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ORIGINAL ARTICLE

Determination of machinery and knife strains in the planing of wood-based panels

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Abstract In this study, strains that are caused by wood-based panels on horizontal milling machines and other cutting devices were examined. In order to fulfill this aim, samples of wood-based panels such as particleboard, medium density fiberboard (MDF), blockboard, okoume (*Aucoumea klaineana*) plywood, poplar (*Populus* × *euramericana*) plywood, and oriented strand board (OSB) were examined. The strains that milling machines and planer head with reversible knives suffered were measured by an amperemeter using an experimental mechanism with six different wood-based panels, three different engine revolution speeds (rev/min), and three drive forward speeds (m/min). Using the experimental data and the data derived from wood-based panels, engine revolution speed, and drive forward speed, several regression equations were developed in order to anticipate probable strains for each of the wood-based panels. As a consequence, the utmost strains observed on machinery during planing were caused by okoume plywood, followed by MDF, OSB, particleboard, blockboard, and poplar plywood in decreasing order of intensity. It was also observed that the spent current values (*A*) increased during planing in which engine revolution speed and drive forward speed are always kept high. It was also clearly seen that the wood-based panels were more resistant to the machinery and the knives when they were operated at higher speeds. The results of experiments correlated well with the predicted values produced by the anticipation regression models ($R^2 = 0.898$–0.965).

Keywords Wood-based panels · Planing · Strain · Electrical current · Resistance

Introduction

Scientists and engineers have constantly been studying new processing techniques and technologies for efficient manufacturing processes in the increasingly important wood production industry [1, 2]. One of the most important shaping methods used for the production of these products is the process of planing. During the production period, machinery such as milling machinery, planing machinery, thickness machinery, and others are made use of [3].

In order for wooden materials to be processed in high quality, it is necessary to use planing machinery and cutters properly. To do so, one needs to be informed about the wooden materials being processed, wood processing techniques, existence of sawdust, cutting device geometry, engine revolution number, and the type and expiry date of the cutter used [4, 5]. The processing parameters have to be optimal in order to minimize the cost and use of production materials while not decreasing the product quality. Regarding the product quality and particularly the cost, the hardening which is seen during the planing process and the cutting power were seen to both have a significant effect [6].

In a recent study entitled "Main and normal cutting forces by machining wood of *Pinus sylvestris* L.", the multi-factor, non-linear dependencies between main Fc (N) and normal (radial) Fn (N) cutting forces and eight machining parameters using a sawing simulation of wood

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from *Pinus sylvestris* L. were evaluated. It was determined that an increase of the thickness of the cutting layer increased the main cutting force, an increase of the thickness of the cutting layer increased the absolute value of the radial cutting force [7].

Gunay et al. [8] stated that the cutting power used during sawdust holding directly affects cutting performance and cost of the parts. Also, it was stated that even when the cutting parts of the machinery used for metal and metal-derived materials processing are sharp enough, they were found to harden against the stretches that occur during sawdust holding. It is also stated that thanks to developing computer technology in recent years, computer programs (Ansys, Franc2d) are useful in aiding the prediction of the stretching values in advance, helping to make sawdust-holding mechanisms more efficient. The cutting energy, which is the energy needed during sawdust holding, has been studied experimentally and the cutting powers measured. The components of power were found to be in direct relation with forwarding speed and it was also seen that when cutting power is increased, the specific cutting energy decreases [9]. In order to measure cutting power on a lathe, milling cutter and stoning machine, a dynamometer, which measures stress, was made [10].

Research on planing phenomena is increasing because planing, strain, and surface roughness directly affect the quality of material in the woodworking industry [11]. In practice, it is important to quantify and control the surface roughness that results from differences in the treatment of wood with tools and machines [12].

During the planing process, the resistance that hard wooden materials such as oriental beech (*Fagus orientalis* L.), sessile oak (*Quercus petrea* L.), ash (*Fraxinus excelsior* L.), and black locust (*Robinia pseudoacacia* L.) had against milling cutter machinery and cutter types were studied. Three different engine revolution powers and drive forward speeds were used and the strains were measured by an amperemeter. The greatest strain was seen on sessile oak followed by black locust, ash, and oriental beech, respectively. During the planing process, which was done with reduced engine power and driver forwarding speed, the current that was used by the machine was low. The experiment results and the results derived from prediction methods were seen to have a very high correlation ($R^2 = 0.92$). It was clearly seen that it is possible to anticipate the required current values in advance with 1.6–4.3 % error ratios according to each wooden materials' determination coefficient depending on engine revolution speed and drive forward speed according to the realized regression analysis equation [13].

