INNOVATION IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN, 1/2016 (9): 76–81

INFLUENCE OF THE TYPE OF UPHOLSTERY MATERIALS ON THE SOFTNESS OF UPHOLSTERY WITH INNER SPRING UNITS

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ABSTRACT

The upholstery with inner spring units, is composed of materials, which have various stress-strain behavior under load. In the work is studied softness and behavior of structures composed of different combinations of upholstery materials. The type of the innerspring unit, materials and thickness of the upper layers are changed. As criteria for evaluation of the specimens are used coefficients of softness and requirements for general deformation of the structure of the upholstery for seat and back elements. Conclusions are made and recommendations for their application in the structure of upholstered furniture.

Key words: upholstery materials, innerspring units, Bonnell spring unit, Pocket spring unit, structure of upholstery.

INTRODUCTION

In recent years, although the economy is experiencing a crisis, the production of upholstered furniture and especially mattresses has been sustainable. This is due to the application of new materials and the search for adequate strategies for finding markets in Europe and the neighboring countries. The use of new materials in the structure of the upholstery is mostly intuitive, but research on the deformation behavior under load has not been conducted lately in our country.

The upholstered furniture consists of a frame and upholstery. The frame provides the strength and durability of the structure, while the upholstery provides the comfort and aesthetic characteristics of the furniture. Various materials are used in the construction of the upholstery. These materials can generally be grouped into the following groups:

- material for foundation to the upholstery;
- materials for the spring part and filling;
- binding material;
- furniture fabrics;
- decorative upholstery materials.

In the spring part of upholstery materials are applied in order to ensure softness and comfort when used. According to the choice of the basic core materials can be made the following classification:

- inner spring core;
- a core of latex, viscoelastic or other flexible polyurethane foams;
- special design (with coir fiber pad, water, wool and peat, with rye straw and/or other materials).

Research on the deformation behavior of upholstery materials in Bulgaria were held long ago and for other manufacturers (Genchev 1995, Genchev 1998). Innovation in the industry is mainly made on the basis of analyzes of trends in the structure and form building of furniture (Genchev 2009). Deformation behavior is established and the design of the Bonnell spring unit is optimized (Kapica et al. 1994). Study on the distribution of the stress on mattresses mixed structure of a core in combination with coil springs with diameter of 60 and 26mm is conducted (Smardzewski et al. 2006). The purpose of the combination is to achieve a progressive stiffness characteristics – high deformation at low

load, subsequent proportional deformation at average loads and low deflection at high loads.

The purpose of this work is to study the deformation behavior of upholstery with Bonnell spring unit and Pocket coil spring unit and the influence of different layers of materials on the softness.

MATERIALS AND METHOD

The subject of the study are upholstery materials used by the company "HEGRA D" Ltd. in the construction of mattresses and upholstered furniture. Innerspring core are made Bonnell spring unit and Pocket coil spring unit.

The Bonnell spring unit is composed of double conical springs made of carbon spring steel wire with a tensile strength of not less than 1400N/mm^2. The main design parameters are as follows:

- wire diameter 2.2 mm;
- the outer diameter of coil 80 mm;
- diameter of the smallest loop of coil 45 mm;
- number of the turns 5;
- height of the spring unit 130 mm.

The Pocket coil spring unit is composed of cylindrical springs with coil diameter 65 mm, with 6 turns and height 120 mm, made of steel spring wire diameter 1.8 mm.
As filler materials were used:

- coir fiber pad with thickness of 10 mm and density 90 kg/m^3; soft polyurethane foam with thickness of 10 mm and density 25 kg/m^3;
- soft polyurethane foam with thickness of 30 mm and density 25 kg/m^3;
- latex foam with thickness of 30 mm and density 65 kg/m^3;
- needle punched felt with mass per unit area 500 g/m^2;
- quilt panel with polyester wadding with mass per unit area 250 g/m^2.

The effect of each layer of filler material on the softness of upholstery with innerspring core is tested.

