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A SURVEY FOR DETERMINATION OF WASTAGE RATES AT MASSIVE WOOD MATERIALS PROCESSING

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ABSTRACT

The aim of this study is to determine the wastage rate that occurs during the production process from logs to timbers and from timber to final production of massive wood material.

The difference between the measured total volume of scotch and black pine logs and the measured volume of timbers produced is called as "log-timber wastage". Similarly, the difference between the volumes of the final scotch pine and beech timbers productions is called as "timber-final product wastage".

In this study, mean wastage rate was found 37.4 % for 33 logs with a mean diameter of 36.9 cm. The wastage rate was also found 30 % for production of flushdoors frames and 46 % for production of massive wooden frames.

The results were compared with both national and international studies. The use of computer aided manufacturing instead of conventional production machines to manufacture massive wood materials would reduce the wastage rate.

KEYWORDS: Massive wood, wastage rates, productivity, pine, beech.

INTRODUCTION

As a result of increasing demand for the forest products while forest resources are decreasing currently and the over price increases have lead the consumer to use the raw material wood the most reasonable possible. Processing this material with minimum loss is of vital importance both for the company that involved in the production and for the country economy (Korkut 1999).

For this reason, in order to determine loss percentage, data collected from production line.

Samples were randomly selected from logs in the production phase of timber-working companies and the results were evaluated in the "results for the timber production from logs" section (Korkut 1999).

Losses in the final production from timber were investigated on 2 different products. In similar way as the previous one, data were collected and later evaluated from a timber processing plant, producing flush doors and desktop picture frames.

The overall process in the timber industry generally is cutting the round wood into pre-determined dimensions using saws. During this process different residue classified as sawdusts, trimmings, wings, small timber and discards were produced. Some of these residues, for example wings may be utilized by sawing into smaller timber. Others, however, constitute the raw material of another industry, in timber industry they are considered as residues or losses.

Several studies were conducted on this subject and many different results were appeared because of the many factors affecting the productivity.

According to Fischer's Sankey Diagram, the utilization of a tree:

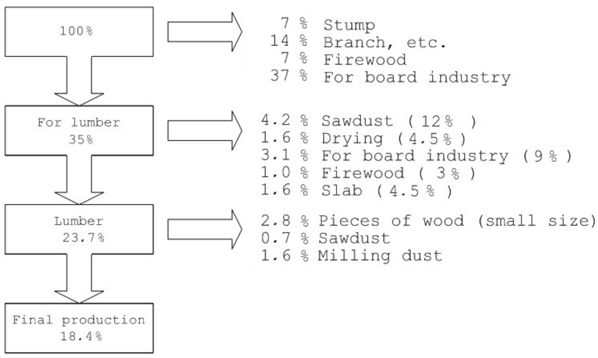

Fig. 1: Evaluation rates from timber to final production, according to Fisher's Sankey diagram (Ozen 1982, Kurtoğlu and Sofuoğlu 2008, Kurtoğlu and Sofuoğlu 2006).

According to Fischer's Sankey Diagram, only 23.7 % of a tree that felled is converted to timber and only 18.4 % is converted to final product. The remaining 81 % is waste (Ozen 1982). When considered the whole volume of the tree volume, one can infer that only 18.4 % of the wood has been utilized. Because as can be seen from Sankey Diagram of Fischer in the Fig. 1, there are many options that allow utilization in the "residue" section. These residues have been utilized as combustible in the underdeveloped countries. On the contrary in developed countries these residues have been utilized as raw material in chipboard, fibreboard and cellulose industries.

In some Works at literature, with regard to cutting timber, the output values are: timber 71 %, sawdust 12 %, and drying tolerance 4 %, utilizable other residues 13 %. However, in another survey the yields are determined as main product 42 %, sawdust 12 %, wings 8 %, chocks 3 %, by-products 23 %, total timber yield 65 % (Ozen 1982).

In The Turkish Standarts TS 654 (1975), yield percentages of softwood edged, prism timber are 55-72 % for fir and spruce, loss percentage is 28-45 %; whereas in pine and cedar yield percentages is reported to be between 44-65 % and related loss percent is 33-55 % (TSE 654 1975).

