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Innovation of Traditional Furniture Surface Decoration Techniques with CNC Laser-Assisted Regression Modeling Production Method: Product Design Study

Inovacija tradicionalnih tehnika ukrašavanja površine namještaja proizvodnom metodom regresijskog modeliranja podržanom CNC laserom: analiza razvoja proizvoda

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ABSTRACT • *Recently, efforts have been made to develop decoration techniques with CNC router machining and contact production machines in the furniture industry. However, this method is insufficient in micro-processes that require precision. In this research, the innovation of traditional furniture surface treatment techniques as a regression modeling production method with laser technology was examined. For this purpose, beech wood was processed in a CNC laser processing machine with a 130-watt carbon dioxide gas tube, and sample product design and manufacture were made. It has been determined that many furniture surface treatment techniques can be applied with the regression modeling method of CAD/CAM supported laser technology.*

KEYWORDS: *laser woodworking, mother-of-pearl, filigree, inlay, wood carving*

SAŽETAK • *U posljednje se vrijeme tehnike ukrašavanja u industriji namještaja razvijaju uz pomoć CNC glodalica i strojeva s kontaktnom obradom. Međutim, ta metoda nije zadovoljavajuća za fine obrade, za koje je potrebna velika preciznost. U ovom je radu istražena mogućnost inovacije tradicionalnih tehnika ukrašavanja površine namještaja proizvodnom metodom regresijskog modeliranja laserom. Za tu je namjenu CNC laserom s plinskom cijevi ugljikova dioksida snage 130 W izrađen ogledni proizvod od bukovine. Utvrđeno je da se mnoge tehnike obrade površine namještaja mogu primijeniti zajedno s CAD/CAM metodom regresijskog modeliranja podržanom laserom.*

KLJUČNE RIJEČI: *laserska obrada drva, majka bisera, filigran, intarzija, rezbarenje drva*

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1 INTRODUCTION
1. UVOD

Furniture surface decoration is the evaluation of furniture with shapes, pictures and motifs by using various techniques in order to add beauty without disturbing its function. The motifs, figures, symbols and shapes used in decorations are the products of thoughts and behaviors at a certain point in history. Carving is an ornamentation technique in which the excess parts of the motifs drawn on wood are removed with special carving pens or machines and shaped as relief. If the surface depth is 3-4 mm, it is called low carving, and if it is more, it is called high carving. Inlay is an ornamentation technique made by embedding materials such as solid, ivory, wood veneer, mother-of-pearl, metal on solid or coated surfaces according to the motif (URL1). Furniture, which has been developed according to societies and cultures since ancient times, started to change in terms of technology, understanding and use at the beginning of the 20th century. In the 20th century, an industrial society was formed and handicrafts lost their old value. In this period, when architecture and furniture design were in close relationship, many architects also made furniture designs with a holistic method (Gesamkuntswerk) approach. For this reason, it is seen that some furniture design movements and architectural movements overlap and affect each other in the 20th century (Çifçi and Demirarslan, 2021).

Technology has contributed to the development of art movements. Technology becomes a part of culture and innovations and offers the opportunity to reach practical, fast and easy solutions. Time-saving technology can be used as an auxiliary element through mechanical tools. While technology represents power in terms of economy, speed and increasing product quality, it also supports positive efficiency. While art is affected by the development of technology, industry and industrial products also benefit from art and design (Aytepe, 2013).

