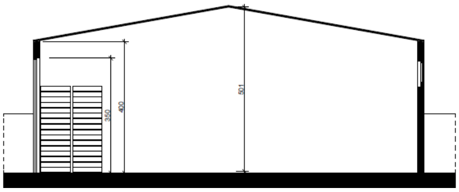

Figure 7. Final product warehouse (cross-section)

6.5. Determining auxiliary machines in the processes of production and storage

Developing the design of the production of pellet, as additional factors, the auxiliary machines in the processes of production and storage ought to be taken under consideration. In Table 3, the collation of indispensable machines together with the instances of their prices is presented.

Table 3. Auxiliary machines in the processes of production and storage

Machine	Quantity [pieces]	Price [PLN]	Value [PLN]
Fork-lift trolley	1	36,499	36,499
Beds	4	500	2,000
Air conditioning and ventilation devices	9	1,800	16,200
Fire-protection devices	15	200	3,000

6.6. Analysis of demand for raw materials

Prior to commencing the analysis of the processes of production, a particular attention ought to be paid to the demand for raw materials of the enterprise. Pellet is acquired principally from sawdust, therefore, its structure (BOM, and that stands for a Bill of Materials) is comparatively straightforward, which is presented in Figure 8.

Figure 8. Acquisition of pellet

The structure of pellet may be different depending upon the raw material in use, for example:

- 1 tonne of pellet from coniferous trees 7 cubic meters of sawdust (pine: 100%/fir: 100 %/ spruce: 100%),
- 1 tonne of pellet from deciduous trees 6.5 cubic meters of sawdust (beech: 100%),
- 1 tonne of pellet from deciduous and coniferous trees 7 cubic meters of sawdust 5 cubic meters of sawdust (pine/spruce) 2 cubic meters of sawdust (beech).

In Table 4, and also in Table 5, the costs of the purchasing the raw materials: of pellet from coniferous trees, and also of pellet from the coniferous and deciduous (in the order like above) ones, are presented.

Table 4. Kind and quantity of the raw materials indispensable for the production of 1 tonne of pellet from coniferous trees

Kind of a raw material	Quantity	Price	Value
Sawdust from coniferous trees	5 cubic metres	18 PLN/cubic metres	90 PLN
Sawdust from deciduous trees	2 cubic metres	22 PLN/cubic metres	44 PLN
TOTAL			134 PLN

Table 5. Kind and quantity of the raw materials indispensable for the production of 1 tonne of pellet from coniferous and deciduous trees

Kind of a raw material	Quantity	Price	Value
Sawdust from deciduous trees (beech)	6.5 cubic metres	22 PLN/cubic metres	143 PLN
Sawdust from coniferous trees (pine, fir and spruce)	7 cubic metres	18 PLN/cubic metres	126 PLN
TOTAL			269 PLN

6.7. Analysis of the process of production

The design of the layout of the premises of the enterprise is presented in Figure 9.

The following elements are included in it:
(1) final product warehouse;
(2) production zone
(2.1.) machine for the production of pellet;
(2.2.) fuel storage zone No.1;
(2.3.) boiler room;
(2.4.) tool warehouse;
(2.5.) rest and refreshment facilities;
(2.6.) zone of the completation of pallet loading units;
(3) yard for containers with sawdust;
(4) maneuvering yard;
(5) dustbin;
(6) yard for fuel No.2;
(BH1) - gate No.1 of the production zone;
(BH2) - gate No.2 of the production zone;
(BM1) - gate No.1 of the final product warehouse;
(BM2) - gate No.2 of the final product warehouse.

