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A research on particle board factory by utilization of integer linear programming

Yunus SAHIN[1], Hasan SERIN[1]*

[1]Kahramanmaraş Sütçü İmam University, Faculty of Forestry, Kahramanmaras, TURKEY
*Corresponding author: hasanserin@ksu.edu.tr

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Abstract

Aim of study: There are some factors which effect production of establishments for instance; quality, cost, time, capacity of production, raw material, market structure, and, customer variables. The establishments have to perform their productive activity in accordance with these variables for minimum cost or maximum profit. Therefore, it is necessary to make a production planning for doing something at correct time. While making the production planning, quantitative determine techniques are used for solving of complex problems. The linear programming which is the best among the quantitative techniques provides active and optimum production planning.

Area of study: This study was conducted at the particle board factory, located on the Mersin city, Turkey.

Material and Methods: In this research, particle board factory and its production process were examined. The linear programming method was run on LINGO 13.0 programme.

Main results: In this study, it was determined that particle board production quantity, particle board stock quantity for a year. The demand was covered completely. 1000 number demand at production of particle board were covered with stock product by different production quantities in particular months.

Research highlights: Development of the firms on this way will lead to further in terms of economic of country and its development.

Keywords: Linear programming, Production planning, Cost, Forestry

Yonga levha fabrikasında doğrusal programlama kullanımı üzerine bir araştırma

Özet

Çalışmanın amacı: İşletmelerin üretimini etkileyen faktörler; fiyat, kalite, zaman, üretim kapasitesi, hammadde, piyasa yapısı ve müşteri değişkenleridir. İşletmeler üretim faaliyetlerini bu değişkenler doğrultusunda minimum maliyet ya da maksimum kar amacına yönelik yürütmek durumundadırlar. Bu sebeple yukarıda sayılan faktörler bakımından nelerin, nerelerde, kimler tarafından, ne zaman ve nasıl yapılacağına ilişkin bir üretim planı yapılması gerekmektedir. Üretim planlanması yapılırken ortaya çıkabilecek karmaşık sorunların çözümünde kantitatif karar verme teknikleri kullanılır. Bu tekniklerin başında gelen doğrusal programlama metodu, yapılan üretim planının etkin ve optimum olmasını sağlar.

Çalışma alanı: Bu çalışma Türkiye'nin Mersin ilinde yer alan yonga levha fabrikasında gerçekleştirilmiştir.

Materyal ve Yöntem: Yapılan çalışmada yonga levha fabrikası ve bu fabrikanın üretim yöntemi incelenmiştir. Lineer program metodu LINGO 13.0 üzerinde çalıştırılmıştır.

Sonuçlar: Bu çalışmada, yıllık olarak yonga levha üretiminin miktarı ve yonga levha stok miktarı belirlenmiştir. Talep tamamıyla karşılanmıştır. 1000 sayıda yer alan üretimdeki talep kısmi olarak aylarda farklı üretim miktarlarıyla stok üretimi ile karşılanmıştır.

Araştırma vurguları: Bu yöntem ile işletmelerdeki gelişme sayesinde sürdürülebilirlikleri devam edecek ayrıca ülke ekonomisi ve kendi ekonomilerine büyük katkı sağlayacaktır.

Anahtar Kelimeler: Doğrusal Programlama, Üretim Planlama, Maliyet, Ormancılık

Introduction

The production of board which has a wood-based homogeny structure has started in 1940s. Particleboard and fibreboard industries have established in Turkey, 1950s. Particularly, these industries have rapidly developed after the Second World War, because it has been in need of large scale materials for working on restructuring of cities. Particleboard, constitutes dried wood chips which are glued together with a resin which cures under the influence of high pressure and heat. Wood chips are derived from wood raw materials, such as round wood, sawdust, shavings, flakes, and recovered wood from various sources.

Particle board is used in furniture, forestry enterprises, glue industry, timber factories, paper sector, construction, decoration, energy sector, and other fields. Particle boards have many mechanical and physical characteristics (Akbulut, 2000);

- Smooth surface and it can be produced all thickness,
- Homogeny structure and it can be joined with nail, screw, and glue,
- It provides saving from labour because of it's produced large sizes,
- It can be applied top surface process,
- It can get new characteristics by treating with hydrophobic, protector, and fire-retardant materials,
- It can be handed easily and it has not defects such as knot, decay, and fibre curvature in solid wood panels also it is cheap.

