Performance properties of classical and modern upholstery techniques

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Abstract: In this study, determination of performance properties of seating elements prepared with classical and modern upholstery material and techniques was aimed. For this aim, 8 experiment samples of applet upholstery on webbing (AUW), applet upholstery with spiral spring (AUSS), applet upholstery with zigzag spring (AUZS), wall-less foam upholstery on webbing (WLFUW), wall-less foam upholstery on zigzag spring (WLFUZS), walled foam upholstery on webbing (WFUW), walled foam upholstery on zigzag spring (WFUZS) and crushed upholstery on spiral spring (CUSS) were prepared on the test frames. With the application of solidity test for seating place was tested and the deformation value was determined on the samples, prepared according to FNAE 80-214 standards. As a result, the lowest value of deformation was found on the crushed spiral upholstery while the highest value was found on the applet upholstery on webbing. It is possible to say that modern upholstery gave better performance than classical upholstery.

Keywords: Classic upholstery techniques, modern upholstery techniques, furniture performance tests, force-deflection coefficient.

1 Introduction

It is a sad truth that classical filling equipment in upholstery is costly in terms of time, labor and economy. For this reason, especially after 2nd World War, rubber and rubber filling materials supplanted of classical upholstery materials. The main purposes of that are both saving time and labor and also producing useful furniture (İlter 1990). In literature search, limited number of studies was encountered about determination of performance features of upholstery techniques produced by traditional and modern materials. It was specified that studies were done by the aim of determination of sectoral situation and the problems and material's attitudes towards external factors such as burning, discoloration, etc. Searches related to this study were presented below (Yılmaz 2008). Eckelman and Zhang (1995) introduced GSA (General Service Administration Performance Test for Upholstered Furniture) which is used in engineering design of furniture framework and evaluation of attitudes of upholstered furniture and they discussed basic factors and concepts that needed in order to develop a universal acceptable performance experiment method. Eckelman and Erdil (2001) introduced the details of performance experiment method (FNAE 80-214) developed for upholstered armchairs and sofas and the equipment which will be used in laboratories for the application of this method. Also they indicated acceptable force values showing light, medium and heavy usage with the aim of application conditions. Smardzewski (2013) was to develop a new construction of an upholstery spring of bilinear stiffness. On the basis of the conducted studies and analysis of their results, it was shown that traditional bonnell and barrel springs exhibit linear stiffness within the range of deflections of up to 70 % of their initial pitch. New spring designs change stiffness already at deflections of 34% of their pitch. Smardzewski et al. (2008) searched the elastic properties of hyper-plastic polyurethane foams applied in furniture industry, to elaborate mathematical models of these materials on the basis of non-linear Mooney-Rivlin models and to conduct a non-linear numerical analysis of contact strains in a deformed seat made of polyurethane foam. The results of the experiments revealed that the mechanical properties of polyurethane foams are described properly by the Mooney-Rivlin model. Kapica and Smardzewski (2001) searched the mechanical response of two-layers polyurethane foam systems to compression loads depending on different physical and geometrical parameters of the set. The performed investigations revealed that it was possible to model analytically and practically the rigidity of elastic systems of upholstered furniture, in particular in the case of multifunctional constructions and furniture intended for sick or disabled persons. Eckelman (1998) introduced some constructional performance experiments applied on chairs, armchairs, office chairs, tables and box furniture. Eckelman (1999) introduced cyclic stepped increasing load method and determined chair performance experiments acceptable force value developed using this method. Eckelman and Erdil (2000) specified the details of experiment method (FNEW 83-269) developed for office chairs experiments, the equipment in used and acceptable design values. Winandy (1978) searched the availability of laminated wood materials on upholstered furniture frameworks. As a result he reported laminated dowel joints may be used in framework furniture production. Kasal (2004) stated that wood composite materials as an alternative to wood material and demounted joining techniques providing advantages for the designers, producers, consumers and dealers as an alternative to stationary joining might be used in production of frame constructed furniture especially framework parts of upholstered furniture. Altınok et al. (2007), as a result of static force experiments of seating place and backboard of chairs and armchairs, stated that there weren't any evolving and loosening in joints of rail to leg elements and any cracking, permanent bending or breaking in seating place and the other elements. Lin and Eckelman (1987) evaluated the effect of joining solidity on box furniture using 3 type joint techniques whose rigidity values change. As a result, joining had an important effect on the box solidity. Eckelman and Munz (1987) developed a general method to determine the effect of joints on rigidity of box system. According to the results, they suggested that when boards joined rigidly rather than semi-rigid joining such as hinges and like that, board sides resisted to bending like a beam. Eckelman et al. (2002) emphasized that sofa framework design was quite complicated because upholstered with zigzag spirals had a force on pre-rail elements of zigzag spirals from upper side to backwards and they stated that pre-rail element had to be analyzed as an out of plane surface element rather than a simple beam. Wang et al. (2007) different sized "T" corner joints from oriented spall boards (OSB) and moment carrying capacity of upholstery frames prepared as glued and non-glued (wire nail) against static force, they stated that moment carrying capacity increased as a result of the increase of corner joint length and glued elements carry higher moment force rather than non-glued elements. Zhang et al. (2005) which is for determination of fatigue performance at the end of 25000 cyclic of the upholstery frames prepared from boards made of wood (ply board, OSB and spall board), they expressed ply boards are the best results and gradually followed by OSB and spall boards.

