

A study on hinges and cabinet doors

Sedanur Seker¹, E. Seda Erdinler¹, Y. Ziya Erdil²

¹Istanbul University-Cerrahpasa, Faculty of Forest, Department of Forest Industry Machine and Management, Istanbul, Türkiye

²Muğla Sıtkı Koçman University, Faculty of Technology, Department of Woodworking Industrial Engineering, Muğla, Turkey

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Abstract

The deflection of cabinet doors is a factor that effects both functional and aesthetic values of cabinet furniture. Function and aesthetics are core design issues for cabinets. This study determined deflection values of cabinet doors under varying conditions such as density moisture content, screw pull, clutch, and close and opening angle. In the study, furniture cabinet doors consisting of two different materials (medium-density board and particle board), two hinges, three hinges and four hinges were tested separately. The study is based on the BS EN 16122 standard. However, the TS EN 9215 standard was followed to reveal the deformations in the door after increasing loads and angles. As a result, it was found that the material type, angle, load is important.

✉Erdinler E. Seda, Department of Forest Industry Machine and Management, Faculty of Forest, Istanbul University-Cerrahpasa, Istanbul, Türkiye, e-mail: seda@iuc.edu.tr

Introduction

Wood materials and wood-based materials constitute an important component of the furniture phenomenon and furniture construction design. Knowing previously the behavior of the materials involved in the formation of the furniture product against physical and mechanical effects provides technical, aesthetic and economic benefits to designers, manufacturers and users.

Kowaluk et al. (2011), studied, particleboards with different densities from specially prepared particles of black locust and willow. As an alternative light weight product. The standard mechanical parameters of panels were investigated, as well as the corner wall connections with eccentric connecting fitting element and have measured the screw withdrawal resistance and hinge bearing for investigated panels. They have found all panels, excluding low-density black locust panels, suitable for furniture production (Kowaluk et al., 2011).

Previous studies state that demountable fasteners are predominant in cabinet furniture, although they are uncommon in frame furniture (Prekrat and Spanic, 2009;

Ozkaya et al., 2010; Kucuktuvet et al., 2017; Efe and Imirzi, 2007; Yuksel et al., 2015; Smardzewski et al. 2016; Vassiliou and Barboutis, 2005). Screws and hinges are used in the doors and these fasteners are deformed by being exposed to loads like the door.

As a result of industrial applications that continue to develop, a wide variety of hinges and fittings are used to provide the rotational movement of a door. According to Smardzewski, the doors in case furniture can be opened by an angle from 110° to 360°, depending on the construction elements (Smardzewski 2015).

Using the finite element method (FEM), Zhou et al. (2012) in their study determined the maximal deflection values and strains for furniture doors, at varying configuration of hinge distribution. Based on the results, also with a consideration of the elastic properties of the employed wood-derived materials, the researchers came forward with a method of determination of the optimal number of hinges and distances between them (Zhou et al., 2012).

Furthermore researchers have studied the main assessment criterion of joint strength was the value of the breaking force or bending moment. On the other hand, stiffness have evaluated on the basis of the deflection value along the direction of load application or on the basis of the value change of the angle between the arms of the joint (Chai et al., 1993; Nicholls and Crisan, 2002).

As in Smardzewski et al. (2014) determination of furniture door stiffness manufactured from laminated particleboards are also studied. In the related study, the researchers investigated the strength and stiffness of doors by observing the impact of spacings between concealed hinges as well as the diameter of screws mounting these hinges on. According to the overall results, door stiffness increased together with the increase of distances between hinges (Smardzewski et al., 2014).

This study aimed to reveal the deformations that occur in the doors after increasing loads and angles. With the lead of RS EN 9215 standard.

Methods and materials

Cabinet doors

Typical wooden cabinet doors of MDF and PB with dimensions of 1800 mm (height) × 450 mm. (width) × 18 mm (thickness) were chosen randomly from the company's production line to investigate. In the study, total of 6 cabinet doors manufactured with two different materials were tested. The cabinet doors were labelled as from 2 hinges MDF1, PB1; 3 hinges MDF1, PB1 and 4 hinges MDF1, PB1 (Fig. 1). Accordingly,

moisture and density determinations were conducted with 15 small samples taken from each door. Moisture determination was performed according to EN 322(1993), while density determination was performed according to EN 323(1993) while density determination was performed according to EN 323(1993) standard. In this direction, the moisture content and density values are shown in Table 1.