In another study, it was also determined that the specific gravity is a significant element in cutting forces. It is typical to find wood from the same species with completely different specific gravities. It is also well known that sometimes, two species with the same specific gravity need very different cutting forces, or species with completely different specific gravities need similar cutting forces. These considerations show that specific gravity and humidity alone cannot fully explain relationships between wood species and cutting forces. That is the reason why the internal structural characteristics of each species must be considered [14]. Several authors have worked on the influence of specific gravity and found a very good linear correlation between specific gravity and force requirements [14–16]. Nevertheless, there is a correlation between specific gravity and power requirement (power being directly linked to cutting forces) [17–20].

This research aimed to study the strains that particleboard, medium density fiberboard (MDF), blockboard, okoume (*Aucoumea klaineana*) plywood, poplar (*Populus* × *euramericana*) plywood, and oriented strand board (OSB) show against the machinery and the cutters during a process where three different engine revolution speeds and three different drive forward speeds were used in the milling machine. The strain values were determined by the power the engine used according to engine revolution speed and drive forward speed. Using the experimental data obtained and the data derived from wood-based panels, engine revolution speed, and drive forward speed, several regression analysis equations were developed in order to anticipate probable strains for each of the wood-based panels and a multi-linear regression analysis was made.

Experiments

Wood-based panels

In the experiments particleboard in compliance with the standard of TS EN 312 [21], MDF in compliance with the standard of TS 64 [22], a nine-layered okoume and poplar plywood in compliance with the standard of TS 46 [23], OSB according to the standard of EN 300 [24], and pine core blockboard were used.

Experiments were done on the samples supplied satisfying TS 2470 (1976) standards [25]. The humidity values of the samples were determined to meet TS 2471 (1976) standards [26] and their density values were determined to meet TS 2472 (1976) standards [27].

The average moisture content, oven-dry specific gravity, and air-dry density means of wood-based panels are given in Table 1.

Table 1 The average moisture content, oven-dry specific gravity, and air-dry density means of wooden composite materials

Wood-based panels	Average moisture content (%)	Specific gravity oven-dry (g/cm^3)	Air-dry density (g/cm^3)
Poplar plywood	8.5	0.42	0.45
Blockboard	8.7	0.49	0.52
Particleboard	6.9	0.62	0.65
OSB	7.6	0.57	0.59
MDF	7.1	0.67	0.69
Okoume plywood	9.1	0.49	0.57

Machine and knives

A milling cutter machine with a driver of 2900, 6000, and 10000 rev/min revolution speeds was used for the planing of the experimental samples. In the planing of the wood-based panels, a planer head 50 mm wide and 85 mm in diameter was chosen because it is the most preferred in the industry. Hard metal, wear-resistant, reversible knives made from carbon steel with a 40° sharpening angle resistant were used. Utmost importance was given to the use of sharp knives. The knives were adjusted on the machine to a position where they would be planing in such a way that would result in the removal of layer with a thickness of 2 mm. The planer head and the knives used are shown in Fig. 1.

Preparation of the samples

The width of the experimental materials that were to be planned was increased to 50 mm, which was the width of the knives. The materials were prepared to a width of 500 mm and length of 600 mm in order for them to be processed easily by the driver (Fig. 2).

Adequate draft materials were prepared by giving a rough tolerance to the prepared wood-based panel sizes. The prepared draft materials were kept in a covered place at 20 ± 2 °C and 65 ± 3 % relative humidity until their weights became stable (12 % balance humidity quantity) according to TS 2471 (1976) standards [26]. The dried draft materials were then made ready for the experiment at their final sizes and the volumes of the wood-based panels used in the experiments were calculated.