As one could see, in the processing of softwood logs the loss of 30-40 % wood could not be prevented. Between productivity and loss there is an inverse ratio. Losses are utilized as combustible material in underdeveloped and developing countries, whereas in developed countries they are either converted to chipboard and fibreboard products in integrated plants or they are used in pulpwood production.

In TS 654, the loss percentage in processing softwood cants according to tree species are as follows: in Fir and Spruce sawdust 15-18 %, trimmings 6-10 %, wings 4-8 %, small timber 1-2 %, stake 2-4 %, discards 0-2 %, total loss is 28-45 %; while in pine and cedar, sawdust 15-20 %, trimmings 8-12 %, wings 8-12 %, small timber 1-3 %, stake 2-5 %, discards 1-3 % and total loss is reported to be 33-55 % (TSE 654 1975).

In another study by Frühwald, related to processing solid wood, process phases were illustrated from planted tree in forest to final product and residues occurred. In this study Fruhwald indicated that waste material constitutes 70 % of log volume and the remaining 30 % is converted to final product (Frühwald 1998, 1999).

Production data of the pioneer state company in woodworking industry, ORUS Bolu, between the years 1942-1992 is presented for pine and fir. Processing yields as well as the total yield is supplied for each year. According to these results between 1949 and 1992, the average yield is determined to be 60.13 % for the pine and 62.54 % for the fir. The highest yield for the pine was achieved in 1988 as 69 % and the lowest yield was 47 % in 1995. In the fir the highest yield was 70 % in 1988 and the lowest yield was 54 % in 1981 (Mistepe 1999).

Another study was conducted on "productivity in ORUS Companies" and raw material productivity (yield) between the years 1984-1996 was determined as percentage. Data was presented in three parts as softwood, hardwood and total logs. Also average raw material productivity of the 13 years was determined. According to the general results obtained, the average productivity of the 13 years is 67.2 % for the softwoods; 73.4 % for hardwoods, 80.7 % for the other logs and 70.1 % in total woods evaluated (Mistepe 1999).

In this subject a further study, carried by Ors and Alkan 1986 was investigated length and yield relationship to explain cutting yield. Results were found to be as yields of 55 % in 4 m logs, 52 % in 6 m logs, 50 % in 8 m logs and 47 % in 12 m logs.

In the study of Gursu and Oktem in 1975, the medium yield of the logs of 25-30 diameters that was machined with band saws and gang saws were found to be 61 % in pine and 62 % in fir. In the study of the yield were found to be 67 % in spruce of the same diameter (Gursu and Oktem 1975).

Related to productivity, in the study of Ors and Alkan the yield is reported to be between 67-70 % in unwedged 25-30 timber production regardless of tree species. When edging is applied the yield decreases about 8 % and the yield would be 59-62 % (Ors and Alkan 1986).

Again in another study with the title "Investigations on Yields and Residues of the Turkey's Principal Tree Species by Diameter Grades" by Gursu and Oktem (1975), yields were calculated on various 4 m long and 23-57 cm diameter logs and it was observed that yield percentages increase as the diameter increases. Yield was found to be changed between 55.83 % and 63.53 % in 23-57 cm diameter logs (Gursu and Oktem 1975).

MATERIAL AND METHODS

Material

Study material Scots pine (*Pinus sylvestris* L.) and Black pine (*Pinus nigra* Arnold.) logs and timbers which do not only have an important place in Turkey's forest reserves but also commonly used by woodframing and furniture industries, as well as beech (*Fagus orientalis* L.) timbers were selected as research material.

In Turkey forests, pines were represented by 5 species: Scots pine (*Pinus sylvestris* L.), black pine (*Pinus nigra* var. Pallasiana Arnold), Turkish pine (*Pinus brutia* Henry), Umbrella pine (*Pinus pinea* L.), and Aleppo pine (*Pinus halepensis* Mill.) (Goker 1969).

Scots pine constitutes 5.5 % of Turkey's forest reserves (Bozkurt 1992). Scots pine may be used in buildings in all areas that wood material has been utilized. Principally it has been used to have good quality material. Wood material that has narrow annual rings has been used in woodframing industry, whereas wood material that has broad annual rings has been used in wood frames of buildings. Others uses include furniture making, plywood production, decorative sliced veneer production, turning, chemical wood pulping, when impregnated railroad ties productions, fence stakes making, chipboard production, packing case making, fibreboard production, telecommunication and mine poles productions and underwater constructions (Bozkurt and Erdin 1989, Yaltirik and Efe 1994).