In the past, there have been some studies on furniture surface decoration arts, especially in the cultural sense. The evaluation of the shells of freshwater mussels, which show a substantial population, collected from Hatay province, in the old Ottoman handicraft mother-of-pearl inlay, in making buttons and ornaments, has been investigated and it has been tried to clarify how they can be evaluated in a wider range (Şereflişan, 2014). Although mother-of-pearl inlays and coppersmithing attract little attention today, other fields are experiencing great difficulties. Gaziantep University, Gaziantep Chamber of Coppersmiths and Sedefçiler and the Ministry of Culture and Tourism are working to protect these areas (Aktürk, 2016). It is aimed to research the place and importance of mother-of-pearl inlay in Gaziantep, its current situation and the products made. It has been determined that there are approximately 50 workshops dealing with the art of mother-of-pearl inlay in the city center, and these workshops are gradually closing. In mother-of-pearl inlay, it is necessary to turn our lost arts into a state policy and to create a budget for our traditional arts in order to eliminate economic concerns and prevent the artifacts left from our traditional arts only in museums (Özdemir and Yıldırım, 2016). The situation of mother-of-pearl inlay workshops in Gaziantep region was investigated. According to the information obtained at the end of the research, while many mother-of-pearl inlay workshops were operating in the past, it has been determined that this number has decreased considerably today. In the following years, it is understood that this profession will be one of the dying professions in Turkey with the closure of the workplaces currently doing this job (Eser and Bal, 2017). The chest, which is a status symbol in the dowry tradition of the Turks, has been examined in terms of its usage and decorations. It is important to transfer traditional Turkish furniture styles and to inspire new designs (Selhan and Usal, 2010). Mother-of-pearl inlay can be applied on large or small furniture in any finished size, usually on small souvenirs and solid wood furniture. Products to be inlaid with mother-of-pearl are generally produced from solid walnut wood. The walnut wood gets a more beautiful color at the end of the darkening process and the inlay process comes to the fore. Apart from walnut wood, hard solids such as rosewood, beech and mahogany are frequently preferred (Tamamoğlu, 2020). The professions of wood carving, wood inlay, mother-of-pearl inlay and filigree were declared national treasures by the Ministry of National Education of the Republic of Turkey (URL2).

With CNC laser, popular operations on wood such as cutting and engraving can be performed. Some parameter studies have been examined in the international literature on these processes. The effects of power, speed, focal distance, air pressure on the machining performance of the machine parameters in laser processing of wood or wood-based materials were studied (Cherif, 1990; Barnekov *et al.,* 1986; Eltawahni *et al.,* 2011; Yuzhı *et al*., 2017; Kudela *et al.,* 2020; Vidholdova *et al*., 2017; Petru *et al*., 2017), as well as the optimization of these parameters (Eltawahni *et al*., 2013; Merchant, 1995; Jiang *et al*., 2021). There have been some studies on the predictive modeling method in laser woodworking (Li *et al*., 2021; Gurau *et al.,* 2017; Li *et al*., 2018). In laser wood engraving, only the patterns created with vector drawing are not processed. Studies have been carried out on the processing of images with photographic properties in laser wood engraving (Jurek and Wagnerová, 2021), and the effects of wood moisture content on laser processing (Rezaei *et al*., 2022).

With the use of CNC machines in furniture production, computer aided design and production systems can work together. In order to produce the parts of the furniture designed with CAD systems in the computer environment, the designs of these parts can be directed to the CAM systems. In laser cutting and engraving processes made on wood and its derivatives, the probability of faulty production is very low compared to the processes made with traditional methods and using cutters in CNC machines. In laser cutting processes made on wood materials, very precise and thin cuts that cannot be made in CNC machines with cutters can be made easily (Karabıyık, 2016). It has been proven that folding furniture can be produced more efficiently with these machines to increase the usability and aesthetics of a space by using CNC router and CNC laser (Oates, 2015). In order to show new applications of compatible mechanisms to folding systems in furniture design and to produce such mechanisms with non-traditional methods, chair, stool and childcare furniture applications have been shown as a result of research on how such structures can be created with folding compatible mechanisms using new methods with laser (Daiel, 2021).