Specimens with dimensions 600x600 mm are tested. They are built on a hard top foundation and felt. Then, the innerspring units are installed, burlap also, and are successively subjected to load, as it is placed on each of the filler material.

The specimen is loaded smoothly and height (respectively deformation) is reported at interval 5 daN in 5 to 20 daN and at interval 10 daN in 20 to 80 daN. Load element is disc-shaped with a diameter of 250 mm.

Before the test, the specimens were conditioned for 3 days in a room with a relative humidity of 45–70 % and an air temperature of 15 to 30 ºC.

Initial coefficient of softness S_i is calculated using the formula:

$$S_i = \frac{H_5 - H_{15}}{10}, \text{ mm/daN} \qquad \textbf{(1)}$$

where: H_5 and H_{15} are the heights (thicknesses) of the samples loaded with 5 and 15 daN, mm.

The general deformation of the elements for lying and back is defined by the formula:

$$D_{glb} = H_0 - H_{30}, \text{ mm} \qquad \textbf{(2)}$$

where: H_0 is the initial height of specimens determined at load 3daN, mm;

H_{30} – the height of the samples at load 30daN, mm.

The general deformation of the elements of seats is calculated according to the formula:

$$D_{gs} = H_0 - H_{70}, \text{ mm} \qquad \textbf{(3)}$$

where: H_{70} is the height of the test specimens under load 70 daN, mm.

The coefficient of softness of the elements lying and backs is determined by the formula:

$$K_{slb} = \frac{H_{30} - H_{40}}{10}, \text{ mm/daN} \qquad \textbf{(4)}$$

where: H_{30} is the height of the specimens under load 30 daN, mm;

H_{40} is the height of the samples at a load of 40 daN, mm.

The coefficient of softness of the elements of seats is determined by the formula:

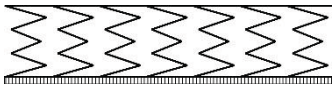
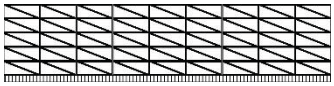
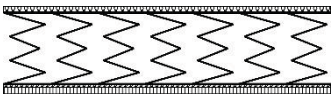
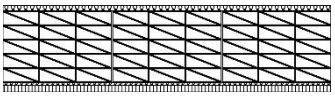
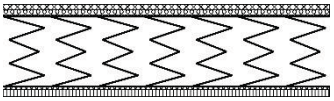
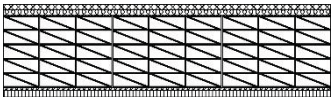
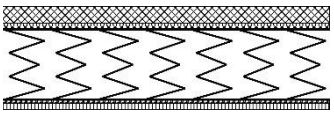
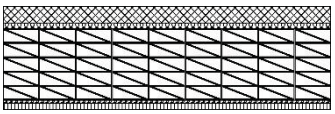
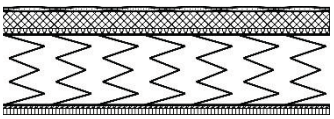
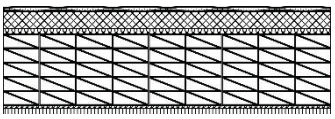
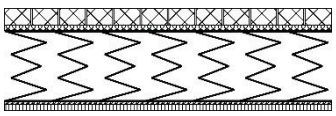
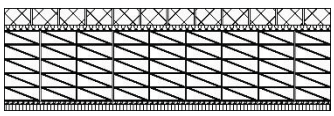
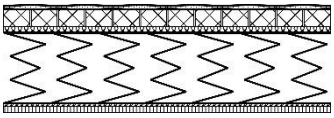
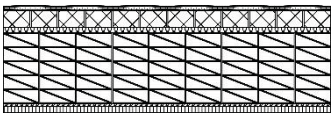
$$K_{ss} = \frac{H_{70} - H_{80}}{10}, \text{ mm/daN} \qquad \textbf{(5)}$$

where: H_{70} is the height of the specimens under load 70 daN, mm;

H_{80} is the height of the samples at a load of 80 daN, mm.

