A Multi-Stage Production Planning Model For Ardabil Tannin Peak Sabalan Company

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Abstract

In this paper, a multistage production planning model has been developed for Tanin-Peak Sabalan Company in Ardabil city of Iran. Subjected to different constraints, objective function of the model can minimize the total cost or maximize the total benefit. This company receives the order of different products at random times. Then, the production department of the company starts producing the orders but they don't know if they can provide the orders in due dates. When we face with such a case, we will try to define the bottle neck and solve the problem using suitable methods. By means of this model, three past orders of the company have been evaluated.

Keywords — *Production planning, multistage, bottleneck.*

I. INTRODUCTION

Decision making is one of the main tasks to perform by any organization manager. Correct decision is the result of proper planning. Complexity of management issues, instability and uncertainty of conditions, constraints of resources and the need for innovation in trade, requires us to utilize new knowledge and technology in order to make rapid and optimized decisions [1].

Operations research is the best tool to obtain this goal by means of model definition.

The researcher's aim in this research is the creation of a multistage production planning model for this company that one of its applications is recognizing the feasibility of the orders coming from management in due date.

Tanin-Peak Sabalan Company is located in Iran, Ardabil city; it produces much kind of balls with beta brand. The model response will be one of the following:

a) The market demand is more than production capacity.

b) The market demand is less than production capacity.

In the first option, the model determines if order can be provided in due date or not.

In the second option, the model determines optimized production planning.

II. MULTISTAGE PRODUCTION PLANNING

Mathematical programming models especially linear programming models, usually are used for analysing multistage systems. All of these models have a common aspect respect to the specification of the multistage models. Material balance equation for every inventory point must be existed.

Kinds of multistage production planning and their history are listed as follows:

A. *Linear Planning Models*

Some researchers published a paper that gives some insights by looking at the queuing that results in delays; it suggests an optimization model that takes in to account load dependent lead time and routing alternatives [2].The planning and scheduling of production in a multi task/multistage batch manufacturing process typical of industries such as chemical manufacturing, food processing and oil refining is studied [3].Some researchers conducted a study in electronic equipment manufacturing company with the aim of achieving a multistage production model in a dynamic environment for improvement in future [4].

B. *One Period Possible Period*

Mathematical modelling framework is developed for generating production plans in a multistage manufacturing process [5].Some researchers conducted a study in a refrigerator company in Iran with the subject of multistage production optimization in uncertain condition [6].

C. *Multistage Systems with Stored Value*

Some Researchers considered the production environment that produces intermediate products, by-products and finished goods at a production stage. Complexities in the production process arise due to the desired coordination of various production stages and the recycling process [7].

D. *Full Size Multistage Economic Issues*

When the cost of preparing and launching in a multistage system is important, system analysis will be complex. When there are several stages in series that all of them produce one product, production will be cumulative. Then among every stage will be a store. In such systems, problem is determining the optimized value of stores with considering preparing costs.

III. PROPOSED MULTISTAGE PRODUCTION PLANNING

Before defining the model, several units of the company are described in brief. In this company output of each unit is input of the next unit. The units are:

1) Rubber making unit: unit that produces two kinds of rubber sheet. One sheet is black and it is used to build the bladder and other one is used to outer cover sheet that can come in any colour.
2) Bladder unit: black rubber sheets are converted to bladder in this unit
3) Winding yarn unit: the second layer of each rubber ball is wind. All bladders are winded in this unit.
4) Carcass covering unit: in this unit colourful rubber sheets cover winded bladders and this is the third layer of rubber balls.
5) Print and panel unit: in this unit all prints cover balls.
6) Finishing rubber vulcanization is the unit that cooks all raw balls.
7) Packing unit.

All units are shown in Fig.1.

Each unit is considered separately and for each of them the unique model is developed.

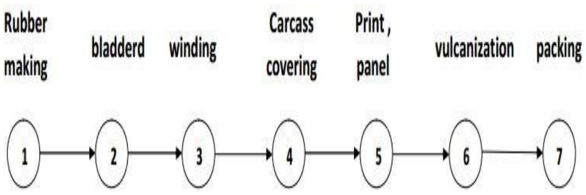

Fig. 1 Company units

A. Notations

X_{ijk} : Production value of product i in j th step in shift k

C_{ijk} : Unit production cost of product i in j th step in shift k

T_{ijk} : Time spent for product i in j th step in shift k

d_i : Demand of product i

n_i : Number of needed moulds for product i

$i = 1,2,...,19$

$k = 1,2,3$

j has different values in different units but its maximum value is 7.