Fig. 1 Planer head with reversible knives (J 0740-rebating cutter block, Z2 + V2-reversible carbide knives; NETMAK group permission)

Current measurement

The draft materials at 12 % of humidity were put into the machine at three drive forward speeds, 4, 6, and 12 m/min with three different revolution speeds, 2900, 6000, and 10000 rev/min. The current used by the machine during planing was measured by an amperemeter. A double amperemeter of 8 and 12 A with a sensitive analogous indicator and dial was used. As the amperemeter was connected to the circuit, the electric current was allowed to pass through the amperemeter. As the electrical current supplied to the engine was the same on three phases, the analogous amperemeter was connected to one phase and the experimental mechanism was made ready. The electricity for the driver was supplied from another electrical input so that it did not affect the electricity the engine used. Because the machine uses more power when it is first started and when the cutters started planing the samples, an amperemeter of 12 A with a higher indicator was used. After the acceleration became stable, another amperemeter of 8 A was put in use to do accurate calculations. During planing, when the engine acceleration and the value seen on the amperemeter became stable, the measured values were recorded. The device was placed in a position where it could not be affected by dirt and dust. The experimental mechanism is shown in Fig. 3.

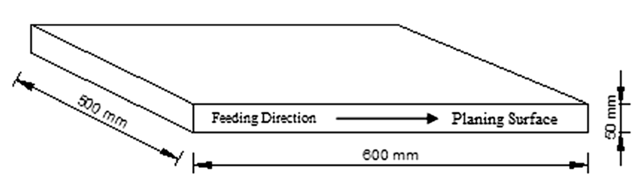

Fig. 2 Test sample

Evaluation of the data

In order to determine the resistance against the machine and the cutters when operated at different drive forward and engine revolution speeds during planing, combinations of three different engine revolution speeds and three different drive forward speeds were tested on five specimens from each of the six different types of wood-based panels, for a total of 270 samples. The resulting data were statistically analyzed.

A variance analysis was made in order to test whether or not there was a statistical difference between the means of groups according to the property under examination. If a statistical difference between the groups was determined, from which group the difference comes into being was determined by use of multi-comparative testing methods.

A multi variance analysis was made in order to determine the effects of wood-based panels, engine revolution speed, and drive forward speed on the current values that were experimentally derived. In order to compare and contrast the variances between the groups, the Duncan multi-comparison analysis was also made. Additionally, modal equations were made to predict the required current values by making a multi-linear regression analysis for each wood-based panel type according to engine revolution speed and drive forward speed.

Results and discussion

Current measurement

The results of the variance analysis made according to drive forward speed, engine revolution speed, and the type of wood-based panels on the electrical current values derived from the experimental studies are given in Table 2.

The results displayed in Table 2 indicate that the factors and the factor interactions were meaningful at a significance level of $\alpha = 0.05$. Then, the results of Duncan analysis done on wood-based panels, engine revolution speed, and drive forward speed using least significant difference (LSD) critical value are shown in Table 3.

The results displayed in Table 3 indicated that the lowest strains shown against the machine and the cutters were seen on poplar plywood (4.247 A) followed by blockboard (4.536 A), particleboard (4.612 A), OSB (5.038 A), MDF (5.142 A), and okoume plywood (5.267 A), consecutively.

In terms of engine revolution speed, the lowest strains shown against the cutters and the machine were seen at 4.188 A at 2900 rev/min speed followed by 4.805 A at 6000 rev/min and 5.426 A at 10000 rev/min, consecutively.

In regards to drive forward speed, the lowest strains shown against the cutters and the machine were seen at 4 m/min (4.204 A) followed by 6 m/min and 12 m/min (5.577 A), consecutively.

The results of the Duncan test for the triple interaction between wood-based panels, engine revolution speed, and drive forward speed are given in Table 4.

According to these results, the poplar plywood was seen to have the lowest strains on the cutters on the engine running at 2900 rev/min at 4 m/min drive forward speed (3.450 A) and the highest one was OSB with 10000 rev/min engine speed at 12 m/min drive forward speed (7.210 A).

When the engine revolution or drive forward speed was increased, the strain was also seen to increase. This is

