Chapter 1

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ECONOMIC ASPECTS AT PRODUCTION OF SOLID WOOD PANELS

Abstract: This paper deals with the describing of selected economic aspects in the production of glued solid panels especially from beech wood. The most relevant and important aspects were chosen and described. Through this, mentioned above steps, we can create the methods how is possible to systematically reduce the losses of production. Raising process improvements contribute to ensure the quality, economic effectiveness of production, productivity growth and overall competitiveness of business.

Key words: glued wood panels, beech, quality, economy of production

1.1. Introduction

Wood has become the main raw material for many products mainly due to its technical and aesthetic characteristics. The importance of wood raw material had been developed with the evolving times, not only because of its outstanding looks, but also with the development of society, which helps us still research and explore new features and properties of wood (GÁBORÍK J. 2012). These facts create scope for its wider application in the production process and further use.

The use of wooden materials produced by passing through a series of procedures that we can call synthetic wood started to become widespread with the increase in technological opportunities, especially after the 1950s (ŐZKAYA K. 2011). The tendency to the wooden panels industry has moderately increased in the recent years in order to meet the high

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production demand and the product variety improving as parallel to the technologic and economic development (DILIK T. et al. 2012).

Due to the increased number of manufactures and a high level of competition on the market as well as the reduced portion of quality raw materials, a positive cost-benefit ratio of producing is possible only with the reducing the amount of waste and producing high quality products. In this respect it is possible to produce and use these panels in a more economic fashion (PREKRAT S. et al. 2004).

1.2. Material and methods

Today it can be said for all industry branch, it is critically important to manufacture a product in an economic manner in addition to the quality of product. As known, the economical production of a product, besides its quality, carries great importance due to the improving production systems.

As a raw wood material for our research are used the panels from beech with thickness 45 mm. These beech panels are glued in accordance with DIN EN 204. Wooden scatlings are joined by length with finger joint and by width by using a flat joint to produce the glued solid wood panel as is illustrated in Figure 1.1:

Fig. 1.1. Glued solid wood panel.

Source: www.bucina-ddd.sk

Survey the economy of production

According to the data obtained from the survey (BILGIN Y. 2010), the cost elements and their rates in the glued wood panel production are shown in Table 1.1.

Table 1.1. Costs elements in glued wood panels production

Cost factor	Rate in total costs of production
energy	6 %
raw material	43 %
labor	18 %
auxiliary materials	10 %
marketing expenses	15 %
others	8 %

Source: BILGIN, 2010

It is seen in Table 1.1 that the most important share among the costs elements belongs to the ***raw material (43 %)*** and ***labor (18 %).***

An important factor in relation to the different stages of production and overall production efficiency is technology of product construction. Technology of product construction can be understood as a set of properties of shape and design of the product, leading to a total effective production and ensuring of the efficiency and quality of production. Production of glued solid wood panels consists of several interrelated phases. For the purpose of research, these processes will be conceived as cost centers. Thus, it will be necessary to determine the place where the inputs and outputs are quantified in physical and monetary units.

Production process of glued solid wood panels may consist of ***2 main costs centers:***

• **1st COST CENTER-** costs originated at this centre are associated with the preparation of beech scantlings before entering the production process. The material loss is caused mainly due to the poor quality of raw

material processed to produce briquettes, fiber and particle boards. Because of the hygroscopic properties of wood, an important attribute for the economy and production quality is monitoring of storage conditions in pre-production phase. From a technological point of view of ensuring production at this stage, we focus on monitoring humidity of beech scantlings as input material (%), as well as storage conditions, concretely the overall humidity and temperature of storage environment.

• **2nd COST CENTER -** costs associated with this center originate in processes of length bonding of beech scantlings (finger joint, producing endless scantlings), transverse cutting, width bonding using an adhesive and pressing. An important attribute in terms of the technological structure, economy and the quality is control of finger joint manufacturing, glue application on beech scantlings , method of pressing operation and finishing (surface treatment, final grinding).

1.3. Results and discussion

Investigation in 1st cost center

Wood moisture, air humidity and temperature of environment

In this step we investigated the conditions in environment, where are prepared wooden scantlings, which are settled for directly consumption in production. It was done 6 measurements during 3 months, for evaluation we used the basic tools of descriptive statistic and results are follows:

- average air humidity of environment 46 %,
- average temperature of environment 16.6°C.