Table 1. The moisture content and density values

	Material	Door with 2 hinges	Door with 3 hinges	Door with 4 hinges
MDF	moisture cont.	%7.86	%7.26	%7.40
	density	0.718 g/cm ³	0.717 g/cm ³	0.716 g/cm ³
PB	moisture cont.	%8.47	%9.54	%8.12
	density	0.63 g/cm ³	0.64 g/cm ³	0.60 g/cm ³

All screws were screwed in with the assistance of commercial screwdrivers equipped in a clutch. The screwdriver was set to achieve a drive-in moment value of 2.4 Nm.

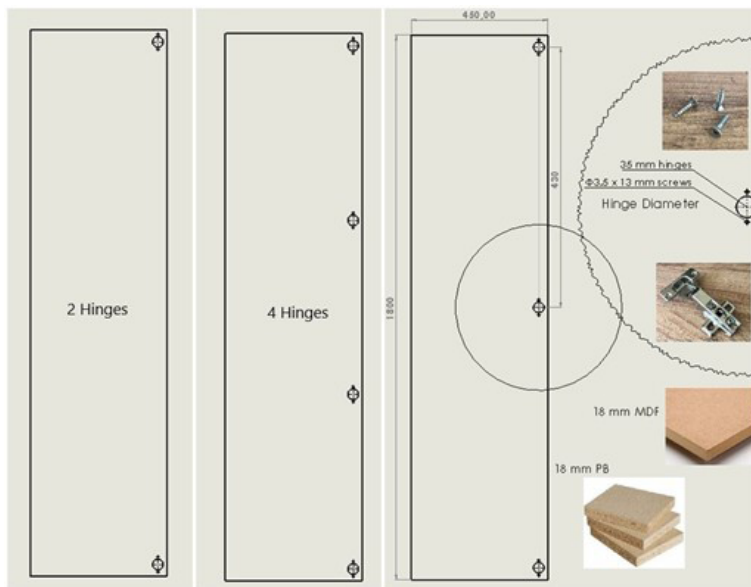


Fig. 1. Illustration of tested cabinets and materials

Test method for doors

Each of the hinges were marked around by a pen in order to investigate their displacement and rotation. Loading of the door with the specified mass is as shown in Fig. 2. The load is suspended 100 mm from the edge furthest from the hinge. The door is

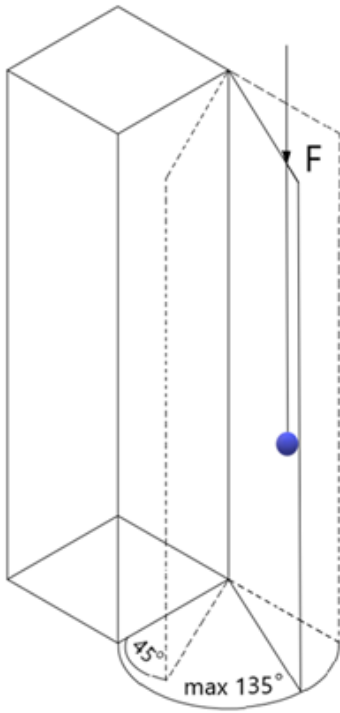


Fig. 2. Loading position of the doors

opened and closed ten full turns (back and forth) from position of 45° from fully closed position to 10° position from fully open position to maximum 135° position with an auxiliary element. Opening and closing was performed by Durability and Stability Furniture Testing Equipment machine. The study is based on the BS EN 16122(2012) standard. However, the TS EN 9215(2005) standard was also followed in order to reveal the deformations that occur in the door after increasing loads. For this reason, forces of 375N and 450N were loaded in addition to 300N loads and opening from fully closed to 10° angle, from fully closed to 135° angle and additional 10° from 45° from fully closed position are performed in accordance to TS EN 9215.

The cycle was repeated 10 times for each sample. The main criteria of the quality assessment of the examined hardware comprised deformations caused by the applied load force and deflection values of all samples.

Results and discussion

In the study, cabinets with two, three and four hinges were tested according to the standards. As the result of the tests deformations were observed at the hinges, doors and the fixation points of the door and the body part of the cabinets. Opening and closing angles, applied loads and repetition results were taken into consideration.

