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Optimization of Glued Laminated Timber Production in Pt Samtraco Cahaya Utama Samarinda by Using Lindo Software

Ita Merni Patulak[1*], Abubakar M. Lahjie[2], Edy Budiarso[2], B.D.A.S. Simarangkir2

1. Faculty of Forestry, Mulawarman University, East Kalimantan, Indonesia
2. Doctorate Program, Faculty of Forestry, Mulawarman University

* E-mail of the corresponding autor: mernivania@gmail.com

Abstract

This research aims to find out optimal returns from of Glued Laminated Timber products manufactured by PT Samtraco, whose today's products include Laminating Block, Finger Joins Laminating, Finger Joins Laminating Boards, Solid and Beams. It also aims to find out the output of the combinations of Glued Laminated Timber manufacturing models so that the production facilities can be used up.This research was located in Loa Buah Village, Sungai Kunjang Sub-district, East Kalimantan.

The research findings revealed that in Model I the net optimum returns derived from this manufacturing model can be identified after the gross returns was subtracted by the expenditures of each constraint variable, where its gross optimal returns was US$ 1.217.250 with the exchange rate of US$ 1 equalsRp. 9800, therefore, its gross returns was Rp 11.929.050.000. After it was deducted by the expenditures with the amount of Rp 10.676.499.750, then the value of its net returns was 1.252.550.250.

In Model II, the value of optimal net returns can be determined by identifying the gross optimal returns with the amount of US$ 1.240.000 with the exchange rate of US$ 1 equals Rp 9.800, therefore, its gross returns was Rp.12.152.000.000. After it was deducted by the expenditures with the amount of Rp. 10.876.040.000, then the value of its net returns was Rp. 1.275.960.000.

In Model III, the value of net optimal returns derived from this manufacturing model can be determined after the gross returns was deducted by the expenditures of each constraint variable, where its gross optimal returns was US$ 1.294.000 with the exchange rate of US$ 1 equals Rp. 9.800, therefore, the gross returns was Rp. 12.681.200.000. After it was deducted by the expenditures with amount of Rp. 11.286.268.000, then the value of its net returns was Rp. 1.349.932.000.

Based on the value of optimal returns from each model, raw materials dominated the production cost of lamina wood, reaching 57% in the Model 1,59% in Model 2, and 61% in Model 3, and the subsequent costs including delivery, electricity and labors were below 10% respectively.

1. Introduction

The establishment of artificial board industries, such as Glued Laminated Timber, is an alternative to solve problems concerning the utilization of the waste produced in the wood industry. In a Glued Laminated Timber industry, the waste produced by the industry, sawmills, plywood factories and logging activities are utilized in such a way that it can be transformed into artificial wood (i.e. Glued Laminated Timber), which can be used as a substitution for real wood.

Glued Laminated Timber is one of the products which can utilize the waste of wood industry. This fact indicates that the Glued Laminated Timber products use raw materials maximally (Endang Sastradimadja, 1999). The processed wood consumption in Indonesia itself is bigger than the exported wood products, although the export of processed wood products is indeed potential.

To produce good quality Glued Laminated Timber, with the physical and mechanical characteristics close to or even better than the original wood, some aspects need to be considered, as follows: the kinds of wood used as the raw materials having a high level of density, kinds and conditions of the adhesive, and the treatments given during the process of producing the Glued Laminated Timber itself.

Considering how important wood utilization in East Kalimantan in general and in PT. Cahaya Samtraco Utama Samarinda as a company operating in Glued Laminated Timber industry in particular, it is then necessary to conduct a research concerning the optimization of production in the Glued Laminated Timber industry done by PT. Cahaya Samtraco Utama in Samarinda.

2. Glued Laminated Timber Industries

Glued Laminated Timber is defined as the combined layer of several pieces of timber/ wood which are glued by using adhesive following a parallel direction of the fiber. The wood used for producing Glued Laminated Timber can be in forms of sawn wood/ timber or veneer (Paribroto, 1979). Masano and Sutigno (1986) state that Glued Laminated Timber is a kind of timber which is comprised of several parts of smaller timber glued together. These smaller parts are glued to one another in a straight or curved way, as long as they are parallel to the direction of the fiber. Glued Laminated Timber can be produced in several layers, at least two.