B. Proposed Model

Objective function for all units is to minimize the total cost as follow:

$$Min \quad f = \sum_{i=1}^{19} \sum_{j} \sum_{k=1}^{3} C_{ijk} X_{ijk}$$

All costs C_{ijk} are estimated and $C_{ij1} \le C_{ij2} \le C_{ij3}$

In this way, first, shift one is filled, and then shift two and three are filled respectively, if needed.

The amount of j is variable and it shows the station number (step number).

All units contain several steps. All of them with their functions and constrains will describe in the next sections.

The amount of T_{ijk} is obtained by using the Time measurement method that listed in appendix in Tab.4, Tab.5, Tab.6, Tab.7, Tab.8, Tab.9, Tab.10.

The amount of d_i is variable and depends on orders value.

C. Mathematical Model for Rubber Making Unit

This unit has 5 step and maximum value of j in this section is 5 (Fig.2).

First and second constrains show the time constraints of each shift and each step and third constraint shows the amount of demand.

As the amount of wastage in all stations of production is trace, it is considered zero. Then the output of final step of stations will be equal d_i.

The most important constraint in each station is time constraints and machine constraints such as each station has unique constraints.

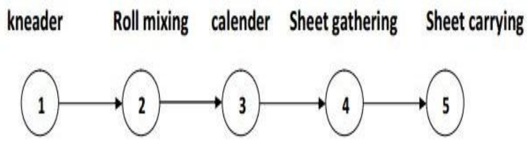

Fig. 2 Rubber making unit steps

$$Min \quad f = \sum_{i=1}^{19} \sum_{j=1}^{5} \sum_{k=1}^{3} C_{ijk} X_{ijk}$$

$$\sum_{i=1}^{19} X_{ijk} T_{ijk} \le 57600 \qquad k = 1,2,3 \quad j = 1,2,3,4,5$$

$$\sum_{i=1}^{19} X_{i5k} \le 4800 \qquad k = 1,2,3$$

$$\sum_{k=1}^{3} X_{i1k} = \sum_{k=1}^{3} X_{i2k} = \sum_{k=1}^{3} X_{i3k} = \sum_{k=1}^{3} X_{i4k} = \sum_{k=1}^{3} X_{i5k} = d_i$$

$i = 1,2,...19$

The amount of 57600 is obtained by multiplying the work hours in the number of available machines and 3600 (one hour). [57600 = 8*2*3600]

The amount of 4800 is obtained by multiplying the work hours in the number of machines and 3600 then result is divided to time of the work.

[4800 = (8*1*3600)/6]

D. Mathematical Model for Bladder Unit

Fig.3 shows steps of this unit.

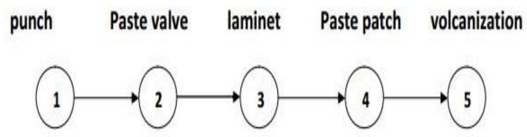

Fig. 3 Bladder unit steps

$$Min \quad f=\sum_{i=1}^{19}\sum_{j=1}^{5}\sum_{k=1}^{3}C_{ijk}X_{ijk}$$

$$\sum_{i=1}^{19}X_{ijk}T_{ijk}\le 28800 \quad k=1,2,3 \quad j=1,4,5$$

$$\sum_{i=1}^{19}X_{ijk}T_{ijk}\le 86400 \quad k=1,2,3 \quad j=2,3$$

$$\sum_{k=1}^{3}X_{i1k}=\sum_{k=1}^{3}X_{i2k}=\sum_{k=1}^{3}X_{i3k}=\sum_{k=1}^{3}X_{i4k}=\sum_{k=1}^{3}X_{i5k}=d_i$$

$$i=1,2,...19$$

The amount of 28800 is obtained from multiplying the work hours in the number of available machines and 3600 [28800 = (8*1*3600)].

The amount of 86400 obtained from multiplying the work hours in the number of available machines and 3600 [86400 = (8*3*3600)].

The amounts of right hand sight of below limits obtained from multiplying the work hours in the number of shifts in the number of moulds and 3600.