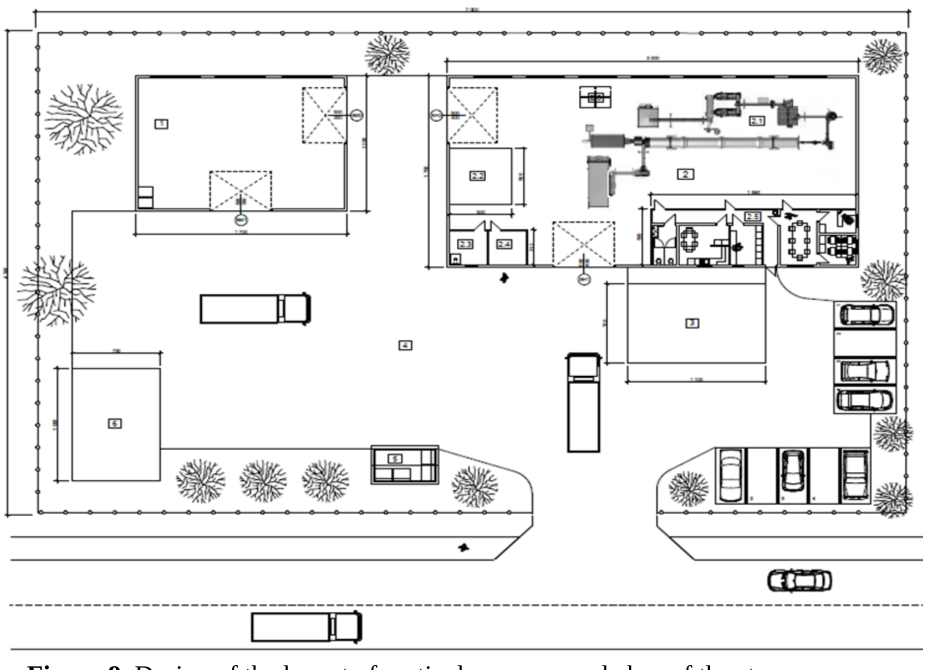

Figure 9. Design of the layout of particular rooms, and also of the storage space

The yard marked with 3 is the yard for the storage of containers with sawdust, which are transported from suppliers. In the further course, the containers are transported under the production line through gate No.1 (BH1), where a given container is connected with the entire line. A container with sawdust is placed in a perpendicular position to entry gate No.2

(BH1) so that a vehicle could be able to enter without difficulties driving backwards through the gate and unload a container at a given yard. The entire process is conducted rapidly and efficiently, therefore, reducing the cost to the minimum. In the production zone (2), there is a space for pallets with a final product (2.6). An employee collects bags weighing 15 kg each from the production line, and, in the further course, the bags are stacked on pallets. The completation zone of pallet loading units are situated close to the packaging machine, so that an employee is spared the necessity of performing unnecessary movements and wasting time on walking with a bag to a pallet. The selection of the yard for completation of pallet loading units results from the wish to reduce all and any movements of employees to minimum in order to ensure the highest level of efficiency. In the further course, the ready pallets are transported by a fork-lift trolley to the final product warehouse (1), where they are prepared for loading on road trailers or other vehicles transporting the final product. The zone of the completation of the final product is situated close to exit gate No.2 (BH2) from the production zone in order to reduce all and any momevents of a fork-lift trolley all over the yard, and, consequently, to reduce all and any costs connected with the transportation of pallets to the warehouse to minimum. An operator of a fork-lift trolley, which is coming to fetch ready pallets, is bringing the empty ones on this same trolley in order to leave them and render it possible to conduct another completation. In the final product warehouse (1), some of the useful area is occupied by empty pallets, whereas some by the pallet loading units, which, after the completation of an order, are loaded on various means of transportation. Zone 2.2 is the zone for the storage of fuel which is required for the process of drying sawdust. From zone 2.2, an employee operating the production line transports fuel to a boiler from the drying room with the use of a pallet truck. In the further course, the fuel is manually charged into a boiler. Into zone 2.2, with the use of a fork-lift trolley, fuel from yard 6 is transported. The yard marked with 6 is the yard in which fuel is stored in larger quantities. From yard 6, fuel is regularly transported to fuel zone 2.2. Fuel yard 6 is situated in the described manner because the deliveries of fuel are comparatively infrequent, whereas they are in larger quantities. Fuel is constituted by sawmill trimmings in the form of bunches. 1 bunch is 2 cubic metres of wood. 2x1x1. The process of transporting fuel from yard 6 to zone 2.2 is not frequent, therefore, it is not required that these two warehouses ought to be situated close to one another. The second variant relevant to fuel includes using pellet. Pellet from yard 2.6 is transported to yard 2.2 in appropriate quantities. Afterwards, pellet is charged into a boiler from the drying room. Yard 4 is is maneuvering yard. It has been designed taking under consideration the needs of using means of transportation as easily and rapidly as it can be done, in order to avoid wasting precious time for maneuvering, for instance, a vehicle, and not block the flow of goods from other zones. In internal buildings Nos. 2.3 and 2.4, the following are situated: the boiler room, and also the workshop with tools, as well as oils and so on, and so forth, indispensable for operating the production line, or for the maintenance of it. Prior to commencing work on the production line, employees collect from the tool warehouse boxes containing particular tools, and also oils and so on, and so forth, indispensable for operating their workstation. Each and every box contains appropriate tools prepared for a given workstation. In the case of a breakdown of a given machine, the employees are not forced to walk through the entire production zone to fetch tools, and they are able to react immediately and without wasting time. The place for waste is situated in the dustbin (5). It is located in a way rendering it possible for employees of a Municipal Services Company, in the course of emptying, to avoid driving further into the yard. Emptying waste containers ought to be conducted rapidly and efficiently, without blocking the maneuvering yard in the course of it.