According to Wardhani (1999) and Martzky (2002), Glued Laminated Timber or glulam is several boards glued together by using particular adhesive following the parallel direction of the fiber which eventually form a single unit of board. Manik (1997) explains that the basic purpose of making Glued Laminated Timber is to create a particular construction design made of perfectly dried wood/ timber with easily obtained raw materials. Glued Laminated Timber is often used for construction design of buildings such as airplane hangars, sport halls, home furniture and sport equipments.

The main difference between Glued Laminated Timber and plywood is on the direction of their framing. For plywood, the direction of the fiber is vertical (upright) whereas for Glued Laminated Timber, the direction of the fiber is parallel. The adhesive used is similar, by using synthetic adhesive or natural adhesive made of plants and animals.

At first, Glued Laminated Timber was made of pine tree wood or other kinds of conifer wood. Nowadays, almost all kinds of wood can be made into Glued Laminated Timber. The production process is quite simple. First, the dimension should be determined based on the purpose of the use. The width of the layer normally ranges from 20- 45 mm. After being dried up to the 10 % of the water content, the layer is coated with adhesive on both sides and then pressed (Marutzky, 2002).

The strengths of Glued Laminated Timber according to Endang Sastradimadja (1999) are as follows: (1) easily obtained raw materials, since smaller sized timber can produce bigger sized beam of wood, (2) ability to produce longer and thicker materials, (3) possible reduction of weaknesses of Glued Laminated Timber, (4) possible curve forms, and (5) possible use of low quality wood/ timber as raw materials.

The most important quality of Glued Laminated Timber lies on its strength and durable adhesiveness. Especially for buildings, the durability factor needs to be taken into account. The durable adhesiveness of Glued Laminated Timber is influenced by the type of its adhesive. Therefore, there is Glued Laminated Timber with exterior quality and the one with interior quality. The important factors in the process of gluing include the following: density, acidity, extractive substance, specific gravity, fiber direction and water content.

Glued Laminated Timber was firstly used in Europe in early 1893 along with the construction of an auditorium in Basel, Switzerland. While in the US, it was used firstly in 1934. Forest Product Laboratory built the first experimental structure which used Glued Laminated Timber by applying the principles of engineering. Since then, the use Glued Laminated Timber has been developed for the construction of other types of structure such as hangar, hall, buildings etc (Haryadi in Adi, 2010).

3. Glued Laminated Timber Industries in Samarinda

Export demand for home furniture and wooden components is quite many and has been increasing from year to year. Labor intensive processed wood industries might provide employment opportunities as well as hold the purchasing power in the area where the company is located. The sub-sector of processed wood industries which produce furniture and wooden components for export market has a very potential business prospect because the raw materials, manpower as well as most of the production factors are available and obtained domestically.

Glued Laminated Timber industry operated by PT. Cahaya Samtraco Utama mainly produces the following items: ***Block Laminating.*** According to Jamaluddin Malik and Adi Santoso (2005), block laminating is a laminating technique which produces a block by piling into the direction of the height/ thickness. Block laminating is usually needed by consumers to make door and window frames, table legs, handicraft, and so on. ***Finger Joint Laminating.*** It is a laminating technique by joining wood/ timber, which are already in forms of fingers, afterwards being piled into blocks. This product is usually ordered by consumers for home/ office interior, handicrafts such as ashtray, flowerpots, etc (Jamaluddin Malik and Adi Santoso, 2005). ***Finger Joint Laminating Board***. Finger joint laminating board is a laminating technique by combining the wood/ timber into the direction of the width to produce boards as raw materials for table leaf, walls, doors, etc. ***Solid.*** Solid is sawn wood/ timber in a form of beams, which does not go through the process of lamination or joint. Solid is normally used for window frames, door frames, table legs, etc. ***Beams.*** Beams are wood/ timber which are laminated into the direction of the length, in order to get longer beams without going through the finger joint process. Beams are mostly used for house pillars or structure construction, etc.

The kind of wood used by PT Samtraco in the production of its Glued Laminated Timber is the red meranti wood (*Shorea leprossula*). The final product of PT. Cahaya Samtraco Utama is Glued Laminated Timber, 85 % of it is exported abroad to Europe (Germany) and the rest is marketed in Asia (Korea and Middle East).