The number of moulds listed in Tab.1

$$\sum_{i=3,4,5,12,17}\sum_{k=1}^{3}X_{i3k}\le 86400$$

$$\sum_{i=6,9,10,11}\sum_{k=1}^{3}X_{i3k}\le 259200$$

$$\sum_{i=1,2,16}\sum_{k=1}^{3}X_{i3k}\le 86400$$

$$\sum_{i=18,19}\sum_{k=1}^{3}X_{i3k}\le 86400$$

$$\sum_{i=8,13}\sum_{k=1}^{3}X_{i3k}\le 259200$$

$$\sum_{k=1}^{3}X_{73k}\le 259200$$

$$\sum_{k=1}^{3}X_{14,3,k}\le 86400$$

$$\sum_{k=1}^{3}X_{15,3,k}\le 259200$$

[86400 = 8*3*1*3600] [259200= 8*3*3*3600]

E. Mathematical Model for Winding Yarn Unit

Fig.4 shows steps of this section.

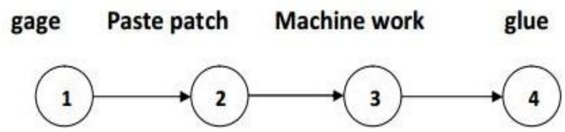

Fig. 4 Winding yarn steps

$$Min \quad f=\sum_{i=1}^{19}\sum_{j=1}^{4}\sum_{k=1}^{3}C_{ijk}X_{ijk}$$

$$\sum_{i=1}^{19}X_{i1k}T_{i1k}\le 57600 \quad k=1,2,3$$

$$\sum_{i=1}^{19}X_{i2k}T_{i2k}\le 28800 \quad k=1,2,3$$

$$\sum_{i=1}^{19}X_{i4k}T_{i4k}\le 28800 \quad k=1,2,3$$

$$\sum_{i=1,2,16,18,19}X_{i3k}T_{i3k}\le 172800\times n_1 \quad k=1,2,3$$

$$\sum_{i=3,4,5,12,17}X_{i3k}T_{i3k}\le 172800\times n_2 \quad k=1,2,3$$

$$\sum_{i=6,9}X_{i3k}T_{i3k}\le 172800\times n_3 \quad k=1,2,3$$

$$\sum_{i=8,13}X_{i3k}T_{i3k}\le 172800\times n_4 \quad k=1,2,3$$

$$\sum_{i=14,15}X_{i3k}T_{i3k}\le 172800\times n_5 \quad k=1,2,3$$

$$\sum_{i=7,10,11}X_{i3k}T_{i3k}\le 172800\times n_6 \quad k=1,2,3$$

$$\sum_{i=1}^{6}n_i=12$$

$$\sum_{k=1}^{3}X_{i1k}=\sum_{k=1}^{3}X_{i2k}=\sum_{k=1}^{3}X_{i3k}=\sum_{k=1}^{3}X_{i4k}=d_i$$

$$i=1,2,...19$$

Since some of the balls have the same size, they are winding in the common machine. Each machine has 6 units then the amount of 172800 is obtained from 8*3600*6.

n_i shows the number of machines for winding X_{i3k} and total number of machines is 12.

F. Mathematical Model for Carcass Covering Unit

Fig.5 shows steps of this unit.

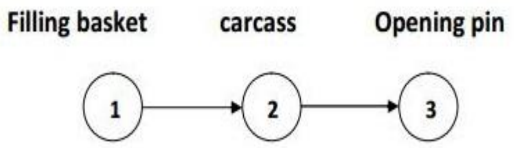

Fig. 5 Carcass covering steps

$$Min \quad f = \sum_{i=1}^{19}\sum_{j=1}^{3}\sum_{k=1}^{3} C_{ijk}X_{ijk}$$

$$\sum_{i=1}^{19} X_{i1k}T_{i1k} \le 28800 \quad k = 1,2,3$$

$$\sum_{i=1}^{19} X_{i2k}T_{i2k} \le 230400 \quad k = 1,2,3$$

$$\sum_{i=1}^{19} X_{i3k}T_{i3k} \le 345600 \quad k = 1,2,3$$

$$\sum_{k=1}^{3} X_{i1k} = \sum_{k=1}^{3} X_{i2k} = \sum_{k=1}^{3} X_{i3k} = d_i$$

$$i = 1,2,\ldots 19$$

Below limits related the mould restrictions. The number of moulds listed in Tab.1.