Quantitative research is an approach for testing objective theories by examining the relationship among variables (Crotty, 1998). The objective of quantitative research is to develop and employ mathematical models, theories and hypotheses pertaining to phenomena. A mathematical model is a description of a system using mathematical concepts and language. Mathematical models are used in natural sciences (physics, biology, chemistry, etc.), social sciences (economics, sociology, political science, etc.), and engineering disciplines (computer science, artificial intelligence, etc.) (Wayne, 1994).

Mathematical models can take many forms, including linear programming, statistical models, game theoretic models, etc. Linear programming (LP) is a method to achieve the best outcome such as maximum profit or lower cost (Chase, et al 2001). This programme is a widely used field of optimization several reasons. Many practical problems in operation research can be expressed as linear programming. LP provided a basis for stochastic, non-linear programming, and so on (Morris, 1967).

Linear programming is heavily used in microeconomics and company management, such as planning, production, transportation, technology, and other issues. A research on Fortune 500, which is big company among the biggest companies in America, was determined that 85% of firms used linear programming at decision making process (Büyükkeklik, 2007).

Linear programming has 3 basic factors: objective function, constraints, and non-negative variables (Özsan, 2006). Objective function is generally established up suitable for maximum profit and/or minimum cost.

- Objective function of maximum problems;

$$Z_{max}=\sum_{j=1}^{N} Xjcj \qquad (j = 1,2, \dots \dots N)$$

Objective function of minimum problems;

$$Z_{min}=\sum_{j=1}^{N} Xjcj \qquad (j = 1,2, \dots \dots N)$$

- Constraints, which use in linear programming, are demonstrated at below:

At maximum problems;

$$\sum_{i=1}^{M} \quad \sum_{j=1}^{N} Xjaij \leq bi \qquad (j = 1,2, \dots \dots N \; i = 1.2 \dots \dots, M)$$

At minimum problems,

$$\sum_{i=1}^{M} \quad \sum_{j=1}^{N} Xjaij \geq bi \qquad (j = 1,2, \dots \dots N \; i = 1.2 \dots \dots, M)$$

- Decision variables must be positive (Non-negative condition, $X_j \geq 0$).

In this study, it was determined that particle board production quantity, particle board stock quantity for a year by using linear programming method at particle board factory.

Material and Method

Material

In this research, particle board factory and it's production process were examined. It was intended that the production of firm was in optimal level. The employers work 26 days in a month so work power is 37440 minutes. The production quantity (m^3) of particle board was determined in reference to months (Table 1).

As shown at Table 2 the machines and number of operators were determined on production process. Time is important factor at production process. The time spent at production was determined at Table 3.

Method

The linear programming method was run on LINGO 13.0 programme. Demands for particle board (covered and uncovered) were 7500 and 1000 number every month in a year, respectively. Beginning product quantity was zero for all products. In this production system, sanding and melamine covering machine were narrow pass. It was ignored that the machines stop in maintenance and failure situation. The developed model was determined according to data and constraints;

Z_{max} = TG - (SM + STM+EASM + EAKM)

Table 1. The production quantity of particle board material (m^3) in reference to months

Months	Production		Number of Worked Day
	m^3	m^3/Day	
January	-	-	31
February	9.148	326.71	28
March	8.506	274.38	31
April	2.932	97.73	30
May	5.245	169.19	31
June	5.355	178.50	30
July	5.258	169.61	31
August	4.615	148.87	31
September	9.681	322.7	30
October	3.569	115.12	31
November	10.735	357.83	30
December	10.464	337.54	31
TOTAL	75.508	206.87	365

Table 2. The machines and number of operators

Machine No	Machine	Machine Quantity	Number of Operator
1	Chipping	2	4
2	Dryer	1	2
3	Sifter	2	2
4	Layer	1	1
5	Press	1	2
6	Sanding	1	2
7	Melamine Covering	1	2
8	Packaging	1	2

Table 3. The time spent at production process

Machine No	Machine	Production Times	
		Particle (Uncovered)	Particle (Covered)
		Minute/Number	Minute/Number
1	Layer	3.5	3.5
2	Press	2.1	2.1
3	Sanding	2.4	2.4
4	Melamine Covering	-	3.1
5	Packaging	2.5	2.5

Results

The enterprise thought two products as uncovered particle board (Y) and covered particle (YL) board at production system. After using the LINGO package programme, outputs of the model were gained. These outputs were showed at tables.