4. RESEARCH METHODOLOGY

4.1. Lindo

Lindo is software which is used to solve the linear programming problems with n variable. By using Lindo, the optimization of problem solution could be obtained quickly and precisely, as well as with a smaller level of errors. If using merely the manual linear programming or using the simplex method, the process might become more difficult and take longer time since accuracy and persistence would be needed. Thus, it is appropriate to solve the abovementioned linear programming problems and all optimization problems in the real life by using Lindo.

Lindo (Linear Interactive Discrete Optimizer) is software which can be used to find a solution to linear programming problems. By using this software, it is possible to calculate the linear programming problem with n variable. The main working principle of Lindo is inputting data, solving problems, as well as predicting truth and appropriateness of the data based on the solution. According to Linus Scharge (1991), the calculation used in Lindo is basically using the simplex method. To determine the optimum va lue by using Lindo, the following stages are considered necessary:

1. Determining a mathematical model based on the real data
2. Determining the program formulation for Lindo
3. Reading the report generated by Lindo

4.2. Optimization

Optimum production level is particular production which is obtained by minimizing the total expense of inventory, which can be reached if the amount of set up expense and carrying expense are minimized. In other words, optimum production level will provide the total expense of inventory, taking into account the level of finished product inventory and demand.

Table 2. Data concerning the products of PT. Cahaya Samtraco Utama (in m^3)

Year	Kind of Product	Log Input m^3/ month	Output m^3/ month
1985-1989	Sawn timber	5000	2550
1990-1995	Sawn timber and Glued Laminated Timber	4500	2160
1995-1999	Glued Laminated Timber and furniture	4000	1840
2000-2004	Furniture and Glued Laminated Timber	3000	1290
2005-2009	Glued Laminated Timber	3500	1400
2010- 2012	Glued Laminated Timber	3000	1050

4.3. Production Waste Management

In addition to the export-ready final products, PT. Samtraco also produced additional products, namely waste. The types of waste produced by PT. Cahaya Samtraco Utama included the waste water and air waste. For the waste water management, designated reservoirs (1,2 and 3) were constructed to filter the water before being discharged to the river. Meanwhile, for the air waste, a particular "shelter" in a form of cyclone with water as the filter to push the dust down, called *Sodax,* was made.

Besides these two types of waste, there were also other types of waste which could be re-used/ re-cycled. These types of waste were generated from the multi-rip and wood- drying activities, namely powder and sawmill wood waste, which were used as boiler fuel for heating during the wood- drying process. Furthermore, sawmill wood waste could also be re-sold to plywood companies such as Sumalindo and Tirta Mahakam. The following pictures illustrate the production process.

Picture 1. The sawmill wood waste

Picture 2. Powder Waste Warehouse

5. Results and Discussion

5.1 Optimization of Production

Models

The displayed formulation of linear programming model for planning had decision variables and constraints, in this case the existing resources to produce all items.

The formulation of decision variable

Decision variable indicated the amount of each product which was supposed to be produced by PT. Cahaya Samtaco Utama, to reach the optimum condition. Therefore, in the formulation of the linear programming model, several decision variables could be obtained, as shown by the tables 3, 4 and 5.

Table 3. Data concerning the decision variable for Samtraco Model I

Decision Variable	Production Type	Product Price (US$ / m^3)
X1	Block Laminating	1,400
X2	Finger Joint Laminating	750
X3	Finger Joint Laminating Board	500

Table 4. Data concerning the decision variable for Samtraco Model II

Decision Variable	Production Type	Product Price (US$ / m^3)
X1	Block Laminating	1,400
X2	Finger Joint Laminating	750
X3	Finger Joint Laminating Board	500
X4	Solid	1,700

Table 5. Data concerning decision variable for Samtraco Model III

Decision Variable	Production Type	Product Price (US$ / m^3)
X1	Block Laminating	1,400
X2	Finger Joint Laminating	750
X3	Finger Joint Laminating Board	500
X4	Solid	1,700
X5	Beams	1,200

Formulation of Constraint Function

In a linear programming model of income optimization, in order to obtain optimum income it would be necessary to find the 14 data related to the products of PT. Cahaya Samtraco Utama such as the ones shown on table 6 above.

