REGIMES FOR PRODUCING OF FURNITURE BENT PANEL BOARDS WITH A LABORATORY VACUUM PRESS

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ABSTRACT:

Regimes for producing of furniture bent panel boards with a laboratory vacuum. By the manufacturing of curved furniture constructive elements of bent laminated furniture boards (arches, doors, drawer fronts etc.), it is important to be establish a technological regime for faultless bending of furniture panels and to know their limit bending radius. The aim of the study is to compile a rational technological regime for faultless production of layered bent glued fiberboard with high density (HDF). The test samples are made from three layers lamellas of HDF with dimensions 260/100/2.8 mm. For gluing them was used a standard polyvinyl acetate adhesive 25 min open time. Bending and forming layer boards was done in a laboratory vacuum press with templates with the following radius of curvature: 50, 100 and 150 mm. To realize this it is determined the time to reach minimum technological strength of the adhesion, the speed of the suction and the boundary minimum bending radius. The results obtained are analyzed and presented graphically.

1. INTRODUCTION

Particle boards and wood fiber boards are the basic material for the production of furniture. The development of the furniture design necessitates the use of structural elements with complex shapes. The technologies and materials for their enrichment and the production of elaborate details are at the heart of the development of modern furniture. Problems come from their complex technological manufacturing, as well as from their subsequent superficial enrichment. Vacuum membrane presses are predominantly used for the manufacture and lining of furniture parts with a complex shape (decorative panels, lining 3D elements, elaboration of complex 3D layered details and etc.). They are the basic machines for production of kitchen doors made of MDF panels with a complex decorative profile. More and more the laminated composites are used since being economically profitable for the manufacturing process. The increasingly dynamic technologies and design concepts require more free-shape design and construction of complex curved elements. The most commonly used materials are massive wood, veneer, flexible plywood, cut MDF, MDF, HDF, fiberglass and others. The following adhesives are commonly used for gluing: PVA, polyurethane and melamine-formaldehyde adhesive for cold bonding. To accelerate the bonding process, additional heat can be introduced by heat input or high frequency heating (Panayotov, Hikov, 2006).
The object of the study is bent glued details of High Density Fiberboards (HDF) made by gluing via PVA glue. For such type of furniture details there is not enough literature to characterize their production. The purpose of the study is to determine the minimum radius of curvature of HDF laminated furniture panels and to determine the rational technological mode of making such details with a vacuum membrane press. The test samples will be evaluated for their dimensional stability by taking into account the change in radius. The radius of curvature is selected in a range of 50 and 100

mm, as details of such curvature radius are most commonly used in the furniture industry. These are details such as drawers, drawers of kitchen and section cabinets, chair backs and more.

2. EXPERIMENTAL SECTION

The test samples are made of HDF with a thickness of 2.8 mm (by "Kronospan") and a density of 900 kg/ m^3. For the statistical reliability of the results, 9 identical test samples were prepared for each study. Two patterns with corresponding internal radius of curvature – 50 mm and 100 mm were used to make them. The test sample is made up of 3 lamellas with sizes 260/100/2.8 mm bonded with PVA glue (by „Protovil WR/P, Collanti Concorde Italy") with 25 min open time. The glue utilization used is the minimum (of 150 g/m^2) being unilaterally applied to the HDF lamellas. It is determined for each lamella by the weight method.

Figure 1: Laboratory vacuum membrane press and the matrix of bending with 100 mm radius

For the production of the samples a laboratory vacuum press with a 3 mm thick rubber membrane is used (Figure 1). The compression force is equivalent to the vacuum applied (-0.06 MPa) in the chamber when the test bodies are being made. It was determined by preliminary researches and rating of the results. These tests also determined the minimum radius of curvature. Radius templates were pyramidal L-shaped pieces with the following radiuses: 50, 100 and 150 mm. A graphical method for measuring the variation of the curvature is used. For this purpose, the change of distance between shoulders of the sample is measured. It was measured after the sample is removed from the template and after the 24-hour „free" stay. It was determined the minimum bend radius (100 mm) of the lamellas with a thickness of 2.8 mm in a three-layer HDF structure. Thus it was determined curve radius of 100 mm for making bent glued samples for the main study.

3. RESULTS

The statistically processed test data are presented in table 1 via the following indicators: average (Y) – „distance between shoulders of the sample", standard deviation (S_x), standard error (mx), variation coefficient (V_x) and coefficient of accuracy (P_x). On figure 2 is presented the arithmetic mean values (distance between shoulders of the sample) of the curved test samples after the producing and after 24 h "free" stay.