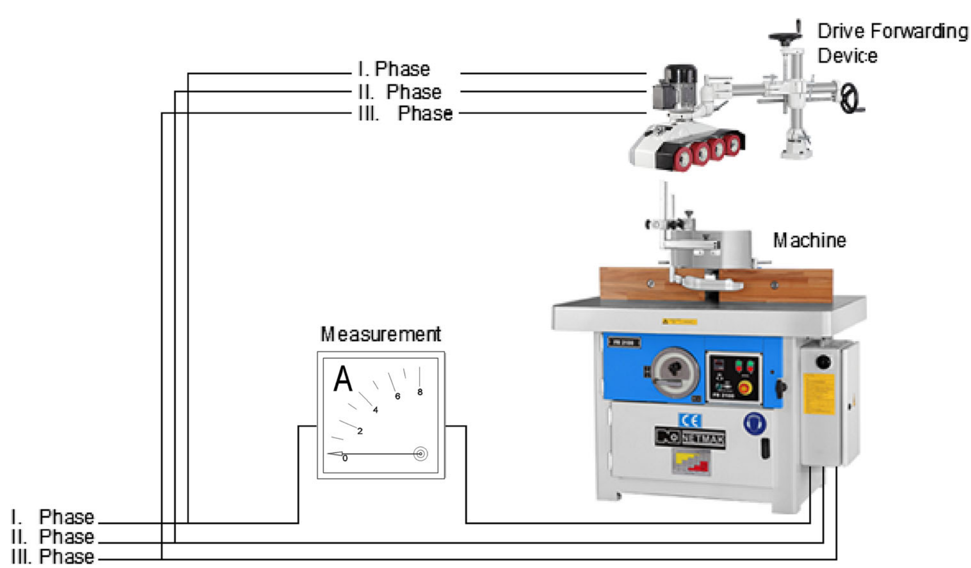

Fig. 3 Pre-prepared experimental mechanism (ST4-automatic feeder, FR 2100-spindle molder; NETMAK group permission)

Table 2 Results of the variance analysis

Factor	Degrees of freedom	Sum of square	Mean square	*F* number	Level of significance ($p \leq 0.05$)
Corrected model	53	211.248	3.986	1.529E3	0.000*
Intercept	1	6237.419	6237.419	2.392E6	0.000*
Wood-based panels (A)	5	36.266	7.253	2.782E3	0.000*
Drive forward speed (m/min) (B)	2	88.648	44.324	1.700E4	0.000*
Engine revolution speed (rev/min) (C)	2	69.043	34.522	1.324E4	0.000*
Interaction (AB)	10	6.692	0.669	256.658	0.000*
Interaction (BC)	4	4.647	1.162	445.624	0.000*
Interaction (AC)	10	3.859	0.386	148.017	0.000*
Interaction (ABC)	20	2.092	0.105	40.123	0.000*
Fault	216	0.563	0.003		
Total	270	6449.230			
Corrected total	269	211.811			

* Significant at 95 % confidence level

A wood-based panels, *B* drive forward speed (m/min), *C* engine revolution speed (rev/min)

Table 3 Comparative results of Duncan analysis on the wood-based panels, engine revolution speed, and drive forward speed

Factors	Number	$\bar{x}$ (A)	HG
Wood-based panels			
Poplar plywood	45	4.247	A[a]
Blockboard	45	4.536	B
Particleboard	45	4.612	C
OSB	45	5.038	D
MDF	45	5.142	E
Okoume plywood	45	5.267	F
Engine revolution speed (rev/min)			
2900	90	4.188	A[a]
6000	90	4.805	B
10000	90	5.426	C
Drive forward speed (m/min)			
4	90	4.204	A[a]
6	90	4.639	B
12	90	5.577	C

$\bar{x}$ arithmetic mean, *HG* homogeneity groups

[a] Current value of the electricity consumed at least

thought to have resulted from the increase in the work (planed sawdust) to be done on each cutting teeth in a unit of time [8, 28]. In addition to this fact there are some other several facts, which were stated in the literature, that must be taken into consideration such as the increase in strains cannot be said to have resulted from the necessary current quantity as it can also be said to result from the necessary power needed by the engine to realize its own revolution. This fact also complies with what is stated in the literature [9, 13]. In the experiments we carried out the cutters were examined under high and low cutting speeds to see the different results. When the cutting speed is high, it is thought that the cutters realize the cutting work without undergoing a high strain and without experiencing a break on the fibers by having a shocking effect. In other words, the cutters and the machine have to have more inaction power to get easily over even the highest strains shown by the wood-based panels. Power, speed, and the factors related to it can be said to affect the power directly [29]. When the cutting speed is low, the breakings of the fibers on the surface are seen to be high during planing, which testifies the fact that when speed is low the breakings of the fibers are to be high. It is also thought that during planing with breakings of the fibers, the cutting end is exposed to friction under pressure with the fibers (sawdust) over a longer period. As a result, it can be stated that under this kind of a circumstance, the material causes a higher strain on the machine and the cutters thereby need a higher electrical current. This shows that there is a strong interaction between drive forward speed, engine revolution speed, and the type of wood-based panel, which is in agreement with the literature [5, 7, 10].