In the studies carried out to date, awareness has been raised that traditional wood decoration techniques are in the category of professions that are gradually disappearing, but sufficient solutions have not been offered. A limited number of studies have been carried out on the wood surface treatment method with CNC router, especially in terms of surface roughness. In addition, in industry the woodworking method with CNC router has had a very positive effect on the continuity of wood surface decoration techniques. Studies have been carried out on wood surface decoration techniques with laser, but these studies have generally remained at the experimental level, and their application in furniture design and production has not been explained. In some studies, only the laser folding furniture production process has been explained. In this study, experimental studies were carried out on a medium-sized CNC laser machine, which is widely used. Beech wood was tested since it is frequently used in industrial production. In line with the findings, furniture surface decoration design and application were made with the predictive modeling method, which is important in industrial production. The design was based on techniques that are about to disappear. An original study was carried out by presenting the materials, machinery, production method, design and manufacturing processes used in an integrated manner in the industrial production sector.

2 MATERIALS AND METHODS
2. MATERIJALI I METODE

2.1 Materials
2.1. Materijali

In the study, 18 mm thick beech wood with a density of 0.720 g/cm³ in air-dry state at 12 % moisture conten was used. In material processing, the experimental samples were cut and engraved in a CNC laser machine with a power output of 130 watts, a 50.8 mm focal length lens, carbon dioxide gas, water cooled, 1.5 mm nozzle diameter and 10.6 µm wavelength. Figure 1.a shows the laser processing stage of the CNC laser machine, Figure 1.b shows the example of the laser cutting experiment, and Figure 1.c shows the example of the laser engraving experiment. In addition, 0.02 mm precision digital depth measuring instrument and magnifying glass (5x) were used to measure laser cutting depths in the study.

2.2. Method
2.2. Metoda

The factorial experimental design allows each of the variable factors to be evaluated with each other. While doing this, in addition to determining the extent of the effect of each variable on the event, different behaviors of the factors that may appear as a result of the interaction of the variables with each other can also be determined. There are many factors that affect laser

a) b) c)

Figure 1 a) Laser processing step, b) Laser cutting test example, c) Laser engraving test example
Slika 1. a) Obrada laserom, b) primjer laserskog rezanja, c) primjer laserskog graviranja

Table 1 Experiment factor design
Tablica 1. Faktori dizajniranog eksperimenta

Test factors / *Varijable testa*	**Levels** / *Razine*		
	1	**2**	**3**
Nozzle height *NH*, mm / *visina sapnica NH,* mm	4.8	5.2	5.6
Power *P* cut / engrave, W / *snaga P rezanja / graviranja,* W	25/55	50/75	100/95
Speed *S* cut / engrave, mm/s / *brzina S rezanja / graviranja,* mm/s	5/50	10/250	20/450

processing performance. According to the data obtained from the experimental studies carried out so far, it is aimed to determine the effect of the factors that are considered important by keeping some factors constant. These factors are nozzle height (*NH*), feed rate (*S*), and laser processing power (*W*). As seen in Table 1 below, there are 3 variable parameters in the design, and each of them takes 3 different values. According to the specified levels, full factorial design, 27 experiments for laser cutting depth (*CD*) and 27 experiments for laser carving (inlay) depth (*ID*) were performed. The resulting design is the Taguchi orthogonal design and it can be named L27(3^3). This indicates that the number of experiments is 27; the 3 factors have 3 different levels.

In the tests performed, the data obtained from the experimental samples were analyzed using the 22nd version of the SPSS statistical package program. Analyses were made on the basis of 95 % confidence level. Multiple linear regression analysis was preferred to determine whether there was a significant difference for each analysis made according to the interaction of laser cutting depth and engraving depth dependent variable and independent variables. Preliminary estimates made to achieve optimum yield in production are calculated according to the regression Eq. 1:

$$\hat{Y}=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3 \quad (1)$$

Where:
$\hat{Y}$: Dependent variable (cutting or gouging depth mm value),
β_0: Constant beta value,
β_1: 1.independent variable (Nozzle height) beta value,
X_1: 1st independent variable (Nozzle height mm) value,
β_2: beta value of the 2nd independent variable (processing power W),
X_2: Value of the 2nd independent variable (cutting speed mm/s),
β_3: 3rd independent variable (processing speed) beta value,
X_3: Indicates the value of the 3rd independent variable (processing speed mm/s).

