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SMOOTHING OF PROFILES ON SURFACES OF MDF BOARDS BY FRICTION METHOD WITH THE ROTATIONAL TOOLS

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ABSTRACT

MDF boards being presently basic material used for furniture doors are frequently milled. The requirements for finishing of profiles cause many complications connected with surface quality on the whole depth of milling. The matter is caused by changing density profile on the cross-cut of the board. The research shows surface smoothing of milled surfaces by rotational tool without edge or with a dull one.

KEY WORDS: moulding, MDF boards, smoothing, friction, surface roughness

INTRODUCTION

MDF Boards are at present main basic material used in furniture production for furniture face (doors), and also in joinery (Nicewicz and Matejak 2000, Proszyk 1999). They are often milled, which is aimed for obtaining decorative profiles.

Very similar situation occurs in doors production where slot milling result in diversified surface forms, being tied with patterns made from wood and are imitation of a given wooden construction.

The requirements concerning profile finishing cause many complications connected with surface quality on the milled decorative relief (Proszyk 1999).

It is caused by a variable density profile on the cross section of a board, which leads to differentiated geometrical structure of surface after shaping.

Lately some research on development of technology of profile smoothing took place. The undermentioned technologies differ mainly in principle of work, shape of milled profile, kind of smoothed material and its density. The basic difference between these technologies is the difference in the tool movement and processed material (Wieloch et al. 2001). The can be grouped into three kinds of technological proceses:

Smoothing with a fixed tool /IH research in Dresden. This technology is based on pressure and friction on a given profile. A fixed smoothing tool electrically heated works in a path made by earlier moulding; pressed down by force smoothes a profile- Fig. 1.

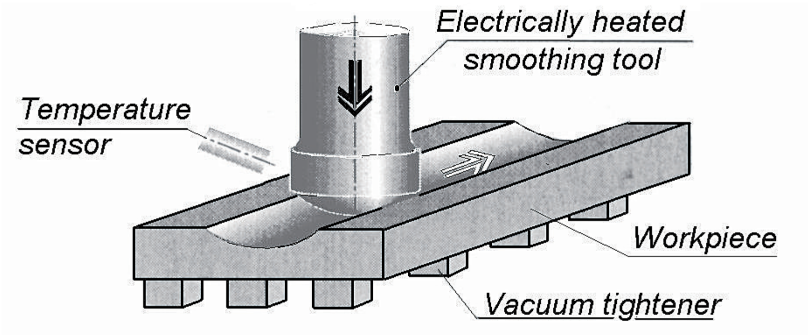


Fig. 1: Smoothing of a profile by a fixed smoothing tool (Sanding, Raatz 1993)

- Smoothing by friction with a rotational tool is based on cyclical burnishing of wooden material. It results in indentation of frayed fibres in burnished surface. Rotational moving tools (rolls) consolidate a profile working after cutting tools (Sandig and Raatz 1993, Wieloch et al. 2001). The smoothing tool is the source of heat on the burnished surface caused by friction. The regulation of temperature is achieved by smoothing and rotational speed of smoothed elements.
- Smoothing by edgeless rotational or with a bunt edge. The process is based on a sliding smoothing of relief elements, machined in a board. The dimensions of a tool are minimally bigger. Rotating tool is inserted into produced earlier shape for example a groove and pressed on walls causes friction. Led along according to earlier trace it smoothes surface especially of central layers. The regulation of temperature is achieved by smoothing and rotational speed of smoothed elements.

MATERIAL AND METHODS

Taking into consideration the above reflections; the possibilities of replacement (at least partial one) of snading moulded grooves by dull burnishing (rounded) at low feed speed and high rotational speed of a tool was tested.

The characteristics of moulding process

The most frequent actions which MDF boards are acted on is moulding of grooves, joints pockets, dovetails, hollows and so on. Usually for such purpose shank cutters (face and milling) or profile cutters are used.

Moulding with shank cutters usually consists of two stages:

- sinking of a tool and its (or moulded element) translocation inperpendicular direction to its rotation axis.