Black pine (*Pinus nigra* Arnold.): is distributed in the vicinity of Anatolia and occasionally in central Anatolia and Thrace (Goker 1969)

It has long stem and is the among first grade forest trees. Older stems have deep furrowed and black bark (Yaltirik and Efe 2000)

It machines well. Drying is considered as relatively simple or simple (Dogu et al. 2001).

As a result of its properties, black pine is utilized without changing its structure as telecommunication poles, mine poles, railroad ties, foundation piles and poles, scaffolding poles, bridge beams and assemblies, pavement parquets, wood pipes, in ships and small boats, house construction, interior design, and especially in furniture production. Apart from these uses it can be used as packaging boxes for solid materials, in agriculture equipments, carriage bodies, cars and in sports plane productions, etc.

Beech (*Fagus orientalis* L.): It comprises about 8 species which establish pure and mixed forests in the cool and temperate regions of the northern hemisphere

It machines well, it may be peeled, machined. There is no difficulty in bonding and surface treatments. It accepts paint and polish well. The wood is hard and heavy, and splits easily. Shock resistance is generally high (Bozkurt 1992, Yaltirik and Efe 1994).

It has much more utilization areas when compared to other hardwoods. It is used especially in solid furniture making, paneling, sports equipments, tools production, coil making, tool handles, turning, in the production of musical equipments, in parquet, plywood, decorative veneer panels and barrel industries, as a fibre and paper wood, in carriage bodies production, in charcoal, wood tar and acetic acid production and when impregnated in railroad ties productions (Bozkurt and Erdin 1989, Yaltirik and Efe 1994).

Methods

This study is consisted of the loss percentage data obtained in the production of timber production from logs and final products production from the timbers.

Research material; is obtained in the timber production from randomly selected logs of different diameters of Scots pine (*Pinus sylvestris* L.) and black pine. The lengths of the logs sawn were between 250 and 400 cm. The sawing operation is realized with carriage band saw machine.

In the final product production from timbers, two products were researched. In the first study, the data were obtained in the production of 105 flushdoors from 3rd grade Scots pine (*Pinus sylvestris* L.) timbers for the student's dormitory at Dumlupinar University, Simav Technical Education Faculty, Furniture and Decoration Education Department, Research and Application Laboratory.

In the second study, the data were obtained also in the same Laboratory from the production of 38 desktop picture frames using 3rd grade beech (*Fagus orientalis* L.) timbers. In this production the parts which contain defects were separated from the timbers and flawless solid beech timbers were used.

The machines used for the production are the machines operated by classic methods (machines without digital control and computer aid and without any optimization). Production were realized with these machines and the data were realized without considering the factors such as length, diameter, cutting method, etc. with the aim of practical future application. In the measuring process, gauges to measure the diameters such as diameter gauges, calipers and steel meters were used.

In the production of timbers from logs, the data were obtained from the production of solid wood frames in two different companies. In carriage band saw machine before the cutting operation, lengths and bigger and smaller extreme diameters of the logs were measured and the volumes were calculated using the formula below. Later the timbers produced were measured again and their volumes were obtained. The remaining part (saw dust, trimmings, wings, chocks, etc.) were considered as loss.

$$V= (\pi/4) \times d^2 \times L \quad (\pi /4 : 0.785)$$

where: V - Log volume (m^3)
d - Medium log diameter (m)
L - Lenght (m)

In the production of final products from the timber, the data from the production of 105 flush doors for the student's dormitory using 3rd grade Scots pine timbers was used. The dimensions and volumes before and after the production were obtained and the losses were calculated using this data. The measurements of the timbers with different dimensions that were processed in two loadings were gathered and volumes were calculated. Later the losses from the production process were calculated measuring the volumes of each solid wood part of the final products of 10 different flush doors with same heights and different wideness. In Fig. 2, the constructions of the flush doors that were produced were shown.