3 RESULTS AND DISCUSSION
3. REZULTATI I RASPRAVA

3.1 Laser cutting results
3.1. Rezultati rezanja laserom

The laser cutting depths (*CD*) obtained according to the test factors of nozzle height (*NH*), feed rate (*S*), laser processing power (*W*) in laser cutting applied to the parallel directions of the wood laser cutting samples are shown in Table 2.

Multivariate linear regression analysis was performed to determine the effects of nozzle height, cutting power and cutting speed on the laser cutting depth of the beech massif. The analysis results of the laser cutting process are shown in Table 3 below.

According to the analysis results in Table 3, the nozzle height negatively and significantly affected the laser cutting depth with an effect size of 15 % (pr^2 = 0.148). The laser cutting power positively and significantly affected the laser cutting depth with an effect size of 52 % (pr^2 = 0.519). The laser cutting speed, on the other hand, negatively and significantly affected the laser cutting depth with an effect size of 60 % (pr^2 = 0.599). It was found that the regression analysis

Table 2 Laser cutting depths of solid beech materials used in case study
Tablica 2. Dubine laserskog rezanja masivne bukovine upotrijebljene u studiji slučaja

SN	*NH*, mm	*P*, W	*S*, mm/s	*CD*, mm	*SN*	*NH*, mm	*P*, W	*S*, mm/s	*D*, mm	*SN*	*NH*, mm	*P*, W	*S*, mm/s	*CD*, mm
1	4.8	25	5	5.30	10	5.2	25	5	6.07	19	5.6	25	5	4.07
2	4.8	25	10	3.60	11	5.2	25	10	4.60	20	5.6	25	10	2.70
3	4.8	25	20	1.40	12	5.2	25	20	3.20	21	5.6	25	20	1.70
4	4.8	50	5	11.87	13	5.2	50	5	10.67	22	5.6	50	5	7.47
5	4.8	50	10	5.37	14	5.2	50	10	7.87	23	5.6	50	10	4.20
6	4.8	50	20	3.73	15	5.2	50	20	5.50	24	5.6	50	20	2.40
7	4.8	100	5	14.00	16	5.2	100	5	13.47	25	5.6	100	5	9.23
8	4.8	100	10	7.77	17	5.2	100	10	9.33	26	5.6	100	10	6.17
9	4.8	100	20	4.40	18	5.2	100	20	6.93	27	5.6	100	20	3.57

Table 3 Regression analysis results
Tablica 3. Rezultati regresijske analize

Variables *Varijable*	***Beta(β)***	****Beta(β)***	**Partial correlation (*pr*)** *Parcijalna korelacija (pr)*	**Significance** *Značajnost*
Control constant / *kontrolna konstanta*	8.560	-	-	0.000
Nozzle height / *visina sapnice*	-0.224	-0.216	-0.385	0.000
Cutting power / *snaga rezanja*	0.058	0.538	0.721	0.000
Cutting speed / *brzina rezanja*	-0.343	-0.631	-0.774	0.000

*Standardized / *standardizirano*

model was 95 % reliable (p<0.05), and 72 % of the variation in cutting depth ($R^2_{adjustad}$ = 0.723) was explained by the independent variables. As a result of mathematical modeling of the beech massif, the following regression equation was generated using the data in Table 3, in order to theoretically provide optimum laser cutting and to predict the cutting depth.

$$\hat{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

Depth of cut = 8.560 + (Focal length* - 0.224) + (Cutting Power*0.058) + (Cutting Speed*-0.343)

3.2 Laser carving results
3.2. Rezultati graviranja laserom

The laser carving (inlay) depths (*ID*) obtained according to the test factors of nozzle height (*NH*), feed rate (*S*), laser processing power (*W*) in laser engraving applied to the parallel directions of the wood laser engraving samples are shown in Table 4.