The following version of the upholstery were studied (Table 1):

Table 1: Studied variants of upholstered structures with innerspring core

Version		Structure	
		Bonnell Spring Unit	**Pocket Coil Spring Unit**
(1)	• Innerspring unit • Hard top foundation Total height ~ 135/125 mm		
(2)	• Coir fibre pad • Innerspring unit • Hard top foundation Total height ~ 145/135 mm		
(3)	• Polyurethane foam with thickness of 10mm • Coir fibre pad • Innerspring unit • Hard top foundation Total height ~ 155/145 mm		
(4)	• Polyurethane foam with thickness of 30mm • Coir fibre pad • Innerspring unit • Hard top foundation Total height ~ 175/165 mm		
(5)	• Quilt panel with polyester • Polyurethane foam with thickness of 30mm • Coir fibre pad • Innerspring unit • Hard top foundation Total height ~ 185/175 mm		
(6)	• Latex foam with thickness of 30 mm • Coir fibre pad • Innerspring unit • Hard top foundation Total height ~ 175/165 mm		
(7)	• Quilt panel with polyester • Latex foam with thickness of 30 mm • Coir fibre pad • Innerspring unit • Hard top foundation Total height ~ 185/175 mm		

RESULTS AND ANALYSIS

The results of the main criteria characterizing the upholstery are shown in Table 2.

Table 2: Indicators of softness

Version	Bonnell Spring Unit					Pocket Coil Spring Unit				
	S_i [mm/daN]	K_{slb} [mm/daN]	D_{glb} [mm]	K_{ss} [mm/daN]	D_{gs} [mm]	S_i [mm/daN]	K_{slb} [mm/daN]	D_{glb} [mm]	K_{ss} [mm/daN]	D_{gs} [mm]
(1)	1.6	1.2	40	0.7	88	2.3	1.7	60	0.1	102
(2)	1.9	1.5	48	0.7	99	2.4	2.0	61	0.2	113
(3)	1.9	1.5	51	0.7	97	2.9	2.0	67	0.2	120
(4)	1.9	1.6	58	0.7	108	2.9	2.2	73	0.6	135
(5)	2.3	1.7	65	0.7	115	2.9	2.6	73	0.8	143
(6)	2.4	1.5	58	0.7	107	3.2	1.9	80	0.3	136
(7)	2.6	1.5	62	0.7	110	3.5	1.9	80	0.4	136

Fig. 1 and Fig. 2 present graphically the deformation behavior under load of specimens with a Bonnell spring unit and Pocket spring unit.