In the second study of final products production from timber, the data was obtained from the production of 38 desktop picture frames using 3rd grade beech timber at Dumlupinar University, Simav Technical Education Faculty, Furniture and Decoration Education Department, Research and Application Laboratory. The volumes of the timbers before and after the production were calculated and the losses were determined using this data. In this production flawless solid wood material was obtained from 3rd grade beech timbers and this material were used in production.

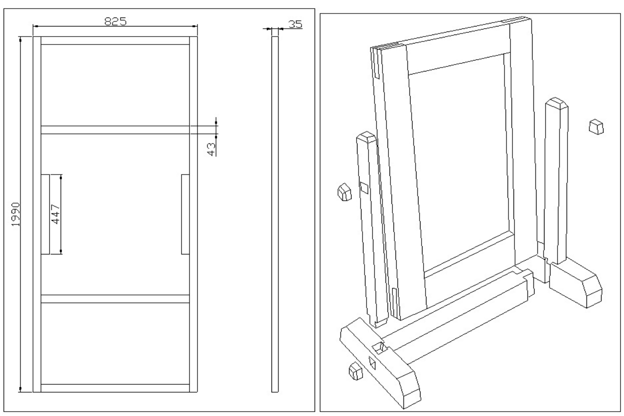

Fig. 2: Flushdoors frame (dimensions for number of 1 door is mm) and massive wooden frame (Jacobson 2000).

RESULTS AND DISCUSSION

The findings were examined in two parts; the findings of timber production from logs and the findings of final products production from timber. Again the findings of final products production were examined as flush doors production data and desktop picture frames production data. The factors affecting the yield (diameter, length, cutting method, etc.) were ignored.

Timber production from logs

The data were obtained from timber production of Scots pine (*Pinus sylvestris* L.) and Black pine (*Pinus nigra* Arnold.) logs.

In the Tab. 1 log volumes before the production, timber volumes after production, yield and loss percentages were shown.

Primarily the volumes of the logs before the production were determined. And after obtaining timber volumes right after the production, results were obtained. In the study logs and timbers of black pine and scots pine species, which were used commonly in Turkey, were used. Data were collected from the randomly selected logs of 250–400 cm lengths. The by-products other than the main product timber were considered as a loss or in other words all the solid material other than timber were evaluated as losses. However, some of these solid materials could be used in other areas. Flat sawn method was applied in the production.

In the present study it was determined that the average loss ratio is 37.4 % in the 33 logs of diameter average 36.9 cm. The remaining 62.6 % is composed of timber. In TS-654 (1975), in softwoods the loss value is between 33 % and 55 %. The value obtained in this study (37.4 %) is found to be between these limits. However, this value is near to the minimum limit. Losses occurred as wood dust, trimmings, wing boards, small timber, chocks and discard material.

Tab. 1: Logs volumes of production input, lumber volumes output, rates of productivity and wastage.

Log No.	Log volume (input) (cm^3)	Lumber volume (output) (cm^3)	Productivity (%)	Wastage (%)	Log No.	Log volume (input) (cm^3)	Lumber volume (output) (cm^3)	Productivity (%)	Wastage (%)
1	237462.5	153120.0	64.5	35.5	18	540786.5	397300.0	73.5	26.5
2	282600.0	160880.0	56.9	43.1	19	331662.5	226000.0	68.1	31.9
3	255046.5	144000.0	56.5	43.5	20	429866.0	310400.0	72.2	27.8
4	384650.0	222000.0	57.7	42.3	21	373738.5	271000.0	72.5	27.5
5	180864.0	64640.0	35.7	64.3	22	264074.0	158400.0	60.0	40.0
6	418326.5	233880.0	55.9	44.1	23	302335.4	207687.5	68.7	31.3
7	949850.0	447820.0	47.1	52.9	24	325885.4	239375.0	73.5	26.5
8	122479.6	52000.0	42.5	57.5	25	204112.3	134812.5	66.0	34.0
9	1425368.7	842400.0	59.1	40.9	26	333931.6	251500.0	75.3	24.7
10	325567.8	179982.0	55.3	44.7	27	294681.6	215625.0	73.2	26.8
11	487441.0	233214.8	47.8	52.2	28	283385.0	190125.0	67.1	32.9
12	1673306.0	925740.0	55.3	44.7	29	159404.1	90875.0	57.0	43.0
13	362984.0	234600.0	64.6	35.4	30	358659.1	275087.5	76.7	23.3
14	477594.0	268000.0	56.1	43.9	31	185566.6	112250.0	60.5	39.5
15	594166.5	443320.0	74.6	25.4	32	207289.1	144325.0	69.6	30.4
16	301754.0	205000.0	67.9	32.1	33	233586.6	163125	69.8	30.2
17	237462.5	156600.0	65.9	34.1			**Average**	**62.6**	**37.4**