Multivariate linear regression analysis was performed to determine the effects of focal length, engraving power and engraving speed on the laser engraving depth of the beech massif. Since the effect of nozzle height on laser engraving depth is statistically insignificant, it was not included in the analysis in order not to adversely affect the predictive value of other variables that gave significant results. The analysis results of the laser engraving process, which give significant results, are shown in Table 5.

According to the analysis results in Table 5, laser engraving power positively and significantly affected the laser engraving depth with an effect size of 65 % (pr^2 = 0.649). On the other hand, laser engraving speed affected the laser engraving depth negatively and significantly with a 70 % effect size (pr^2 = 0.703). It was found that the regression analysis model was 95 % reliable (p<0.05), while 80 % of the variation in the engraving depth ($R^2_{adjustad}$ = 0.804) was explained by the independent variables. As a result of the mathematical modeling of the beech massif, the following regression equation was generated using the data in Table 4, in order to theoretically provide the optimum laser engraving and estimate the engraving depth.

$$\hat{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

Carving depth = 2.756 + (Carving Power*0.033) + (Carving Speed*-0.019)

Table 4 Laser engraving depths of solid beech materials used in case study
Tablica 4. Dubine laserskoga graviranja masivne bukovine upotrijebljene u studiji slučaja

SN	***NH*, mm**	***P*, W**	***S*, mm/s**	***CD*, mm**	***SN***	***NH*, mm**	***P*, W**	***S*, mm/s**	***D*, mm**	***SN***	***NH*, mm**	***P*, W**	***S*, mm/s**	***CD*, mm**
1	4.8	25	50	2.07	10	5.2	25	50	1.70	19	56	25	50	1.70
2	4.8	25	100	1.10	11	5.2	25	100	0.83	20	5.6	25	100	0.87
3	4.8	25	200	0.50	12	5.2	25	200	0.50	21	5.6	25	200	0.43
4	4.8	50	50	4.73	13	5.2	50	50	4.40	22	5.6	50	50	4.40
5	4.8	50	100	2.57	14	5.2	50	100	2.33	23	5.6	50	100	2.23
6	4.8	50	200	1.37	15	5.2	50	200	1.10	24	5.6	50	200	1.10
7	4.8	100	50	6.10	16	5.2	100	50	3.83	25	5.6	100	50	6.33
8	4.8	100	100	3.60	17	5.2	100	100	3.03	26	5.6	100	100	3.73
9	4.8	100	200	1.73	18	5.2	100	200	1.53	27	5.6	100	200	1.80

Table 5 Regression analysis results
Tablica 5. Rezultati regresijske analize

Variables / *Varijable*	***Beta(β)***	****Beta(β)***	**Partial correlation (*pr*)** *Parcijalna korelacija (pr)*	**Significance** *Značajnost*
Control constant / *kontrolna konstanta*	2.756	-	-	0.000
Carving power / *snaga graviranja*	0.033	0.596	0.806	0.000
Carving speed / *brzina graviranja*	-0.019	-0.674	-0.839	0.000

*Standardized / *standardizirano*

a) b) c) d)

Figure 2 Traditional wood surface decoration techniques: a) manual pattern copying stage, b) hand carving stage, c) hand or CNC router Machine engraving stage, d) filigree (wire inlay) engraving stage
Slika 2. Tradicionalne tehnike ukrašavanja površine drva: a) faza ručnog kopiranja uzorka, b) faza ručnoga graviranja, c) faza ručnoga ili CNC glodanja, d) faza graviranja intarzija (žičani umetak)