Each of the wood-based panels showed pro rata relationships according to the current they required when compared with their specific weight (r^{12}), humidity, parallel to fibers pressure resistance, and Brinell hardness values. This shows the correlation between the density of the wood-based panel and the electrical current used [7]. It can be said that when the density of the wood-based panel increases, the increased density forces the machinery and the cutters to work harder.

Table 4 Results of the Duncan test for the interaction wood-based panels, engine revolution speed, and drive forward speed

Wood-based panels	Engine revolution speed (rev/min)	Drive forward speed (m/min)	$\bar{x}$ (A)	HG	Wood-based panels	Engine revolution speed (rev/min)	Drive forward speed (m/min)	$\bar{x}$ (A)	HG
Blockboard	2900	4	3.538	B	OSB	2900	4	3.662	C
		6	4.150	HG			6	4.214	IH
		12	4.616	NML			12	5.200	U
	6000	4	4.180	IHG		6000	4	4.380	J
		6	4.250	I			6	4.832	P
		12	4.624	NM			12	5.796	Z2
	10000	4	4.580	ML		10000	4	4.776	P
		6	5.050	TS			6	5.282	V
		12	5.832	Z2			12	7.210	Z5
Okoume plywood	2900	4	3.932	F	MDF	2900	4	3.800	ED
		6	4.178	IHG			6	4.326	J
		12	5.232	VU			12	5.078	T
	6000	4	4.608	NML		6000	4	4.332	J
		6	5.470	Z			6	4.974	R
		12	6.068	Z3			12	6.100	Z3
	10000	4	5.200	U		10000	4	5.000	SR
		6	5.582	Z1			6	5.550	Z1
		12	7.132	Z4			12	7.118	Z4
Poplar plywood	2900	4	3.450	A[a]	Particleboard	2900	4	3.550	B
		6	3.750	D			6	3.916	F
		12	4.132	G			12	4.662	ON
	6000	4	3.850	E		6000	4	4.182	IHG
		6	4.250	I			6	4.468	K
		12	4.668	ON			12	5.466	Z
	10000	4	4.182	IHG		10000	4	4.466	K
		6	4.552	L			6	4.700	O
		12	5.360	Y			12	6.100	Z3

$\bar{x}$ arithmetic mean, *HG* homogeneity groups

[a] Current value of the electricity consumed at least

Table 5 The results of multiple linear regression analysis made for each composite wooden material type

Wood-based panels	Model equation ($y = a + bx_1 + cx_2$)	Determination coefficient (R^2)
Poplar plywood	$y = 2.655 + 0.00013x_1 + 0.102x_2$	0.950
Blockboard	$y = 2.784 + 0.00015x_1 + 0.105x_2$	0.898
Particleboard	$y = 2.465 + 0.00014x_1 + 0.162x_2$	0.953
OSB	$y = 2.179 + 0.00019x_1 + 0.212x_2$	0.946
MDF	$y = 2.298 + 0.00021x_1 + 0.201x_2$	0.965
Okoume plywood	$y = 2.538 + 0.00021x_1 + 0.183x_2$	0.938

Regression analysis

A multi-linear regression analysis was made for each wood-based panel taking the engine revolution speed and drive forward speed into consideration. The R^2 values derived from the experiment and their role models are given in Table 5 and the comparisons with the results of the multi-linear regression analyses are shown in Table 6.

In the modal of equation; "y" is the electrical current, "x_1" is the engine revolution speed, "x_2" is drive forward speed and a, b, and c, are the coefficients found after the regression analysis.

Table 6 The comparison of the values derived from the results of the experiment and the carried out multi-linear regression analysis