$$\sum_{i=3,4,5,12,17} X_{i2k}T_{i2k} \le 86400 \quad k = 1,2,3$$

$$\sum_{i=1,2,16} X_{i2k}T_{i2k} \le 86400 \quad k = 1,2,3$$

$$\sum_{i=7,10,11} X_{i2k}T_{i2k} \le 432000 \quad k = 1,2,3$$

$$\sum_{i=6,9} X_{i2k}T_{i2k} \le 172800 \quad k = 1,2,3$$

$$\sum_{i=18,19} X_{i2k}T_{i2k} \le 86400 \quad k = 1,2,3$$

$$\sum_{i=8,13} X_{i2k}T_{i2k} \le 86400 \quad k = 1,2,3$$

$$X_{14,2,k}T_{14,2,k} \le 86400 \quad k = 1,2,3$$

$$X_{15,2,k}T_{15,2,k} \le 86400 \quad k = 1,2,3$$

$$\sum_{i=3,4,5,17} X_{i3k}T_{i3k} \le 172800 \quad k = 1,2,3$$

$$\sum_{i=1,2,16} X_{i3k}T_{i3k} \le 86400 \quad k = 1,2,3$$

$$X_{6,3,k}T_{6,3,k} \le 172800 \quad k = 1,2,3$$

$$X_{7,3,k}T_{7,3,k} \le 259200 \quad k = 1,2,3$$

$$X_{8,3,k}T_{8,3,k} \le 172800 \quad k = 1,2,3$$

$$X_{9,3,k}T_{9,3,k} \le 86400 \quad k = 1,2,3$$

$$X_{10,3,k}T_{10,3,k} \le 172800 \quad k = 1,2,3$$

$$X_{11,3,k}T_{11,3,k} \le 172800 \quad k = 1,2,3$$

$$X_{12,3,k}T_{12,3,k} \le 86400 \quad k = 1,2,3$$

$$X_{13,3,k}T_{13,3,k} \le 172800 \quad k = 1,2,3$$

$$X_{14,3,k}T_{14,3,k} \le 86400 \quad k = 1,2,3$$

$$X_{15,3,k}T_{15,3,k} \le 172800 \quad k = 1,2,3$$

$$X_{18,3,k}T_{18,3,k} \le 86400 \quad k = 1,2,3$$

$$X_{19,3,k}T_{19,3,k} \le 86400 \quad k = 1,2,3$$

G. Mathematical Model for Print and Panel Unit

Fig.6 shows steps of this unit.

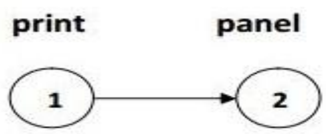

Fig. 6 Print and panel steps

$$Min \quad f = \sum_{i=1}^{19}\sum_{j=1}^{2}\sum_{k=1}^{3} C_{ijk}X_{ijk}$$

$$\sum_{i=1}^{19} X_{i1k}T_{i1k} \le 230400 \quad k = 1,2,3$$

$$\sum_{i=1}^{19} X_{i2k}T_{i2k} \le 403200 \quad k = 1,2,3$$

$$\sum_{k=1}^{3} X_{i1k} = \sum_{k=1}^{3} X_{i2k} = d_i$$

$$i = 1,2,\ldots 19$$

[230400 = 8*3600*8] [403200 = 8*3600*14]

H. Mathematical Model for Vulcanization Unit

Fig.7 shows steps of this unit.