The main purpose of this study is to make an acceptable standard for the sector comparing the performances of classical and modern upholstery techniques, to determine the deformations under various forces, to obtain numerical data about performance features of chair seating elements produced with different upholstery equipments.

2 Materials and methods

2.1 Materials

In our country upholstery equipments produced and commonly used have been used as experiment materials. 8 type seating place elements with classical and modern materials were chosen as experiment sample. 3 from each upholstery type and totally 8x3=24 samples were prepared.

2.2 The preparation of experiment samples

The same type upholstery frame was used in all of the samples. The upholstery frames were made of beech wood in size of 50x30mm. After the elements cut at the size of 55x35mm as a draft at temperature 20 ± 2 °C and at relative humidity 65 % ± 5 indoor were waited until they reach a constant weight, they were mortise joined and polyvinyl acetated mounting glue (PVAc) for fixing.

All of the samples were covered with the same kind of fabric (580 gr/mtul).

On prepared upholstery frame, 8 type technique seating elements which were applet upholstery on webbing, applet upholstery with spiral sipring, applet upholstery with zigzag spring, wall-less foam upholstery on webbing, wall-less foam upholstery on zigzag spring, walled foam upholstery on webbing, walled foam upholstery on zigzag spiring and crushed upholstery on spiral spring were prepared.

2.3 Method

Loads were done according to FNAE 80-214 for experiment samples. Experiments were done in Gazi University, Technical Education Faculty, Department of Furniture and Decoration Education Mechanic Test Laboratory furniture performance test device.

In this study, 20 cyclic force was applied on chair seating places according to the method. The experiment started with 445 N forces from back side and 222 N forces to the front side on chair seating surface. At the end of each 25000 cyclic the forces applied from the back side increased to 111 N, from front side to 55,5 N. The values belonging to experiment loads were given in Table 1.

Table 1. Loads (N)

Pistons	**Cyclic**		
	25000	50000	75000
Back Piston	445	556	667
Front Piston	222	278	334

Loading apparatus used in the experiment are shown in Figure 1.

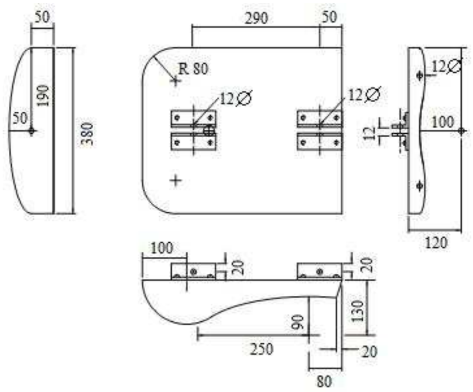

Figure 1. Loading apparatus

During the experiment, after each 5000 cyclic, the force was stopped and deflection amount was calculated with a standing comparator measuring at 0,01 the precision from back piston (Figure 2).

Figure 2. Experimental setup

3 Research results

The statistical values of deformation obtained from loads in experiment samples were shown in Table 2.