Wood-based panels	Engine revolution speed (rev/min)	Drive forward speed (m/min)	Real current values (A)	Predicted current values according to the regression model equations (A)	Differences, between predicted and real current values (%)	Arithmetic mean (%)	Wood-based panels	Engine revolution speed (rev/min)	Drive forward speed (m/min)	Real current values (A)	Predicted current values according to the regression model equations (A)	Differences, between predicted and real CURRENT values (%)	Arithmetic mean (%)
Blockboard	2900	4	3.538	3.651	3.095	11.709	OSB	2900	4	3.662	3.621	1.132	13.743
		6	4.150	4.356	4.729				6	4.214	4.740	11.097	
		12	4.616	5.600	17.571				12	5.200	6.830	23.865	
	6000	4	4.180	3.653	14.426			6000	4	4.380	3.628	20.728	
		6	4.250	4.357	2.456				6	4.832	4.750	1.726	
		12	4.624	5.680	18.592				12	5.796	6.830	15.139	
	10000	4	4.580	3.655	25.308			10000	4	4.776	3.629	31.607	
		6	5.050	4.354	15.985				6	5.282	4.700	12.383	
		12	5.832	5.650	3.221				12	7.210	6.801	6.014	
Okoume plywood	2900	4	3.932	3.920	0.306	14.205	MDF	2900	4	3.800	3.725	2.013	13.631
		6	4.178	4.961	15.783				6	4.326	4.812	10.100	
		12	5.232	6.944	24.654				12	5.078	6.898	26.384	
	6000	4	4.608	3.980	15.779			6000	4	4.332	3.721	16.420	
		6	5.470	4.960	10.282				6	4.974	4.813	3.345	
		12	6.068	6.947	12.653				12	6.100	6.897	11.556	
	10000	4	5.200	3.900	33.333			10000	4	5.000	3.726	34.192	
		6	5.582	4.968	12.359				6	5.550	4.810	15.385	
		12	7.132	6.945	2.693				12	7.118	6.892	3.279	
Poplar plywood	2900	4	3.450	3.442	0.232	10.145	Particleboard	2900	4	3.550	3.554	0.113	10.755
		6	3.750	4.073	7.930				6	3.916	4.355	10.080	
		12	4.132	5.220	20.843				12	4.662	5.948	21.621	
	6000	4	3.850	3.444	11.789			6000	4	4.182	3.551	17.770	
		6	4.250	4.070	4.423				6	4.468	4.350	2.713	
		12	4.668	5.223	10.626				12	5.466	5.946	8.073	
	10000	4	4.182	3.449	21.253			10000	4	4.466	3.550	25.803	
		6	4.552	4.078	11.623				6	4.700	4.352	7.996	
		12	5.360	5.225	2.584				12	6.100	5.944	2.624	

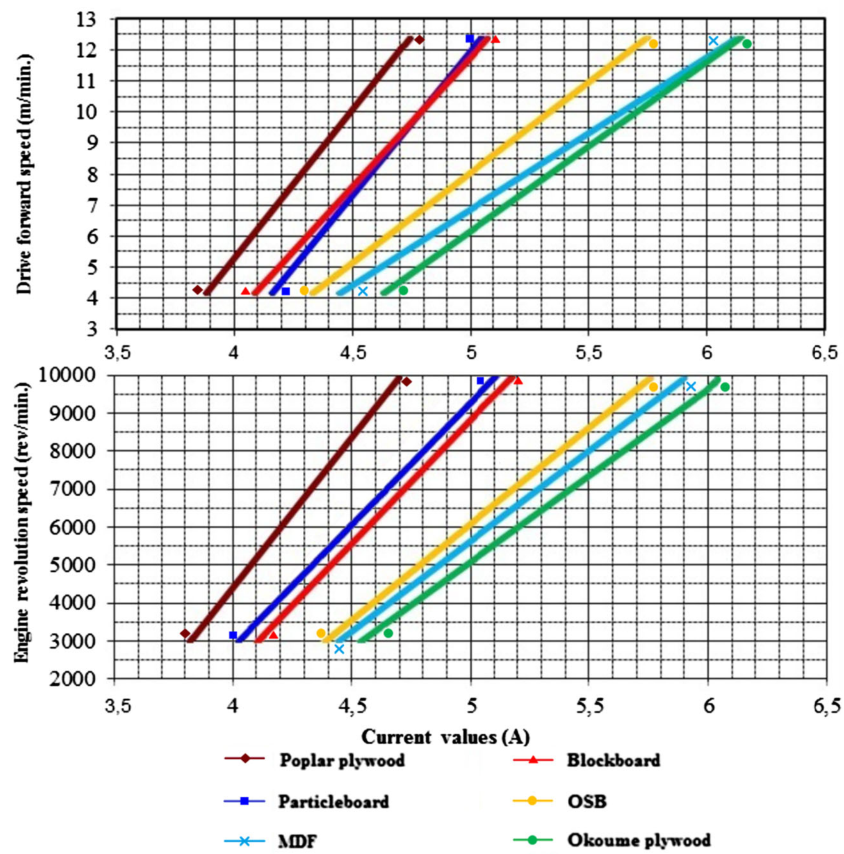

Fig. 4 Relationship between current values, wood-based panels, engine revolution speed, and drive forward speed