According to the standard STN EN 386 the air temperature of environment has to be more than 15°C and relatively air humidity has to be in the range of 40 – 75 %. It means that conditions were satisfied. The next step was to investigate the moisture content (MC) of wooden scantlings. According to the standard STN EN 386, moisture content of scantlings must be in range of 8 to 15 percent in assembling of endless scantling. Difference among moistures of every single scantling in bonded component must not exceed 4%. Samples from beech wood had

thickness 45 mm and were cut as follow (Fig. 1.2) and dried according standard STN EN 322:

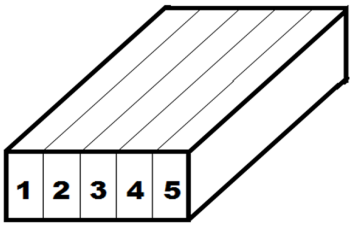

Fig. 1.2. – Cutting scheme of beech scantling.

The results are interpreted in the following Figure 1.3.

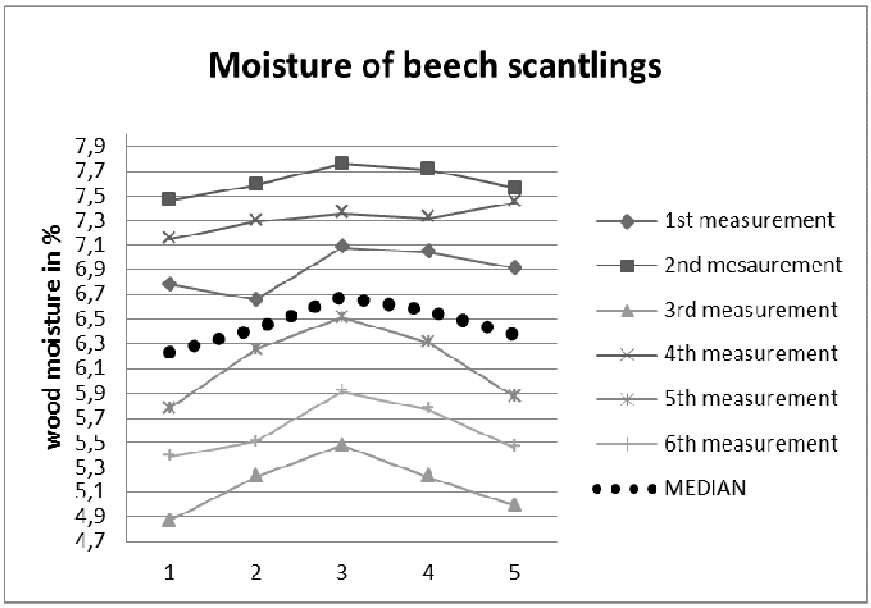

Fig. 1.3. Moisture of wood scantlings.

Source: own study

Based on the above results we can claim that the moisture content of beech scantlings, which are directly processed in the production, is at an average level of 6.47%. Relative moisture is higher in the middle of beech scantlings than at its edges (Fig. 1.3). Economic efficiency of production is influenced by the quality of bonding, which depends on the moisture content of glued wooden scantlings. As Pervan et al. (2009) wrote it was proven that change from dry to mild conditions to very humid condition has significant influence on shear strength of finger jointed beech wood scantlings. In can be conclude that moisture content has influence on bonding strength which is lower in steamed compared to non-steamed wood. Also lower rate of wood moisture has influence to the bonding quality. The water penetration from adhesive is much faster in dried wood (where $w \leq 8$ %, creates poor bonding) in compare with wood with moistures stated in standard EN 386. Based on this fact and investigation we can conclude that in the company was not ensure prescribed rate of wood moisture (8-15%) in beech scantlings which were used for bonding with adhesive. Őzkaya (2011) observed that when the moisture content is not within the suitable 12-16% range, then resistances decreased. Along with changes in moisture in particular, openings occur in parallel to the fibers and the bending strength decreases (ŐZKAYA K. 2011). Based on these facts very dry or very wet wood panels have negative influence to the bonding quality and also to the effectiveness of production.