Table 2. Deformation values (mm)

Load (N)										
Back Piston		**445**			**556**			**667**		
Front Piston		**222**			**278**			**334**		
Upholstery types		**Cyclic**								
		5000	**15000**	**25000**	**30000**	**40000**	**50000**	**55000**	**65000**	**75000**
AUW	X_{ort} (mm)	5,30	5,80	7,00	7,50	8,80	10,20	11,00	12,20	13,40
	S	0,05	0,04	0,02	0,01	0,06	0,01	0,07	0,04	0,08
	V (%)	0,94	0,69	0,29	0,13	0,68	0,10	0,64	0,33	0,60
AUSS	X_{ort} (mm)	5,39	5,74	6,35	7,87	8,21	8,40	8,44	8,53	8,64
	S	0,04	0,01	0,02	0,15	0,04	0,06	0,04	0,03	0,04
	V (%)	0,67	0,17	0,24	1,94	0,43	0,66	0,49	0,29	0,42
AUZS	X_{ort} (mm)	5,31	7,85	7,96	10,49	10,96	11,15	11,21	11,33	11,40
	S	0,06	0,07	0,08	0,55	0,12	0,13	0,12	0,11	0,11
	V (%)	1,14	0,83	1,01	5,21	1,05	1,19	1,03	0,95	0,97
WLFUW	X_{ort} (mm)	5,09	7,40	7,51	7,66	7,93	8,61	9,27	10,06	10,27
	S	0,04	0,04	0,05	0,02	0,03	0,05	0,07	0,04	0,08
	V (%)	0,79	0,47	0,61	0,23	0,33	0,52	0,76	0,40	0,81
WLFUZS	X_{ort} (mm)	6,99	8,54	9,55	9,63	9,76	9,91	9,98	10,22	10,50
	S	0,09	0,04	0,65	0,05	0,04	0,01	0,01	0,03	0,05
	V (%)	1,22	0,47	0,68	0,51	0,43	0,10	0,10	0,29	0,43
WFUW	X_{ort} (mm)	1,42	2,70	3,10	4,66	5,50	6,17	6,43	6,77	7,07
	S	0,02	0,02	0,03	0,02	0,03	0,03	0,04	0,02	0,04
	V (%)	1,08	0,74	0,81	0,45	0,55	0,43	0,55	0,23	0,50
WFUZS	X_{ort} (mm)	2,96	3,10	3,22	3,34	3,88	4,59	5,07	5,96	6,91
	S	0,03	0,06	0,07	0,07	0,03	0,08	0,04	0,14	0,06
	V (%)	1,08	1,93	2,11	1,96	0,89	1,75	0,75	2,35	0,87
CUSS	X_{ort} (mm)	1,19	2,10	2,51	2,71	3,61	4,08	4,17	4,71	5,10
	S	0,01	0,06	0,05	0,02	0,06	0,03	0,03	0,06	0,06
	V (%)	0,97	2,61	1,82	0,85	1,67	0,62	0,60	1,18	1,08

As a result of the experiments, the lowest deformation value is obtained from crushed upholstery spiral spring (CUSS) (5,10 mm) and gradually followed by walled foam upholstery on zigzag spring (WFUZS) (6,91 mm), walled foam upholstery on webbing (WFUW) (7,07 mm), applet upholstery with spiral spring (AUSS) (8,64 mm), wall-less foamed upholstery on webbing (WLFUW) (10,27 mm), wall-less foamed upholstery on zigzag spiral (WLFUZS) (10,50 mm), applet upholstery with zigzag spring (AUZS) (11,40 mm) and applet upholstery on webbing (AUW) (13,40 mm).

4 Conclusions

According to these results, the best performance was obtained from crushed upholstery on spiral spring (CUSS). Owing to the fact that this upholstery technique is more costly and difficult than the others, it may be said it isn't economical in respect of the sector. The closest result to this upholstery type was obtained from walled foam upholstery on zigzag spring (WFUZS). Since its production is easier, its labor and cost is less, zigzag spiral walled rubber upholstery may be suggested to prefer instead of heliozoan spiral pique upholstery.

When examined upholstered furniture sector, it has been seen that the most common applied upholstery type is walled rubber on webbing. This upholstery type is the third in respect of force-deformation coefficient. It is possible to prefer because its production is easier and it is economical than spiral pique upholstery and zigzag spiral walled upholstery types.

If it is considered that a person sits a chair average 10 times a day, 75000 cyclic equals to approximately 20,5 years. When we consider this duration, all types of upholstery has good performance.

4.1 Observational evaluation

At the end of the experiment, in all types of upholstery, some damages like tears, cracking, breaking and bending were observed. However, cambers appeared in filling materials of zigzag spiral applet upholstery and applet upholstery on webbing.

As a result, it is possible to say that chair seating elements made of modern upholstery equipment have a higher performance than seating chairs made of classical upholstery equipment.

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