In another study realized by (Frühwald 1988), as it was stated earlier, in production of window frames from the logs, the loss quantity is reported to be 40 % and main product timber is 60 %. When compared these results in the present study the losses are occurred to be 2.6 % higher. As reported earlier, in the production of timbers from the logs there are many factors affecting the loss quantity. Taken this together the 2.6 % difference is thought to be originated from these factors (diameter, lengths, cutting methods, etc.). According to Maisenbacher the number of these factors is more than 450.

As it can be inferred from the previous studies in the timber production from logs, the timber yields were found to be range of 71 % - 61 %. From this result it could be seen that the loss percentages are 29 % and 35 % respectively. According to the study of Frühwald, timber quantity is 60 % and loss quantity is 40 %. In the yield calculations of the ORUS Company between the years of 1984 and 1996, the timber yields from the logs were found to be between 52 % and 69 %. Thus the loss quantities are varied between 31 % and 48 % (Sofuoğlu 2001).

In order to determine yield differences with reference to diameters, in the study of Gursu and Oktem 1975, the production were realized using 4 m long logs and the yield is found to be increased with reference to diameter increase and the yield is found to be between 57 % and 63 % in the 23-57 cm diameters. In our study the average diameter is 36.9 cm and the yield was found to be 62.6 %. This yield is considered well for the diameter class.

When analyzed the previous values obtained, the 37.4 % loss quantity determined in our study, is between the limit values of the most studies and the loss quantity is lower when compared to other studies.

As it was stated previously, there are many factors affecting the loss quantity in timber production from logs. According to Maisenbacher the number of these factors is over than 450. Thus the differences between the studies could be originated from these factors.

In the machining of solid wood, with abandoning the classical production and applying the computer aided production the losses could be decreased by 8 %. In machining hardwoods the value is found to be 4 %, while in machining softwoods this value may reach up to 8 %. (Grecon Dimter 2000).

The results suggest that loss quantity could be reduced with applying the advancing technology. For the companies it would be important to use latest technology, renovate the older machines and employing the qualified workers to reduce loss quantity.

Final products production from timber

Data were obtained in the production of two different final products from the main product timber. In the first study the data were gathered from the flush door production from Scots pine, commonly used for door parts production in Turkey and in the second study data were collected from the desktop picture frames production from solid beech timbers.

In these studies the following results were obtained

Findings for flush doors

In Tab. 2, the quantities of the solid wood material for doors of different wideness were shown.

In the Tab. 3, the values of materials used in production of flush doors, materials used, loss and yields were summarized.

Tab. 2: Quantity of using massive wood materials according to every door type (Sofuoğlu 2001).

Door No.	Number of doors	Quantity of used (cm^3)	Quantity of used (every door type) (cm^3)
1	4	48641.6	12160.4
2	14	170667.0	12190.5
3	33	403279.8	12220.6
4	2	24501.4	12250.7
5	2	24621.8	12310.9
6	2	24682.0	12341.0
7	5	57942.5	11588.5
8	32	371795.2	11618.6
9	10	116487.0	11648.7
10	1	12822.6	12822.6
Total	105	1255440.9	11956.6

Tab. 3: Efficiency and wastage in production of pressed door massive construction (Sofuoğlu 2001).

	Volume (cm^3)	Ratio (%)
Input	1827143.75	100
Used at the doors	1275307.00	70
Wastage	551836.00	30

In this study loss quantity from the production of flush door parts from timbers were determined. The loss value was found to be 30 %. The remaining part of 70 % was used in flush door production. The production was realized using 3rd grade scots pine timber. The reason for the this low loss quantity was determined to be originated from using parts with containing defects such as knots and small cracks in inner parts of the flush doors, normally not seen in the final product.