Table 4. Number of particle board quantity (Uncovered-Y)

Machine	Months (t)											
No (j)	1	2	3	4	5	6	7	8	9	10	11	12
1	1325	1323	1009	0	996	1752	2100	2098	0	0	0	0
2	1325	1323	355	1001	996	1752	358	1513	1046	0	1831	0
3	1002	1001	1000	1001	996	1752	358	1000	1559	0	979	1200
4												
5	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1100

As given at Table 4, there was particle board (Y) production table. Particle board demand quantities were given at production line monthly in a year. The demand was covered completely. 1000 number demand at production of particle board were covered with stock product by different production quantities in particular months. There were some 0 values at Table 4 because the firm covered the demand it's stock product at this month.

Table 5. Number of stock particle board (YSS)

Machine	Months (t)											
No (j)	1	2	3	4	5	6	7	8	9	10	11	12
1	0	0	651	0	0	0	1742	2277	1581	1581	100	100
2	323	645	0	0	0	0	0	513	0	0	850	0
3	2	3	3	4	0	752	110	110	669	19	0	100
4												
5	0	0	0	0	0	0	0	0	0	0	0	100

There were stocks between the production machines within production time of particle board in some months. It was seen that the stock quantities went back to acceptable stock level at last of year. As given at Table 5, there was 100 number of stock at last of year and it provided stock constraint that was maximum 1000 number stock.

Table 6. Number of covered particle board quantity (YL)

Machine	Months (t)											
No (j)	1	2	3	4	5	6	7	8	9	10	11	12
1	7505	9842	0	6648	9	0	8151	0	8035	0	0	0
2	7500	8992	8855	6647	7	8	8150	9131	10004	0	0	0
3	7500	8992	8	9994	0	9	8150	6662	10004	9759	1542	0
4	7500	8992	8	7500	8993	7	7500	7500	7500	9759	1542	7500
5	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7600

Covered particle board demand quantities were given at production line monthly in a year (Table 6). There were some 0 values at Table 6 because the firm covered the demand its stock product at this month. Also successive 0 values showed that the firm produced 1000 number production monthly.

Table 7. Number of stock covered particle board (YLSS)

Machine	Months (t)											
No (j)	1	2	3	4	5	6	7	8	9	10	11	12
1	5	5855	0	0	2	0	1742	2277	1581	1581	100	100
2	0	0	8847	1	7	0	0	513	0	0	850	0
3	0	0	0	2494	0	752	110	110	669	19	0	100
4	0	1492	0	0	0	0	0	0	0	7500	0	0
5	0	0	0	0	0	0	0	0	0	0	0	100

It was determined that the stock quantities were occurred within a year plan during the production of covered particle board. As given at Table 7, there was 100 number of stock at last of year and it provided stock constraint that was maximum 1000 number stock. For instance; 1-2-3-5-11th months had 0 value at 3 number machine, 1-3-4-5-6-7-8-9-11-12th months had 0 value at 4 number machine because there was not stock requirement at these months.

Discussions

Covered particle board and uncovered particle board covered demands and quantity of uncovered demand (TKM) was zero (Table4 and Table 6). Because these particle boards produced enough level and the firm had adequate stock quantity. The firm arranged stock cost to production rate after that the stock cost reduced.

As a result, the firm covered the demand of customer properly by working on suitable conditions. The firm will get over with using sources properly and customer satisfaction. After this done research, sustainability of the firm will increase by optimal approaches and it will provide competitive advantage. Development of the firms on this way will lead to further in terms of economic of country and its development.

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