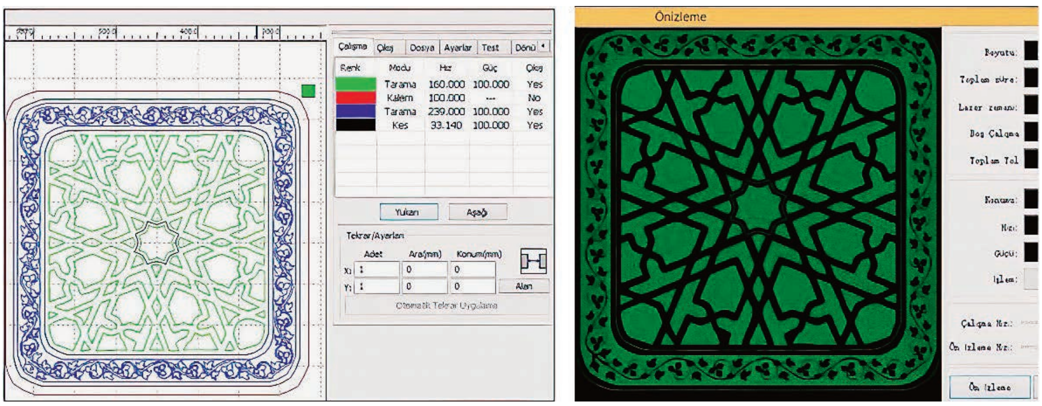
3.3 Design and implementation
3.3. Dizajn i implementacija

In traditional wood surface treatment, it is first necessary to transfer the motif to the wood surface. Motif transfer is done by free hand or by one of the methods of drawing, pasting or copying with a template (Figure 2a). Then, it is necessary to empty the parts outside the motif or to carve the unnecessary parts. This process is done with hand tools (Figure 2b) or with a vertical boring machine or milling machine (Figure 2c). Along with these machines, although the machine is partly included in the production, handwork is also used. If wire inlay is to be done, since the wire channels are very thin, it should be done by hand with special tools (Figure 2d). In recent years, wood surface treatments in large enterprises have been carried out in CNC router fully automatic machines. The biggest revolution in wood surface processing has been achieved with CNC router production. With these machines, many production stages such as motif transfer and handwork are eliminated. However, all of these applications can be defined as machining and contact mechanical production. CNC laser technology, on the other hand, can be called chipless and contactless chemical production. CNC router and CNC laser woodworking have advantages and disadvantages when compared to each other. These differences may vary according to the operation performed.

In order for the CNC laser machine to work, a computer hardware with CAD (Computer Aided Drawing) and CAM (Computer Aided Manufacturing) drawing and code converter programs is also required as a complement to the laser processing center. CAM processes the drawings made in CAD and converts them into machine codes (Alıcı, 2006). In this study, a case study was conducted to determine the applicability of CNC laser wood surface decoration with regression modeling method. The design and production process steps of CNC laser processes, made of beech solid, poplar, walnut solids, mother-of-pearl and wire, applied to three nesting tables, are explained below.

The edge flower carving motif, "Selçuklu" inlay motif and filigree cutting paths to be applied on the beech massif forming the upper table of the coffee tables were drawn in a CAD (computer aided design) program. The upper table motif was transferred to the CAM (computer aided production) program in the software of the CNC laser machine as vector. The design was completed by determining the production parameter values measured according to the surface of the coffee tabletop. The design ready for production is shown in Figure 3a below, and the preview screen is shown in Figure 3b.

During the process of production parameter settings, the cutting power of the laser machine was applied using a 100 watt power to complete the produc-



a) b)

Figure 3 a) CNC laser product manufacturing design CAM program interface, b) CAM program Preview Screen
Slika 3. a) Dizajn CAM programskog sučelja za CNC obradu laserom, b) pregled zaslona CAM programa

a) b) c) d)

Figure 4 a) CNC laser tabletop engraving step, b) CNC laser tabletop table inlay step, c) CNC laser tabletop table Filigree (wire Inlay) step, d) CNC laser table stand leg processing
Slika 4. a) Graviranje ploče stola CNC laserom, b) izrada intarzije na ploči stola CNC laserom, c) izrada filigrana na ploči stola CNC laserom (žičani umetak), d) obrada nogu stola CNC laserom

tion as soon as possible. Since the walnut, poplar solids and mother-of-pearl thicknesses to be inlaid on the "Selçuklu" motif of the coffee table were designed as 3mm, the speed parameter for carving 3 mm on the table surface was calculated from the carving depth regression formula as follows:

Carving depth = 2.756 + (Carving Power*0.033) + (Carving Speed* - 0.019)

3 mm (Desired engraving depth) = 2.756 + (100 W-Max power*0.033) + (Required speed* - 0.019)

(Required engraving speed*0.019) = 6.056 - 3 mm (Required engraving depth)

Required engraving speed = 3.056/0.019 = 160 mm/s.

Since the edge flower motif of the tabletop and legs was designed as 1.5 mm low surface carving, the required speed parameter was calculated from the carving depth regression formula as follows:

1.5 mm (Desired engraving depth) = 2.756 + (100 W-Max power*0.033) + (Required speed* - 0.019)

(Required engraving speed*0.019) = 6.056 - 1.5 mm (desired engraving depth)

The required engraving speed = 4.556/0.019 = 239 mm/s.

Since for the filigree motif in mother-of-pearl inlay on the middle part of the tabletop and the filigree cutting paths on the edges, the width of the wire to be used was measured as 1.5 mm, the cutting speed parameter required for the cutting depth of the notch where the wire would be embedded was obtained from the cutting depth regression formula as follows:

Depth of cut = 8.560 + (Nozzle height* - 0.224) + (Cutting Force*0.058) + (Cutting Speed* - 0.343)

1.5 mm (desired cutting depth) = 8.560 + (5.2 mm - nozzle height* - 0.224) + (100 W-Max power *0.058) + (cutting speed*0.343)

(Required cutting speed*0.343) = 13.195 - 1.5 mm (desired cutting depth)

The required cutting speed was determined as = 11.695/0.343 = 34 mm/s.

The CAM design, developed with the obtained parameters, was completed and the production phase was started. Figure 4a shows the engraving step for inlay, Figure 4b shows the construction of mother-of-pearl and solid inlays, Figure 4.c shows filigree construction, Figure 4d shows the stages of preparation of the legs of the coffee table.

Figure 5a shows the assembled image of the nest table set, whose design and processing have been completed with the CNC laser-assisted regression modeling; Figure 5b shows the image sanded and adapted tables; and Figure 5c shows the final shape with varnish.

Figure 5 a) Assembled coffee table, b) sanded version of tables, c) varnished version of integrated tables
Slika 5. a) Sastavljeni stolić za kavu, b) brušena verzija stolova, c) lakirana verzija integriranih stolova

4 CONCLUSIONS
4. ZAKLJUČAK

In this study, the applicability of traditional furniture surface treatment techniques to the manufacturing method based on CNC laser assisted regression modeling was investigated. As a result of the research, it was determined that the regression modeling method can be successfully applied to furniture surface decoration with CNC laser, considering the material, machine and processing parameters. With the preview method for predictive modeling in industrial wood product design, the view of the cutting path in the production process, the length of the cutting path, the working time with laser processing, and the product output data can be determined in advance. Low wood carving, high wood carving, wood and mother-of-pearl inlay carvings can be done successfully with laser processing. Perfect and fast cutting paths can be embroidered on the most complex motifs, especially for filigree inlay. When a good design is made, the color tones ranging from brown to black on the engraving surfaces, depending on the processing power of the laser, add value to the decoration. It processes highly detailed motifs with much more precision than CNC laser, hand engraving and CNC router processing methods. In addition, it has been determined that laser furniture top surface decoration is very suitable for mass production.

A badly managed process of motif design and production parameter in laser wood decoration can have negative effects such as excessive burns on the ornamental surface, loss of adhesion of the combustion surfaces, extra cutting path and energy consumption, more difficult sanding and polishing of the burned surface.

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