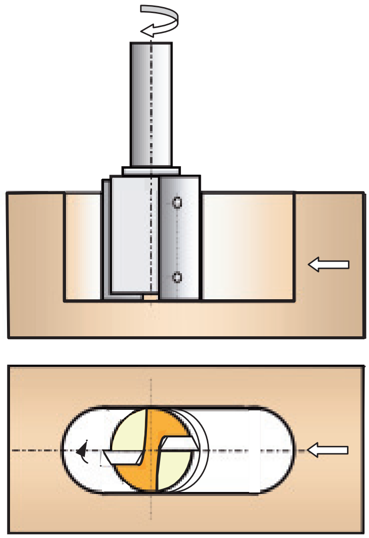


Fig. 2: Scheme of grooves moulding on upperspindle moulding machine or CNC

Milling cutter rotates and moulded element makes sliding movement to achieve appropriate size of dovetail (Lisičan et al. 1996, Staniszewska and Zakrzewski 2002).

Selection of cutting tool for the research samples production

For samples production double edge shank cutter with HM exchangeable edges was used (producer FABA Boboszów). The HM exchangeable edges lower the exploitation costs of the tool because there is a possibility of exchanging of edges only (after dulling) not the whole shank cutter. In this case the exchangeability had a double meaning as it let quickly exchange one edge for another of assumed edge dulling.

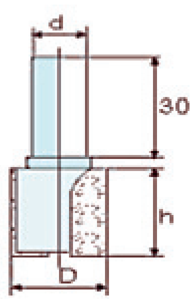


Fig. 3: Shank cutter used for research

Three sets of edges were prepared to make the grooves. The N° 1 edges were sharpened in such a way so that the groove after moulding had diameter d=17,5 mm. The set N° 2 was phazed in such a way as to produce diameter of shank d=17,65 mm.

The side cutting edge was dulled.

The set N° 3 was prepared in the same way as N° 2 but the obtained shank diameter was d=17,75 mm. Phazing of side cutting edge combined with low feed speed was aimed to create friction leading to plasticity of side surface of moulded groove and its smoothing.

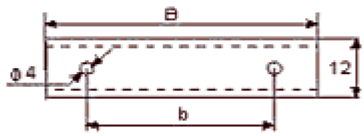


Fig. 4: Exchangeable edge of shank cutter

Selection of parameters for machine cutting

Moulding was performed at rotating tool speed of v = 12000 r/min and feed speed: 2,5 m/min.

Selection of machine tool for samples production and machining parameters

The realization of moulding and smoothing on samples required great accuracy that is why a numerically controlled machining centre working as upperspindle moulding machine (ROVER 321 R produced by BIESSE) was chosen for samples production. It enabled to programme the machining parameters with required preciseness and performing all operations at one fixing of MDF board (which was tested). The application of CNC enabled repetition of condicting the smoothing tool in exactly the same machining path as formerly done by shank cutter. It also enabled changes in feed speed and exchange of shank cutters of different cutting edges.

The selection of wood material for samples production

MDF boards 30 mm thick produced by KRONOPOL from Żary were used during the research. After moulding and smoothing of side surfaces of the groove samples for surface roughness testing were cut. One of the samples which wasn`t smoothed was used as a model for comparison of the effects smoothing. On the tested samples density, moisture content and basic properties of a board were indicated. They were as followes:

- density 750-770 kg/m^3
- bending strength 17-18 MPa

- tensile strength 0,5-0,55 MPa
- modulus of elasticity in longitudinal axis 1900-2100 MPa
- swelling after 24h 8-10 %
- moisture 4-7 %
- modulus of elasticity in perpendicular to board surface 2000 MPa

Changes of surface roughness after smoothing were checked by profilographometer. A contact profilographometer with computer gathered research data (Nowicki 1991, Pohl and Wieloch 1997, 1998, Wieczorowski et al. 2003) were used for this purpose.

The MDF bard was fixed to a moulding machine. First a groove was moulded in the board with a conventional shank cutter, next after the removal of the conventional one, the process of cutting was repeated (in the same path) with dulled edges which had diameters bigger than conventional ones of 0,15 and 0,25 mm. The next stage of the research was to cut the board in such a way as to enable measurement of moulded surface by profilographometer.