Table 6. Constraint Function Variables (Expenses and Inventory)

No	Details of Expenses	Comments	Block Laminating	Finger Joint Laminating	Finger Joint Laminating Board
1	Electricity	Kwh	491,785	57,278	24,300
2	Manpower	Hok	4,590	534	226
3	Machine Depreciation	%	0.83	0.09	0.04
4	Adhesive	Kg/ month	34.42	2,004	850
5	Buildings	%	0.58	0.06	0.02
6	Tax	%	0.0058	0.0178	0.1904
7	Manager	Person	8	1	4
8	Marketing	Day	6	5	3
9	Transportation	%	0.02	0.02	0.02
10	Boiler	Ton	258	30	12
11	Repair	%	0.07	0.07	0.07
12	Administration	Person	14	2	1
13	Shipment	Day	25	17	10
14	Raw Materials	m^3	1,549	677	469

5.2 Production Income

Model I:

Model I was for the income amounted to US$ 1,217,250 per month by producing three product combinations namely Laminating Block, with the total production of 765 m^3, Finger Joint Laminating with the total production of 135 m^3 and Finger Joint Laminating Board with the total production of 90 m^3. The means of production were used up.

Model II:

Model II was for the income amounted to US$ 1,240,000 per month by producing combination of products as follows: Block Laminating with the total production of 725 m^3, Finger Joint Laminating with the total production of 138 m^3, Finger Joint Laminating Board with the total production of 90 m^3 and Solid with the total production of 45 m^3. The means of production were used up.

Model III:

Model III was for the income amounted to US$ 1,240,000/ month by producing combination of products as follows: Block Laminating with the total production of 725 m^3, Finger Joint Laminating with the total production of 138 m^3, Finger Joint Laminating Board with the total production of 90 m^3, Solid with the total production of 45 m^3 and Beams with the total production of 45 m^3. The means of production were used up.

Residual value of the means of production inventory

The means of production used in this research were in forms of the supporting functions in the production process. When the production reached optimum income, the means of production from the three models above showed the value of the used-up of the 14 constraint variables in this research. The residual value and the surplus value could be seen further on table 7.

Optimum Product Income Value

Model I

In Model I, the raw material input for production was 3000 m^3 and the output produced was 990 m^3. The most dominant raw material, with the percentage of 55 %, had a diameter of 50-70 cm; whereas the raw materials with a diameter of 70-90 cm and above 90 cm took up 25 % and 20 % respectively.

Furthermore, for the combination model, the total production of block laminating was 765 m^3, Finger Joint laminating was 135 m^3 and Finger Joint Laminating Board was 90 m^3. The price for block laminating was US$ 1400/ m^3, while for Finger Joint Laminating the price was US$ 750/ m^3 and for Finger Joint Laminating Board it was US$ 500/ m^3. Based on this combination, it was found that the variables of constraint could be used up.

The net optimum income value from the business capital could be obtained after subtracting the expense of each constraint variable from the gross income, in which the gross optimum income was US$ 1,217,250/ month. The currency rate of US$ 1 equals Rp. 9,800; thus the gross income was Rp. 11,929,050,000 after being subtracted from the expense of Rp. 12,676,499,750/ month. The amount of net income gained was therefore Rp. 1,252,550,250/ month.

Model II

In Model II, the raw material input for production was 3000 m^3 with the product output of 998 m^3. 50 % of the raw materials used were the ones with a diameter of 50-70 cm. The rest 30 % and 20 % were the materials with diameters of 70-90 cm and more than 90 cm respectively. The combination model included Block Laminating, with the total production of 725 m^3; Finger Joint Laminating, with the total production of 138 m^3; Finger Joint Laminating Board, with the total production of 90 m^3 and Solid, with the total production of 45 m^3. The price for Block Laminating was US$ 1400/ m^3; for Finger Joint Laminating it was US $ 750/ m^3, for Finger Joint Laminating Board US$ 500/ m^3 and for Solid US$ 1700/ m^3. Based on this combination, the variable of constraint could be used up.

The net optimum income value obtained from Model 2 could be calculated, in which the gross optimum income was US$ 1,240,000/ month, with the currency rate of US$ 1 equals to Rp. 9,800. Therefore, the gross income was Rp. 12,152,000,000/ month after being subtracted from the expense of Rp. 10,876,040,000/ month. The net income value obtained was Rp. 1,275,960,000/ month.