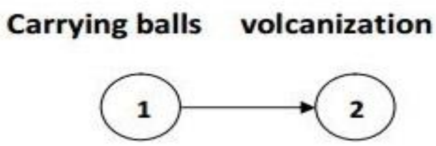

Fig. 7 Print and panel steps

$$Min \quad f = \sum_{i=1}^{19}\sum_{j=1}^{2}\sum_{k=1}^{3} C_{ijk}X_{ijk}$$

$$\sum_{k=1}^{3} X_{i1k} = \sum_{k=1}^{3} X_{i2k} = d_i$$

$$i = 1,2,...19$$

$$\sum_{i=1}^{19} X_{ijk} T_{ijk} \le 28800 \quad k = 1,2,3 \quad j = 1,2$$

$$X_{32k} + X_{42k} + X_{52k} \le 37 \times n_1 \qquad k = 1,2,3$$

$$X_{12k} + X_{22k} \le 37 \times n_2 \qquad k = 1,2,3$$

$$X_{62k} \le 37 \times n_3 \qquad k = 1,2,3$$

$$X_{72k} \le 37 \times n_4 \qquad k = 1,2,3$$

$$X_{82k} \le 37 \times n_5 \qquad k = 1,2,3$$

$$X_{92k} \le 37 \times n_6 \qquad k = 1,2,3$$

$$X_{10,2,k} \le 37 \times n_7 \qquad k = 1,2,3$$

$$X_{11,2,k} \le 37 \times n_8 \qquad k = 1,2,3$$

$$X_{12,2,k} \le 37 \times n_9 \qquad k = 1,2,3$$

$$X_{13,2,k} \le 37 \times n_{10} \qquad k = 1,2,3$$

$$X_{14,2,k} \le 37 \times n_{11} \qquad k = 1,2,3$$

$$X_{15,2,k} \le 37 \times n_{12} \qquad k = 1,2,3$$

$$X_{16,2,k} \le 37 \times n_{13} \qquad k = 1,2,3$$

$$X_{17,2,k} \le 37 \times n_{14} \qquad k = 1,2,3$$

$$X_{18,2,k} \le 37 \times n_{15} \qquad k = 1,2,3$$

$$X_{19,2,k} \le 37 \times n_{16} \qquad k = 1,2,3$$

$$\sum_{i=1}^{16} n_i = 65$$

$n_1 \le 20$, $n_2 \le 5$, $n_3 \le 10$, $n_4 \le 35$, $n_5 \le 20$, $n_6 \le 3$, $n_7 \le 15$, $n_8 \le 15$, $n_9 \le 3$, $n_{10} \le 5$, $n_{11} \le 3$, $n_{12} \le 5$, $n_{13} \le 3$, $n_{14} \le 3$, $n_{15} \le 3$, $n_{16} \le 1$

Since some of the balls have the same size and mould, they are vulcanizing in the common mould.

n_i shows the number of different kinds of mould and total number of moulds that we can use is 65.

Maximum number of each mould is shown by constraints.

The maximum cycle of vulcanization in one shift per each mould is 37.

I. *Mathematical Model for Packing Unit*

Fig.8 shows steps of this section.

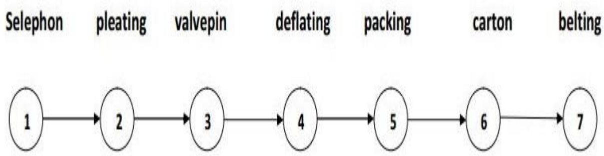

Fig. 8 Steps of packing unit

$$Min \quad f = \sum_{i=1}^{19} \sum_{j=1}^{7} \sum_{k=1}^{3} C_{ijk} X_{ijk}$$

$$\sum_{i=1}^{19} X_{ijk} T_{ijk} \le 28800 \quad k = 1,2,3 \quad j = 2,6,7$$

$$\sum_{i=1}^{19} X_{i4k} T_{i4k} \le 57600 \quad k = 1,2,3$$

$$\sum_{i=1}^{19} X_{ijk} T_{ijk} \le 86400 \quad k = 1,2,3 \quad j = 3,5$$

$$\sum_{i=1}^{19} X_{i1k} T_{i1k} \le 144000 \quad k = 1,2,3$$

$$\sum_{k=1}^{3} X_{i1k} = \sum_{k=1}^{3} X_{i2k} = \sum_{k=1}^{3} X_{i3k} = \sum_{k=1}^{3} X_{i4k} =$$

$$\sum_{k=1}^{3} X_{i5k} = \sum_{k=1}^{3} X_{i6k} = \sum_{k=1}^{3} X_{i7k} = d_i$$

$$i = 1,2,...19$$

In this research to gathering data, observation and time measurement method are used. For calculating the consumed time of each work station and determining the bottlenecks, Lingo software is used to solve the model.

The factory data are shown in the table 1, 2.

Table I : Mould Number in Units

i	**Mould number in marking mould unit**	**i**	**Mould number in carcass unit**	**i**	**Mould number in bladder unit**
1,2,16	1	18, 19	1	18, 19	1
3,4,5,1 7	2	1,2, 16	1	1,2,16	1
6	2	3,4,5, 12, 17	1	3,4,5, 12, 17	3
7	3	6,9	2	6,9,10, 11	3
8	2	7,10,11	5	7	3
9	1	8,13	1	8, 13	3
10	2	14	1	14	3
11	2	15	1	15	3
12	1			18, 19	1
13	2				

14	1				
15	2				
18	1				
19	1				

To examine the propose model, 3 examples of past orders are presented and analyzed in Tab.3.

Outputs of the solved model by lingo, shows that example 1 and 2 are feasible and can be produced. But example 3 is infeasible because vulcanization unit is bottleneck for this order. Then, to fulfill this order at due date, we must find suitable solution for this unit. In such situation, past experiences are showed that the combination of raw materials will be changed in consultation with the chemical engineers.