Damage symptoms door with 2 hinges

Two-hinged identical dimensioned MDF and PB cabinet door tests were performed initially. As the result of the tests, top hinge of MDF doors ended up with severe



Fig. 3. Two-hinged MDF door after test

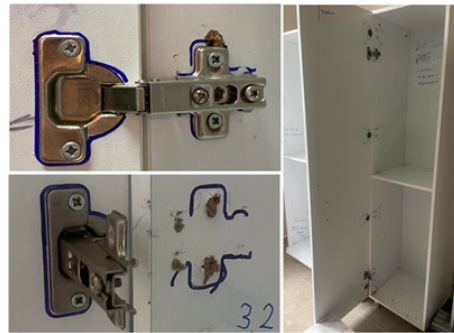


Fig. 4. Two-hinged PB door after test

rotation and bending was observed on the bottom hinges due to loads. The doors were unable to close properly as the result of hinge deformation. (Fig. 3). Meanwhile, malfunctioning of bottom hinge on PB doors occurred after 450N load. Top hinges performed higher rotation with respect to MDF doors and malfunctioning was determined due to bottom hinge displacement (Fig. 4).

Damage symptoms door with 3 hinges

The tests for three-hinged doors with identical dimensions were performed for different materials such as MDF and PB. In the test results of MDF doors under 375N load mid-hinge was dislocated and was out of the system as illustrated in Fig. 5.



Fig. 5. Three-hinged MDF door after test

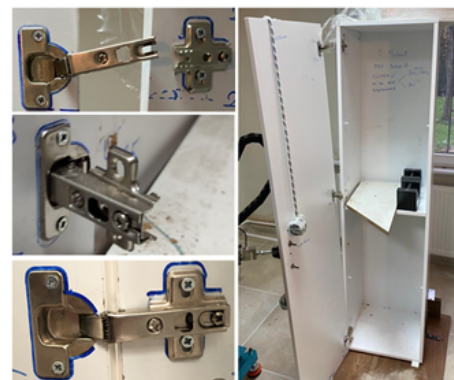


Fig. 6. Three-hinged PB door after test

Hence, the tests were proceeded as the opening-closing functions of the doors were still operating. At the end of the test, deformation due to rotation was observed on the top hinge where it was only the loosening of the screws for the bottom hinges. On the other hand, during the tests of the PB doors, dislocation of screws were observed on the mid-hinges under the load of 375N and under 450N load and 10° angle dislocation of the hinge itself was observed which caused malfunctioning of the door. The test was terminated at this point.

Damage symptoms door with 4 hinges

Four-hinged MDF cabinet tests were performed and the results were successful as shown in Fig. 7. Hence, severe rotation of the bottom hinges and displacement of other three hinges were observed. The tests proceeded as the opening-closing functions of the doors were still operating. Meanwhile, PB doors, as shown in Figure 8, the dislocation of the second hinge from the top occurred under 375 N load due to repetitions. The tests were proceeded as the doors were still functioning. At the final stage of the tests rotation of all hinges, displacement of all hinges, loosening of screws and displacement of door were observed.

In the study, increase in deflection values under different loads were determined. In another study, Smardzewski and Majewski determined the deflection values of the doors under a load of 300 N and determined that the door not only rotated during loading, but also displaced downwards which supports the results of this study.



Fig. 7. Four-hinged MDF door after test



Fig. 8. Four-hinged PB door after test

According to the experiment results, MDF 1 and MDF 2 displayed higher performance values with comparison to PB 1 and PB 2. Similarly, in his study Sert determined higher performance values for MDF on different hinge configurations for MDF and particleboard (Sert 2018).

Conclusions

As a result of these tests, the doors made of MDF material are more durable than those made of PB material. By investigating the density and moisture conditions of all door materials, it was observed that there were no outliers, the torque of all screws was fixed and possible differences were eliminated.

It has also been clearly seen that the position of the hinges on the door, which is generally separated from the system, is collected in the middle hinge, and screw loosening was encountered during the tests.

Material type, angle and load variables were determined to be effective on deflection values utilizing variance analysis. At the same time, the interaction between material type and load was found to be significant.

In the study performing three different loads, four different angles, and two materials, the factor determined to be affecting the displacement amount in the doors is angles. The results also include that it caused visible deformations in the hinges during the tests conducted at different angles in the experiments

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