The design includes as well the office administrative and office premises. These include the part of the premises where the corridor, toilet, cloakroom, kitchen and dining room, conference room, office, and also the room of the president, are situated. The rest and refreshment facilities are situated in such a manner that the employees that arrive at workyard have a comparatively short distance to cover from the car park to the rooms in question. The toilet is situated next to the production line, more or less in the center of the entire production zone, so that the employees do not have to walk a longer distance when they need to use the toilet in the course of work.

6.8. Efficiency of the production line

The plant works since Monday to Friday, and there is a single-shift system, with the shift being eight hours long.In the plant, the employees are permitted to take a single thirty-minute break, and also spend 30 minute preparing the production line to work (lubricating and cleaning a die), as well as cleaning up after the end of the shift.

Therefore, within a single hour, the production enterprise is able to process 7 cubic metres of sawdust, the approximate weight of which is 2,450 kg. A cubic meter of moist sawdust weighs approximately 350 kg.

The quantity of sawdust required for a single shift – 7h x 7 cubic metres = 49 cubic metres. Production capacities:

- 7.18 of a final product pallet per a single shift,
- 975 kg – quantity of a final product on a single pallet,
- 7.18 x 975 = 7,000 kg per a single shift (7 hours of uninterrupted work of the line),
- 7,000 x 5 days = 35,000 kg of the final product/week

6. Conclusions

Small and medium-sized enterprises are the flywheel of Polish economy (Zaborek& Mazur, 2019). The sustainable development of the sector of small and medium-sized enterprises is a fundamental issue for each and every country. Numerous instances of small and medium-sized enterprises show that they are not fully structured, and that they lack appropriate principles and the procedures of action. Usually, an essential problem is appropriate planning and conducting the essential processes of management (Junginger et al., 2008; Dellana & Kros, 2014). Other problems are related to the situation in which employees are not entrusted with clearly-defined tasks. The absence of specialisation brings about chaos and the blurring of responsibilities, and this fact is connected with another, namely with the situation in which managers and owners of enterprises from the sector of small and medium-sized enterprises lack managerial skills, or even, occasionally, a basic knowlegde within the scope of logistics or the management of production. The design presented in this publication is to assist managerial personnel in organising the essential processes of production and logistics in the pellet industry. It includes a number of guidelines optimising the essential processes of the production of pellet. In accordance with the opinion of the authors of this publication, following the recommendations presented in this publication will increase the effectivity and efficiency of management, and also render entrerpreneurs sensitive to the implementation of innovative activites. It ought to, nevertheless, be indicated that this article constitutes a collation of essential recommendations, and that entrepreneurs striving to increase the innovativess of activities ought to tap into, as well, a broad spectrum of the methods, systems and tools of management, adjusting them to their needs, financial possibilities and aspirations.

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