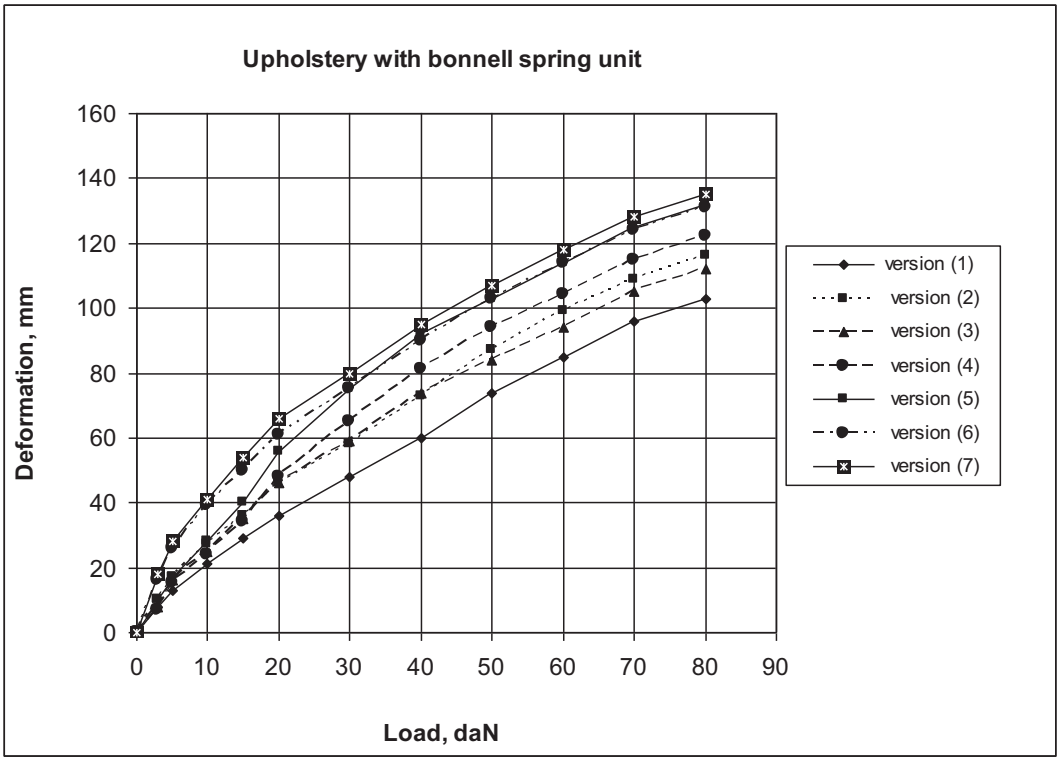


Figure 1: Strain behavior under load of upholstered structure with Bonnell spring unit

From the analysis of the results of Table 2 it can be seen that on a hard fondation without the application of filler materials, the innerspring units do not meet the requirements for soft upholstery. The graphic presentation

in Fig. 1 and 2 shows that the innerspring units have proportional deflection under load. In case of Bonnell spring unit it continues to load up to 80 daN and in case of the speciment of Pocket spring units up to 50 daN. This is due to the varying structure and the smaller diameter of the wire under samples with a Pocket spring unit.