Investigation in 2nd cost center

Finger joints for longitudinal jointing

Longitudinal jointing is used in the manufacture of joined scantlings and is performed through the use of finger joints. The advance of this type of jointing is that it achieves very high bonding strength of the joints (PREKRAT S. et al. 2004).

According standard STN 49 0251 the joints need use 60 mm of the material or less and there is a very small amount of material waste in the making of the finger joint. Finger joints for the structural use of timber in construction are divided (Table 1.2) into two classes depending on stress in use:

1. **stress class I**: high mechanical stress (glued components in buildings);
2. **stress class II**: medium mechanical stress (windows, doors, floors, furniture, etc.);

Based on the stress class (I, II) are recommendations of joint dimensions according to standard STN 49 0251 described in the following Table 1.2.:

Table 1.2. Recommended joint dimension (in mm)

Stress class	Finger length L	Finger distance t	Width of finger w
I and II	7.5	2.5	0.2
	10	3.7	0.6
	20	7.0	1.7
	50	12.0	2.0
	60	15.0	2.7
II	4	1.6	0.4
	15	6.2	1.0
	30	10.0	2.0

Source: standard STN 49 0251

To closer interpretation of Table 1.2 is illustrated the Fig. 1.4, the thickness (T) of investigated wood panels is 45 mm:

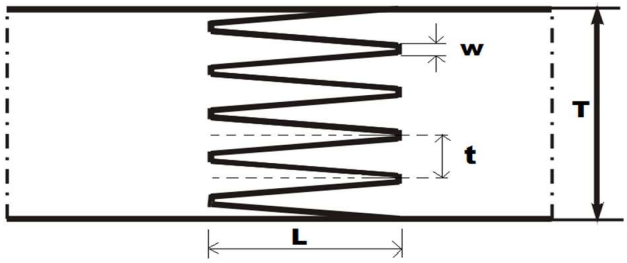

Fig. 1.4. Illustration of finger joint.

Source: standard STN 49 0251

Adhesion

For adhesion of solid wood scantlings is used wide scale of adhesives. The most important impact has polyvinyl acetate dispersion (PVaC), which belongs to the water-borne adhesives. These adhesives are suitable for the cold pressing procedure and which are not harmful to human health and the environment. The pre-formed polymers do not require any heat to cure, are cost effective and are easy to use. Water-borne adhesive are set by the water being absorbed into the wood (ROWELL R. M. 2005). By experimental research was proven, that bonding strength has influence to the roughness of materials. Bonding strength decreases if the roughness is increase. The second fact is also if the wooden scantlings are not cured, they will lose much of their strength at high moisture levels.

Factors that influence the selection of the adhesive include cost of adhesive, assembly process, strength of bonded assembly and durability (ROWELL R. M. 2005). An adhesive is one of the most expensive inputs of production process of solid wood panels. On the basis of technical documents of these adhesive is recommended application of 150 g/m^2.

The cost of adhesive has become more critical as the thickness and dimension of finger joint is changed. Based on the Table 1.2 we can discuss about the consumption of polyvinyl acetate adhesive (PVaC, D3), for finger jointing, in the particular joint dimensions. If we calculate and compare finger joint with length 7,5 mm - the surface of finger joint is about 10.23 % bigger in compare with length 10 mm joint, it has influence on the adhesive consumption. We can also discuss about the recommended adhesive amount 150 g/m^2. It is possible to save costs by

applying of PVaC adhesive in the amount 100 g/m^2, but it is possible to save the cost by this mentioned above way?

If we want to gain cost effective production necessary is to follow the standard STN 49 0251, which determinates the basic requirement for bending strength and follow the standard EN 204 and EN 205 which determinate the minimal requirements for shear strength of bonded joint, according also to the quality of production.

Pressing

In the bonding process, pressure is used to bring the wooden surfaces closer together. Compression pressure and humidity of wood scantlings are directly related to the penetration of adhesive into the structure and interior spaces. The speed and quantity of penetrated glue is increasing with pressure and viscosity reducing of the adhesive. It follows that the most important physical factors that affect the process of pressing are:

1. ***compacting pressure and temperature*** (entered in the technical sheet of the adhesive);
2. ***pressing time;***

The total energy consumption depends on these two factors, which affect the economy and efficiency of the manufacturing process (ŠTEFKA V. 2006).