The measurement was made in E system (slide ratio R = 80mm) which eliminated the shape measuring error and also the necessity of precise set-up of measured surface to guide rails of the profilographometer (Nowicki 1991). The measurement was taken at inductive head (gauge) movement of 0,8 [mm/s] according to Polish standards (Wieloch and Pohl 1999, PN-84/D-01005, PN-87-D/04206, PN-EN 322)

RESULTS AND DISCUSSION

The examples of research results are presented in the form of diagrams of surface roughness profiles (Fig. 5 and 6) and tables with recalculated surface roughness parameters. For better illustration of smoothed surfaces changes the Abbot-Firestone curves were added.

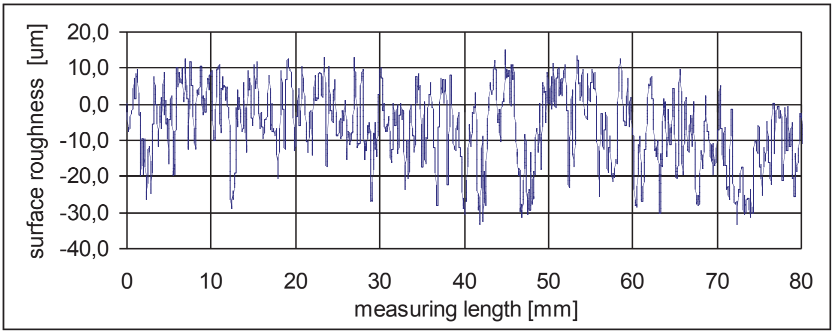
Fig. 5 shows surface measurement after moulding with shank cutter having sharp edge. Fig. 6 shows data of measurement after smoothing with shank cutter which had diameter 0,25 mm bigger than the previous one (indentation 0,125 mm per side).

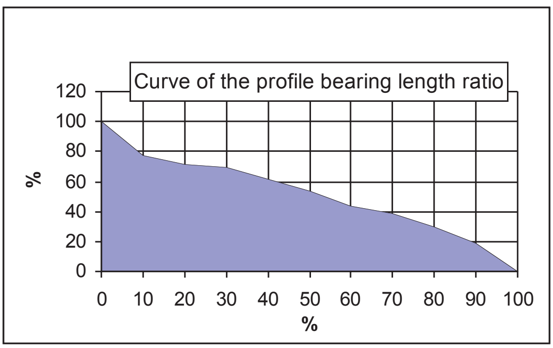
Both figures (5 and 6) show roughness parameters in the form of tables obtained from data elaboration collected during measurement for both kinds of machining recommended by Polish Standards (PN-87-D/04206, PN-EN) 322 in wood industry.

On the basis of conducted research a distinct dependency between diameter of the tool used for smoothing, the size of moulded groove- / depth of burnishing / and surface roughness.

One can also notice distinct surface roughness changes on different depth of moulded MDF board. Certainly it is influenced by density of moulded material. In around-surface layers surface roughness parameters are considerably lower than in the central layers of a board. The obtained surface profiles have their reflection in curve of the profile bearing length ratio, which for smoothed boards were more horizontal in shape.

The characteristics of particular roughness parameters resulting from different profilograms, curves of the profile bearing length ratio shows also dependency of roughness dimension from the thickness of burnished layer. The data analysis shows new possibilities of improvement of surfaces with difficult access as roughness parameters of burnished samples in comparison with not burnished ones show lower considerably values (Fig. 7).