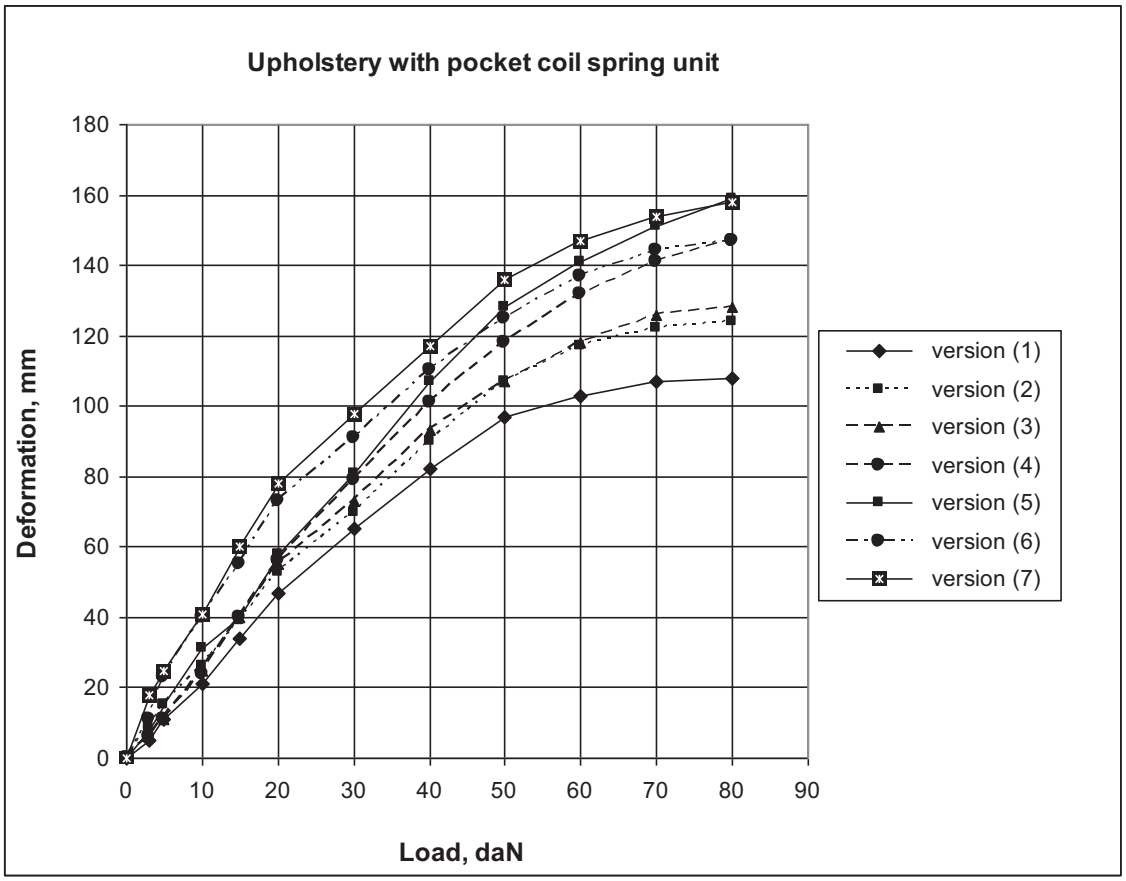


Figure 2: Strain behavior under load of upholstered structure with Pocket spring unit

The total deformation of the elements for seats D_{gs} meets the standard requirements of softness and even without the application of filler materials on them, but the requirements of the coefficient of the initial softness S_i (more than 2.4 daN/mm^2) can be achieved with the application of filler materials. This is reached in the sample bodies with a core of Pocket spring unit even with a coir fibre pad of a thickness of 10mm, whereas in the sample bodies with a core of Bonnell spring unit, this is achieved with the application of coir fibre pad and latex with thickness 30 mm.

The coefficient of softness of seats K_{ss} is high, indicating that these structures with innerspring core have the ability of additional deformation in case of peak usage. This is shown particularly clear in Figure 1 where the graph of the deformation is still proportional, and in Figure 2 where the core is of pocket spring it can be seen that under load more than 60 daN the degree of the increase of the deformation decreases.

Coefficient of softness of elements for lying and back K_{slb} over 0.6 mm/daN is recommended in the research from the literature survey. The data in table 2 shows that the trial samples meet this requirement. The trial specimens also meet the requirement of the general deformation of the elements for backs and for lying D_{glb} for upholstered furniture (over 50 mm).

The results of the investigation of the influence of each layer of upholstery material

on the softness of the upholstery shows that the type and thickness of the surface layers are essential. Samples with surface layers of latex have higher degree of softness**.** The coefficient of initial softness S_i reaches 3.5 mm/daN. The latex layer undergoes large deflections in a smaller load, proved by the lower values of the coefficient of softness of the seat K_{ss}. But these values are higher than the standard requirements for upholstery furniture.

The Pocket coil spring unit has very good characteristics for use in mattresses. With upper layers is increased the possibility of additional deformation in the range of larger loads and using for seats.

The established properties and degree of influence of the separate materials on the indicators of softness can be used as a basis for determining their optimal value according to the function of specific models upholstered furniture and mattresses.

CONCLUSION

The type of the inner spring unit in the structure of the upholstery has a major influence on the degree of softness. Upholstery with core of Bonnell spring unit has linear load-deformation characteristic over the entire load range, which is an advantage over upholstery with core of polyurethane foam. To achieve the requirements for soft upholstery it is necessary the careful selection of the top layers depending on the chosen thickness and hardness of the material. Upholstered furniture with core of Bonnell Spring Unit, combined with coir fiber pad and latex foam can provide a sufficient comfort. The goal of future research is a comparative analysis of the application of flexible polyurethane foam as a cheaper alternative of the latex in the structure of the upholstery to achieve greater economic impact.

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ACKNOWLEDGMENTS

The article is result of research made on the base of the project №65/06.02.2014, sponsored by The Scientific Research Sector at The University of Forestry – Sofia.

UNIVERSITY OF FORESTRY
FACULTY OF FOREST INDUSTRY

INNOVATION IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN

1/2016

INNO vol. V Sofia

ISSN 1314-6149
e-ISSN 2367-6663

INNOVATION IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN, 2/2016 (9): 3–4

CONTENTS