Pressing force and the length of pressing time may vary to achieve economic savings and increasing production efficiency, optimal option can bring a difference to energy costs, which make up 6 % of the total cost of production of glued solid wood panels (Table 1.1).

To accelerate the process of curing the adhesive joints are usually applied high-frequency heating. Its application is suitable in terms of heating location, which is concentrated directly in the adhesive joint. Timber is less heated, that is appropriate for better effect of heat and pressing time, which has a direct impact on the energy aspect and the shape stability of the board and will significantly affect the economics of the whole producing process.

Here are several preconditions that must be met in order to achieve the desired economy effectiveness of production of solid wood panels:

- *raw wood material (panels freed of defects and sorted);*
- *adequate level of moisture in both component that are going to be glued together (8-15%, differences ± 2%);*
- *longitudinal jointing, well worked out surface of joints;*
- *selection and application of adhesives;*
- *application of pressure;*

In accordance with the standards, to achieve desired quality of the overall production.

Because the material costs are the most significant cost factor in the production, (Table 1.1.) necessary is systematically reduce material costs. On this way is the most effective tool of reducing the costs of production preparation in all its pre-production stages. This way is not only effective for reducing of material costs, but also all other types of costs. The majority of the costs are determined at the pre-production stage of total product life cycle

. The level of these costs makes up 80-85% of total costs, which are spent for product during its lifetime (GIERTL G. 2013).

In the Figure 1.5 is shown correlation between costs related to decisions and expended costs:

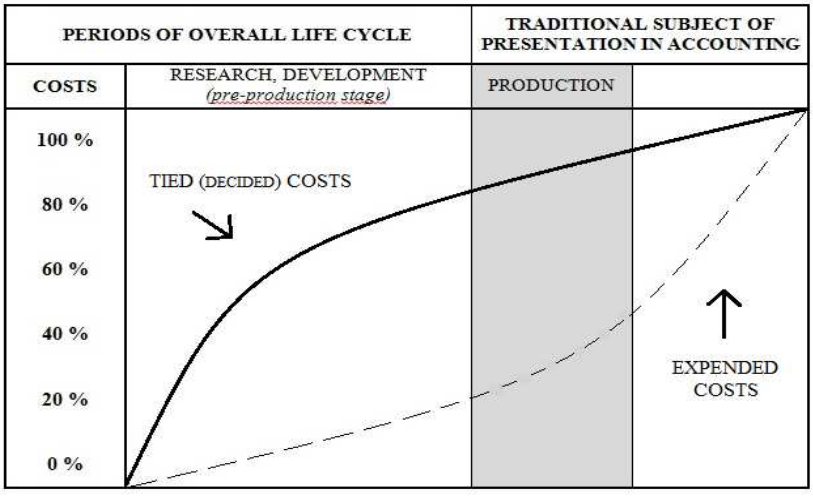

Fig. 1.5. – Relationship between tied and expended costs.

Source: Foltínová A., 2011

1.4. Conclusion

The paper describes only some selected economic aspects, which are necessary to monitor in the production process of glued solid wood panels (environmental conditions, moisture content of beech scantlings, a method for length bonding of scantlings, gluing and compression). All of the mentioned aspects are based on the technological construction of product. It is important to exercise permanently high demands for production process , in order to get more and more outputs of each input resource of tangible or intangible natur. Concretely, it is necessary to ensure higher economic output of the production system, even under conditions that inputs will not grow, ie requirements for input volume of wood raw material, energy, labor and other items of costs (as is shown in Tab. 1.1). All of these aspects is needed to achieve by meeting basic requirements for the final product.

In this new position of total development and increasing of the production efficiency, preparation of production carried out in pre-production stages asquire a special status and become critical factor of technical and also economic and other results of production process.

In addition to the economical and technological developments, the improvin living standards and aslo the impact of the ecological aproaches cause a trend to use the solid wood materials. This fact in one of the reasons for the development of the glued wood panels as determined in various researches.

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