According to the regression analysis results, the coefficients of correlation of predicted current values with engine revolution and drive forward speed are $R^2 = 0.950$ for poplar plywood, $R^2 = 0.898$ for blockboard, $R^2 = 0.953$ for particleboard, $R^2 = 0.946$ for OSB, $R^2 = 0.965$ for MDF, and $R^2 = 0.938$ for okoume plywood. The anticipated values have been determined to be high or low at times according to the real values. These values are between the percentages of 10.145 % minimum and 14.205 % maximum. The mean difference (margin of error) between the anticipated values and the real values belonging to all wood-based panels was found to be 12.364 %. The graphics for the derived regression modal equations are shown in Fig. 4.

Modal equations are not equations which can be determined only when the machinery operates. These equations are determined when the process of wood planing is done by making use of revolution speed and drive forward speed values. As the invariant coefficients of these equations are different (2.655, 2.784, 2.465, 2.179, 2.298, and 2.538), when the drive forward speed and revolution speed are shown to be at the value of "0", this shouldn't be regarded as showing that the machine is consuming different values of electricity while it is working idly and no work is being done on a workpiece.

Experimental results and predicted results are shown together by comparing each one based on the kind of wood, engine revolution speed, and drive forward in Table 6. The predicted current values were calculated based on the regression model equations which are given in Table 5. Using the obtained model equations, the current values can be easily calculated and these calculated results can be compared with the real experimental results to test the validation of these model equations.

As shown in Table 1, it was also determined that specific gravity had a direct correlation with cutting forces. When specific gravity increased, the energy consumption increased. As a consequence it is convenient to say that in addition to specific gravity, internal structural characteristics of each species of wood-based panel must be taken into consideration when anticipating the energy consumption during the process of planing.

Conclusions

This study was aimed to determine the strains on the machinery and the cutters during the planing of various wood-based panels at different engine revolution speeds and drive forward speeds.

As stated by the values given in the Table 1, it was also determined that specific gravity had a direct correlation with the cutting forces. When specific gravity increased, the energy consumption also increased. As a consequence, it is convenient to say that as well as the factors and specific gravity, internal structural characteristics of each species of the wood-based panels must be taken into consideration when anticipating the energy consumption during planing [17–20].

Although they were processed by the same techniques, each of the wood-based panels showed different strains and needed different electrical currents. The highest strain was seen on okoume plywood, which was followed by MDF, OSB, particleboard, blackboard, and poplar plywood panels, consecutively. It is thought that if the wood-based panels are chosen taking this classification into consideration which classifies the wood-based panels according to their strains against the machinery, there will be advantages in regards to electrical consumption and machinery/engine wear because as seen in the classification some wood-based panels have high strains thereby causing more electricity consumption and others have lower strains so that they can decrease production costs meaningfully.

During the planing process in which the engine revolution speed and drive forward speed were high, the electrical current was seen to increase and the panels were seen to show a higher strain against the machine and the engine. In order not to over-wear the engine and the cutters using an unnecessary amount of current that can increase electrical consumption, it is important not to use the engine at high revolution when not needed. If the desired quality of the wood-based panel can be achieved at a slower speed then there is no need to use the engine and the cutters at higher speeds. If the manufacturers choose wood-based panels that are found to be more efficient according to this experiment, they will easily decrease their electricity consumption and machinery, engine, and cutter wear.

According to the engine revolution speed and drive forward speed it was determined that it is possible to predict the necessary current values with a 10.145–14.205 % margin of error according to the determination quotients of the wood-based panels. As a result, by making the most of the regression modal equation, when the engine and revolution speeds are changed, the electrical current the machine needs will be easily anticipated in advance.