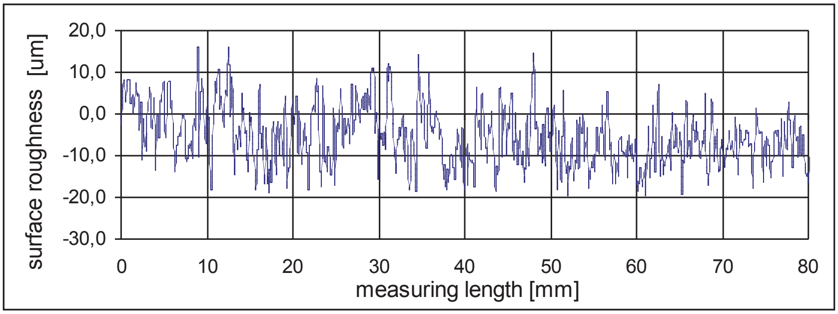


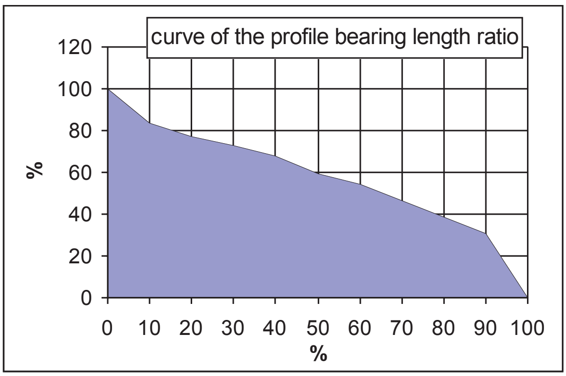


Parameters:	
Ra [um]	8
Rmax [um]	48.4
Rm [um]	35.9
Rz [um]	37.9
Rq [um]	9.8
Rsk [um]	0.2553
Rku [um]	2.8125
Rku* [um]	-0.0492
delta q [um]	0.0982
Sz [mm]	0.44
Sm [mm]	0.68

Fig. 5: Surface roughness of MDF board after moulding on transverse section surface profile; profile parameters ; the Abbott-Firestone curve of the profile bearing length ratio

On the other hand the imperfection of this process is that it can be used only in factories which don`t take full advantage of CNC machining centres because it is connected with low feed speed used in this method.





Parameters:	
Ra [µm]	2.6
Rmax [[µm]]	37.2
Rm [[µm]]	14.2
Rz [[µm]]	9.6
Rq [[µm]]	3.5
Rsk [[µm]]	0.283
Rku [[µm]]	3.4504
Rku* [[µm]]	0.1012
delta q [[µm]]	0.0413
Sz [mm]	0.42
Sm [mm]	0.58

Fig. 6: Surface roughness MDF board after moulding and smoothing on transverse section surface profile, parameters, the Abbott-Firestone curve of the profile bearing length ratio

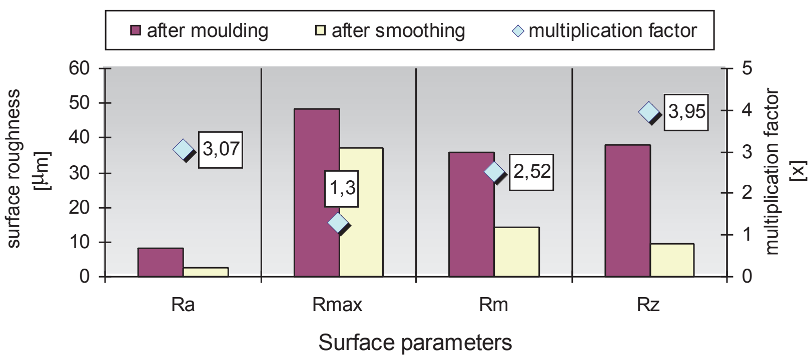


Fig. 7: Changes surface roughness MDF boards on transverse section after smoothing

CONCLUSIONS

Taking into consideration the obtained data and their analysis one can state that:

- The method of smoothing the moulded grooves in MDF boards with rotational tools completely fulfills expectations of surface quality improvement (3 to 4 times according to R_a and R_z parameters).
- Substantial influence on roughness has position on the cross section where burnishing takes place. It results from differentiated density on the cross section of fibre-board. From above we can state that fibre boards which have increased and even density (so called HDF) are more suitable material for this method.
- Moulded and smoothed surface takes slightly different colour which on one hand can eliminate this method for transparent lacquers coating on the other hand however can be desirable because of aesthetic reasons.
- Surface smoothed according to this method causes substantial lowering of porosity in a board preparing it for lacquering, veneering or sticking film.

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