Table 1: Values for statistical significance of the study

Series	Aver.Y, mm	S_x, mm	m_x, mm	V_x, %	P_x, %
Samples after producing	228,68	2,41	0,76	5,80	0,2
Samples after 24 h "free" stay	229,58	2,68	0,85	7,17	0,2

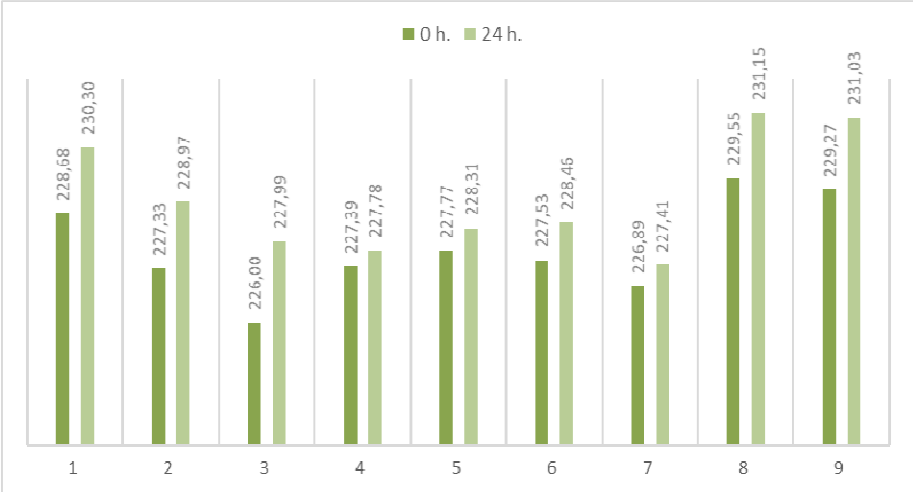

Figure 2: Distance between „shoulders“of curved sample (mm) and its change after 24 hours of "free" stay (for 9 „sample series“)

From the carried out study, it was found that for the non-defective production of bent furniture boards it is extremely important to consider the duration of the working cycle defining the time from the beginning of the vacuuming until reaching the defined vacuum. When the maximum vacuum is reached quickly, the test samples are being destroyed. The cracks are at the boundary between the radius of curvature and the straight parts of the template. For this also helps the high density of the used material. This high density makes it difficult to flex. On the other hand, the applied adhesive moistens the surfaces of the lamellas and plasticizes the material. It was found that in order to avoid this destruction, the vacuuming time must be between 120 s and 180 s. For a longer vacuum time, the glue partially dries and the required technological strength is not reached. This leads to the self-peeling off of the test samples.

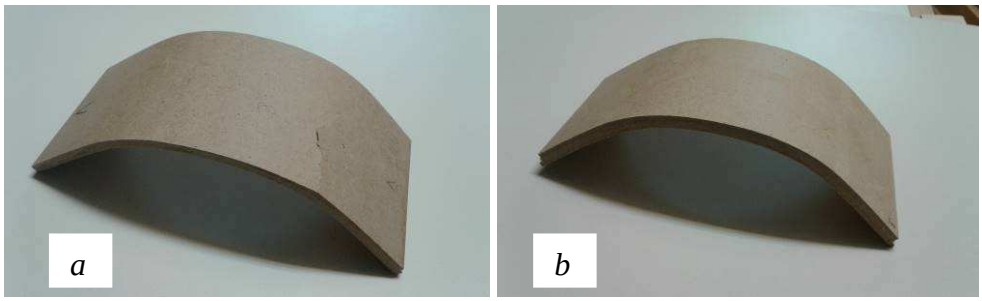

Figure 3: Experimental samples. a - Cracks resulting from bending and welding; b - Non-defectively bent glued sample

Upon reaching a vacuum value above -0.03 MPa, the rubber membrane starts to stretch and applies additional pressure to the surface of the sample. At the boundary between the radius of curvature and the straight parts of the curved details can be seen cracks in the surface. They are due to overcritical tension stresses produced in the outer layer of the test samples. In order to avoid this problem it was

concluded that additional material should be placed between the membrane and the bent part to distribute evenly the pressure from the membrane and to absorb these stresses in some part. For this study, a piece of 3.2 mm thick plywood is placed between the membrane and the bent piece. By means of this no-defect bent boards were obtained.

To obtain non-defective samples, it is recommended that the vacuum duration at maximum vacuum (-0.06 MPa) be in the range between 20 and 30 minutes. In practice, this is the minimum amount of time when the curved parts retain their shape and do not break the lamellas.

From the preliminary experiments, it was found that when using 2.8 mm thick boards in a three-layer construction of the bent glued HDF, the minimum radius of deflection is 100 mm.

4. CONCLUSION

Based on the experiments for making bent glued details of HDF lamellas with PVA glue, we can make the following conclusions:

- the minimum time to reach the technological strength between the HDF blades under vacuum is between 20 and 30 minutes. An extended stay is not necessary due to the following fact: when vacuum is sucked much of the water in the adhesive system, which contributes to faster drying and curing of the adhesive;
- the length of the period to reach the full vacuum has a significant impact. For the non defective bending of the HDF blades, it is in the range of 120 to 180 seconds. At shorter lengths of that time on the surface of the outer lamella is loaded to overcritical tension stresses and cracks are being noticed. With greater duration of the period to reach full vacuum the glue starts to dry of which the adhesive compound has a low adhesion strength;
- because of the high density of the lamellas used, it is difficult to reach a small radius of curvature. The fibreboards with high density, the minimum bend radius of the lamellas with a thickness of 2.8 mm in a three-layer structure is 100 mm;
- to prevent the destruction of the outer lamella of HDF by vacuum membrane press bending with a rubber membrane, it is necessary to put an additional piece of flexible plywood with a thickness of 3,2 mm, which evenly distributes the pressure on the bending part.

ACKNOWLEDGEMENT

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