However, in the woods those are used in the production of apparent parts such as door leafs, door cases, glazing beads, door posts and door rails of prepared wooden doors, bark and inner bark as well as rots and staining, worm holes, resin bags, group knots must not be present. The diameter of healthy knots must not exceed the ¼ of the surface, other type of knots must not be present or the knot hole must be filled. Fibre curling must not exceed 50 mm in one meter, crack wideness must not exceed 1 mm, the length of the crack must not be over 200 mm and the crack length must not be over 1/5 length of the wooden material.

The following are the main reasons for the low loss quantity:

The using of 3rd grade timber without separation of its defects: In flush door production 3rd grade timber was used. As these materials constitute the inner part of the doors the defects such as knots, cracks, colour differences etc, was not separated and material was used directly. The loss quantity is consisted of small parts originated from the head parts of the timber and the loss originated from the thickness saw and band saw, etc. As a result loss quantity is found to be low.

Using materials of bigger dimension in production and not seeking the surface smoothness: Because the material of bigger dimension has been used as a final product, there are few procession steps, thus there are few saw dust produced after sawing and that leads to lower lost quantity. Besides because the materials are used in the inner, not-seen parts sanding was not applied and the loss quantity has been further reduced.

Findings for desktop picture frames

The present study has been realized for 38 desktop picture frames.

In the Tab. 4, the material and its dimensions that were used for the frames are shown.

Tab. 4: Material list of massive wooden frame (Sofuoğlu 2001).

No.	Thickness (cm)	Width (cm)	Length (cm)	Number	Products	Volume (cm^3)
1	1.25	3.00	19.70	2	38	5614.50
2	1.25	3.00	14.90	2	38	4246.50
5	2.40	3.20	9.60	2	38	5603.33
6	2.40	3.20	16.80	1	38	4902.91
7	1.20	3.20	16.80	2	38	4902.91
8	0.30	1.20	1.20	8	38	131.33
					Total	25401.48

In the Tab. 5, the timber used for the production and the output quantity are shown to calculate loss quantity.

Tab. 5: Efficiency and wastage in production of massive wooden frame (Sofuoğlu 2001).

	Volume (cm^3)	Ratio (%)
Input	46800	100
Output	25401.48	54
Wastage	21398.52	46

In this study 3rd grade beech (*Fagus orientalis*) timbers were used to produce desktop picture frames. Data were collected during the production and the loss quantity was determined to be 46 %. The reason why the loss quantity was higher when compared to the flush door production was found to be the following reasons:

Obtaining flawless material from the 3rd grade timber: Because the 3rd grade timber contains defects such as knots, cracks, etc., it was necessary to remove these parts from the timbers. Thus lots of material could not be used in the production, leading to produce higher loss.

The material used as the final product has smaller dimensions: Because the timbers are processed many times in band saws, thickness saws, sanding machines, etc, until they reach final dimensions to be used as final products, the amount of residual material and wood dust produced is generally high. This is the reason for the higher loss.

In the studies realized by Frühwald 1998, 1999, in the final products production from the timbers, loss quantity for the window frames was reported to be 50 %, while in the other studies the loss quantity was cited to be 40 %. The loss quantity of 46 % found in the desktop picture frames production seems to be very close to these values. While the loss quantity of 28 % that was found in the flush door production from the solid wood, seems to be very low when compared to the values above.

CONCLUSIONS

In this work, measurements were taken for the determination of the rates of wastages. The wastages rates were determined two levels. Determining the wastages rates from logs to timbers and from timber to final production of massive wood material (flushdoors frame and massive wooden frame). Was done as a result of the measurements; mean wastage rate was found 37.4 % for 33 logs with a mean diameter of 36.9 cm. The wastage rate was also found 30 % for production of flushdoors frames and 46 % for production of massive wooden frames.

In view of these results, in order to reduce the loss quantity the following measures must be taken:

The factors that lead higher loss must be determined and when possible they must be corrected.

Advancing technology must be followed, when possible latest technology must be applied. With optimization in the production, it is possible to produce more final products and for this less loss is occurred. Also manpower could be used more efficiently and more profit is attained. Moreover, with optimization the data is more reliable that leads more effective control mechanism. Optimum lengths of the parts that will be used in the production could be more precisely calculated, thus loss quantity is reduced, order planning is improved and more profit could be obtained.

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