References

1. Williams D, Morris R (1998) Machining and related mechanical properties of 15 B.C. wood species. Forintek Canada Corp. Vancouver, B.C, Special replication no: Sp-39, 31
2. Lihra T, Ganev S (1999) Machining properties of eastern species and composite panels, Forintek Canada Corp. Western Region, 2665 East Mall, Canadian Forest Service, Project no: 2306, 62
3. Hernandez RE, Bustos C, Fortin Y, Beaulıeu J (2001) Wood machining properties of white spruce from plantation forests. Forest Prod J 51(6):82–88
4. Ilhan R, Burdurlu E, Baykan I (1990) Cutting theory and furniture machines at woodwork. Hacettepe University, Industrial engineering of woodwork, Ankara
5. Korkut I, Donertas MA, Seker U (1999) Design and manufacturing of a 3-D dynamometer. Zonguldak Karaelmas University, Karabuk Faculty of Technical Education, J Technol 2:115–129
6. Gunay M (2003) Experimental investigation of the influence cutting tool rake angle on forces during metal cutting. Master Thesis, Gazi University, Institute of Science, Ankara
7. Porankiewicz B, Axelsson B, Gronlund A, Marklund B (2011) Main and normal cutting forces by machining wood of pinus sylvestris. Bioresources 6:3687–3713
8. Gunay M, Korkut I, Aslan E, Seker U (2005) Experimental investigation of the effect of cutting tool rake angle on main cutting force. J Mater Process Technol 166:44–49
9. Yardimoglu B, Boyar L (1994) Experimental analysis of cutting forces in machining. In: Proceedings of the first national experimental mechanics congress, Istanbul, Turkey 72–81
10. Korkut I (1996) Computer connected dynamometer design and manufacturing measuring with strain gage in turning machine. Ph.D. Thesis. Gazi University, Institute of Science and Technology, Ankara
11. Sandak J, Negri M (2005) Wood surface roughness—what is it? In: Proceedings of the 17th International wood machining seminar, Rosenheim 242–250
12. Efe H, Gurleyen L, Budakçı M (2007) Effect of the cutting direction and number of knives on surface smoothness and bonding strength for Acacia. Journal of Forestry Faculty, Kastamonu University 7:13–23
13. Gurleyen L (2010) The study for the strain of hardwood materials against machines and cutters in planing process. Sci Res Essays 5:3903–3913
14. McKenzie WM, Ko P, Cvitkovic R, Ringler M (1999) Towards a model predicting cutting forces and surface quality in routing layered boards. In: Proceedings of the 14th IWMS, Paris ISBN 2-87614-362-3: 489–497
15. Kivimaa E (1950) The cutting force in woodworking. Rep. no: 18 The State institute for technical research, Helsinki
16. Fischer R (1999) Wood cutting simulation—a program to experiment without a machine. In: Proceedings of the 14th IWMS, Paris ISBN 2-87614-362-3: 553–562
17. Chardin A (1958) Use of the dynamometric pendulum research on the sawing of wood. Rev Bois Trop 58:49–61
18. Koch P (1964) Wood machining process. Ronald press, Cambridge, p 530
19. Sales C (1990) The band saw: theory and practice of sawing logs. Center Tecnique Forestier Tropical, CIRAD-CTFT, France: 152
20. Goncalves MTT, Rodrigues R, Takahashi JSI (1997) An experimental analysis of the influences of machining conditions on the parallel cutting force in orthogonal cutting for ten Brazilian wood species. In: Proceedings of the 13th IWMS. Vancouver, pp 481–487
21. TS EN 312 (2005) Particleboards-specifications, Turkish standards institution, Ankara
22. TS 64 (1982) Fibre building boards-hard and medium boards, Turkish standards institution, Ankara
23. TS 46 (1986) Plywood-veneer plywood with rotary cut veneer for general use, Turkish standards institution, Ankara
24. EN 300 (1997) Oriented strand boards (OSB)—definitions, classification and specifications, European Standardization Committee, Brussels

25. TS 2470 (1976) Wood–sampling methods and general requirements for physical and mechanical tests, Turkish Standards Institution, Ankara
26. TS 2471 (1976) Wood determination of moisture content for physical and mechanical tests, Turkish Standards Institution, Ankara
27. TS 2472 (1976) Wood–determination of density for physical and mechanical tests, Turkish Standards Institution, Ankara
28. Budakci M, Ilçe AC, Sevim Korkut D, Gurleyen T (2011) Evaluating the surface roughness of heat-treated wood cut with different circular saws. Bioresources 6:4247–4258
29. Domestic and Foreign Tree Species (2009) http://www.orman.istanbul.edu.tr/node/10038. Accessed 03 Jul 2011