Model III

In Model III, the raw material input for production was 3000 m^3 with the product output of 990 m^3. 50 % of the raw materials used were the ones with a diameter of 50-70 cm. While, the ones with diameters of 70-90 cm and more than 90 cm each dominated 25 % of the raw materials used.

The net optimum income value from the business model could be calculated after subtracting the gross income with the expense of each variable of constraint. The gross optimum income was US$ 1,294,000/ month with the currency rate of US$ 1 equals to Rp. 9,800. Thus, the gross income was Rp. 12,681,200,000/ month after being subtracted from the expense of Rp. 11,286,268,000/ month. The net income obtained was Rp. 1,394,932,000/ month.

The combination model included Block Laminating, with the total production of 725 m^3; Finger Joint Laminating with the total production of 138 m^3; Finger Joint Laminating Board, with the total production of 90 m^3; Solid, with the total production of 45 m^3 and Beams, with the total production of 45 m^3. The price for Block Laminating was US$ 1400/ m^3, for Finger Joint Laminating US$ 750/ m^3, for Finger Joint Laminating Board US$ 500/ m^3, for Solid US$ 1700/ m^3 and for Beams US$ 1200/ m^3. Based on this combination, the variable of constraint could be used up. Moreover, the company would not reach the optimum value if there was only one item produced, since the means of production would not be used optimally.

6. Conclusion

Based on the data processing results, it was found that the input for Model I was 3000 m^3, which produced an output of 990 m^3, with the optimum production income from the three combined products amounted to Rp.

1,253,547,250/ month. Next, for Model II, the input was 3000 m^3, which produced an output of 998 m^3, with the optimum production income from the four combined products amounted to Rp. 1,275,960,000/ month. Then, for Model III, the input was 3000 m^3, which produced an output of 1004 m^3, with the optimum production income from the five combined products amounted to Rp. 1,394,932,000/ month.

To obtain the optimum value in Model I, the business maker had to combine the product model of Block Laminating, with the total production of 765 m^3, Finger Joint Laminating with the total production of 135 m^3 and Finger Joint Laminating Board with the total production of 90 m^3, so that the means of production could be used up.

In Model II, the business maker had to combine the product model of Block Laminating, with the total production of 725 m^3; Finger Joint Laminating, with the total production of 138 m^3; Finger Joint Laminating Board, with the total production of 90 m^3 and Solid, with the total production of 45 m^3. The price for Block Laminating was US$ 1400/ m^3; for Finger Joint Laminating it was US $ 750/ m^3, for Finger Joint Laminating Board it was US$ 500/ m^3 and for Solid US$ 1700/ m^3. Based on the combination, the variable of constraint could be used up. Moreover, for Model III, the business maker had to combine products of Block Laminating, with the total production of 725 m^3; Finger Joint Laminating with the total production of 138 m^3; Finger Joint Laminating Board, with the total production of 90 m^3; Solid, with the total production of 45 m^3 and Beams, with the total production of 45 m^3. The price for Block Laminating was US$ 1400/ m^3, for Finger Joint Laminating US$ 750/ m^3, for Finger Joint Laminating Board US$ 500/ m^3, for Solid US$ 1700/ m^3 and for Beams US$ 1200/ m^3. Based on this combination, the variable of constraint could be used up.

Based on the research results and discussion, the following findings could be implied: 1) there were three models of combined products that were suitable with the input and market demand; 2) variable values were found with different percentage for each variable; 3) the amount of log input determined the models of production reached, and 4) the biggest input came firstly from the timber raw materials as much as 57- 61 %, secondly from the overseas shipment fee as much as 8.4 – 9.3 %, thirdly from electricity as much as .2- 5 % and then fourthly from the manpower as much as 5.2 – 6 %. The other input amount was less than 4 %.

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1* Ita Merni Patulak, was born on May 25th,1972, in Jember, East Java, Indonesia, having Bachelor of Economic in 1996 from Makassar, Hasanuddin University, Magister Management in 2005 from Samarinda, Magister Management Mulawarman University, and student in Forestry Doctorate Mulawarman University since 2010. Currently work as a lecturer in the Agriculture State of Polytehcnik Samarinda.