Table II : Products Information

i	Products Name
1	Soccer2
2	Soccer2(angry)
3	Soccer3
4	brazuca
5	Soccer3(real)
6	Soccer3.5
7	Soccer4
8	Soccer5
9	Volleyball4
10	Volleyball5
11	Volleyball(8p)
12	Basketball3
13	Basketball5
14	Basketball6
15	Basketball7
16	Handball2
17	Handball3
18	Soccer1
19	Volleyball1

TABLE III : EXAMPLES

i	d_i in Example 1	d_i in Example 1	d_i in Example 3
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	2800	2200	3500
8	500	500	1000
9	0	0	0
10	1500	400	1000
11	1000	1600	1500
12	0	0	0
13	0	300	0
14	300	0	0
15	0	300	500
16	0	0	0

17	0	0	0
18	0	0	0
19	0	0	0

IV. CONCLUSIONS

The developed multistage production planning model is useful for recognizing the feasibility of the orders. The model response can be one of the followings:

a)The order can be provided in due date.

b)The order can't be provided in due date.

If cannot be provided, bottlenecks must determine and measure requirements to be taken.

By using this model, decision making for production unit can be easy and convenient.

This model can be used for other goods and factories which have similar products.

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APPENDIX

TABLE IV : TIMES IN RUBBER MAKING UNIT

i	T_{i1k}	T_{i2k}	T_{i3k}	T_{i4k}	T_{i5k}
1	4.12	10	10	10	6
2	4.12	10	10	10	6
3	4.12	10	10	10	6
4	4.12	10	10	10	6
5	4.12	10	10	10	6
6	4.12	8.11	8.11	8.11	6
7	4.12	8.11	8.11	8.11	6
8	6.12	8.11	8.11	8.11	6
9	8.11	6.1	6.1	6.1	6

10	8.11	6.1	6.1	6.1	6
11	8.11	6.1	6.1	6.1	6
12	13	12	12	12	6
13	13	12	12	12	6
14	13	5.12	5.12	5.12	6
15	13	5.12	5.12	5.12	6
16	4.12	10	10	10	6
17	4.12	10	10	10	6
18	4.12	10	10	10	6
19	4.12	10	10	10	6

TABLE V : TIMES IN WINDING UNIT

i	T_{i1k}	T_{i2k}	T_{i3k}	T_{i4k}
1	5.9	4.6	60	3.5
2	5.9	4.6	60	3.5
3	5.9	4.6	70	3.5
4	5.9	4.6	70	3.5
5	5.9	4.6	70	3.5
6	5.9	4.6	80	3.5
7	5.9	4.6	90	3.5
8	5.9	4.6	100	3.5
9	5.9	4.6	80	3.5
10	5.9	4.6	90	3.5
11	5.9	4.6	90	3.5
12	5.9	4.6	70	3.5
13	5.9	4.6	100	3.5
14	5.9	4.6	110	3.5
15	5.9	4.6	110	3.5
16	5.9	4.6	60	3.5
17	5.9	4.6	70	3.5
18	5.9	4.6	60	3.5
19	5.9	4.6	60	3.5

TABLE VI : TIMES IN BLADDER UNIT

$T_{i1k} = 2.3$	$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i2k} = 15$	$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i3k} = 17$	$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i4k} = 4.4$	$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i5k} = 11$	$(i = 1,2,\ldots 19)(k = 1,2,3)$

TABLE VII : TIMES IN CARCASS COVERING UNIT

$T_{i1k} = 4.5$	$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i2k} = 22.5$	$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i3k} = 18$	$(i = 1,2,\ldots 19)(k = 1,2,3)$

TABLE VIII : TIMES IN PRINT AND PANEL UNIT

i	T_{i1k}	T_{i2k}
1	38	88
2	38	66
3	38	88
4	38	77
5	38	99
6	38	88
7	38	88
8	38	88
9	38	55
10	38	88
11	38	60
12	38	50
13	38	50
14	38	55
15	38	55
16	38	44
17	38	44
18	38	88
19	38	66

TABLE IX : TIMES IN PRINT AND PANEL UNIT

$T_{i1k} = 3.11$	$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i2k} = 12$	$(i = 1,2,\ldots 19)(k = 1,2,3)$

TABLE X : TIMES IN PACKING UNIT

$T_{i1k} = 24$		$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i2k} = 5$		$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i3k} = 14.3$		$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i4k} = 10$		$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i5k} = 17.7$		$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i6k} = 4$		$(i = 1,2,\ldots 19)(k = 1,2,3)$
$T_{i7k} = 4$		$(i = 1,2,\ldots 19)(k = 1,2,3)$