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An impact of foam mattresses design on their elasticity and comfort

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Abstract: An impact of foam mattresses design on their elasticity and comfort. The main aim of this work was to determine the impact of two mattresses design on their elasticity and comfort during their short use. Studies have been carried out with a use of sensor mat Force Sensitive Applications, reading of contact pressures, with participation of 43 volunteers. Each person filled a questionnaire in order to define feelings of comfort. Based on conducted laboratory tests and survey it was stated that design profile has a clear impact on the change in value of contact pressures.

Keywords: foam mattress, contact pressures, comfort

INTRODUCTION

Foam mattresses can have a single-layer form or appropriately combined materials that create an upholstery layer. Vitality of mattresses depends above all on the quality of materials used for their production. From hygienic reasons it is recommended to replace the mattresses every 5 years. Foam mattresses have great popularity. Advanced technology of their production, such as thermo-mechanical modification of the polyurethane foam structures, causes that they aren't as prone to deformation and ensure hygienic use. Producers offer a large range of polyurethane foams, diversified in terms of their density and elasticity. Density of foam used in the upholstery layers of mattresses is in the range of 14.5 kg/m^3 up to 65.0 kg/m^3, elasticity from 1.0 kPa to about 7.0 kPa, deformation lasted from 4% up to 20%, in turn resilience from 37% up to 80% (Matwiej 2011). Carried out so far study research regard elasticity of mattresses with a kind of polyurethane foam of upholsterer's layer using sensor mat (Smardzewski et al. 2008, Matwiej and Senski 2006). There were no attempts to compare experimental results with questionnaire surveys.

An aim of this work was to determine the impact of selected mattresses design on their elasticity and comfort during short use, based on experimental research involving volunteers, using sensor mats and questionnaire survey.

MATERIALS

Two one-piece mattresses were the subject of research with different design, made from the polyurethane foam obtained in *Repolyol* process, about unchanging density and elasticity. Innovative technology of *Repolyol* was implemented by Dendro Poland Company in 2013; it was never earlier applied in the mass production. It relies on processing waste of foam arising in the production process of mattresses, back into *Polyol* and reusing it in the production process of foam. Technological production process of *Repolyol* lasts from 8 up to 10 hours during which, with appropriate acidities and temperature up to 230^{o}C, the polyurethane foam walls are dissolved. This process leads to formation of *Polyol*, and then the foam with identical parameters to polyether, standard raw material used for production of elastic polyurethane foams.

Design of analyzed mattresses differed only in profile cut forms and their thickness. Mattress A (Figure 1) had a single-layer, non-glued, zone-less and double-sided design. Thickness of 115 mm, width of 800 mm and length of 2000 mm. Mattress A had so-called profile of "*chocolate cube*". Mattress B (Figure 2) was also single-layer, non-glued, zone-less and double-sided with a thickness of 90 mm, width of 800 mm and length of 2000 mm. This

mattress had a profile of so-called *eggs*, formed by appropriate profiling machine. Inserts A and B were made of polyurethane foam in *Repolyol* technology with mechanical and physical properties described in Table 1. In both mattresses identical not-quilted covers were used, based on Bratholmen LG fabric containing 73% of cotton and 27% of polyester.

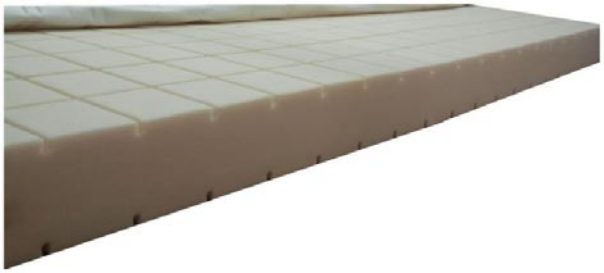

Figure 1. Structure of insert A

Figure 2. Structure of insert B

Table 1. Physical and mechanical properties of polyurethane foams 'Repolyol'

No.	Properties	Norm	Result	Margin
1.	Density	PN-EN ISO 845	27.98 [kg/m^3]	Min: 26.60 Max: 32.20
2.	Elasticity	PN-EN ISO 8307	41 [%]	Min: 40.00
3.	Permanent deformation after compression	PN-EN ISO 1856	3.64 [%]	Max: 6.00
4.	Hardness	PN-EN ISO 2439 Method B (40%)	148.06 [N]	Min: 120.00 Max: 180.00

Test stand was equipped with the bed frame of hard surface, computer with Force Sensitive Applications software (FSA), sensor mat FSA, measure to determine the height of volunteer, weight and two mattresses A and B (Figure 3).

Sensor mat was a tool for measurements of pressures with dimensions of 1920 x 762 mm, along with sensors system 32x32 and Force Sensitive Applications software. Each volunteer lied down on the sensor mat lying directly on tested product. Results presented the map of pressures appearing on contact surface of user's body with mattress. Image analysis enabled selection of the best product and to assess elasticity of designed mattress at the stage of preliminary design.

Figure 3. Test stand

In the study 43 persons participated with different anthropometric measures. The first task of each user was weighing and measuring, and next to lied down on the measuring bed. Recording test image from the mat on the first mattress lasted about 90 seconds. After that the volunteer again lied down on the mattress without the mat and without time limit. The mat hampered to carry out subsequent tasks included in the questionnaire form. Similarly was in case of the second mattress with the same user. Total time of the test per volunteer was 10 minutes.

The questionnaire form included issues and questions, such as:

— Sex, height, weight
— How do you assess the softness of mattress?
— How do you assess the comfort of used mattress?
— With a need to buy a mattress on which would you decide?

RESULTS

Laboratory tests enable to observe a diversified load distribution and different values of pressures for persons with different sex, height and weight. Research results are the maps of pressures distribution on usable area of mattress. Presented in Figure 4 and 5 maps of pressures distribution respectively apply to mattress with a profile of “chocolate cube” and profile of “egg”. In both cases, a volunteer was the same woman with height of 176 cm and weight of 53 kg, which constituted the user most similar to the average of surveyed women. From the analysis of selected test case it results that the value of maximum pressure was greater in case of mattress A, which was 7.07 kPa. In case of mattress B it was 4.73 kPa. Comparison of different, average, statistical male volunteer with height of 185 cm and weight of 86 kg was presented on Figure 6 for mattress A and Figure 7 for mattress B. Analysis shows that maximum pressure with a man lying on mattress A was 13.33 kPa and this result is greater than in case of mattress B, where it was 9.91 kPa.

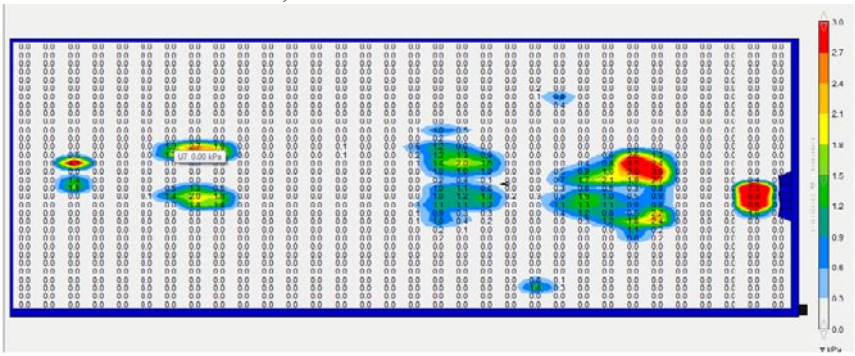

Figure 4. Map of pressures formed on mattress A, used by chosen woman

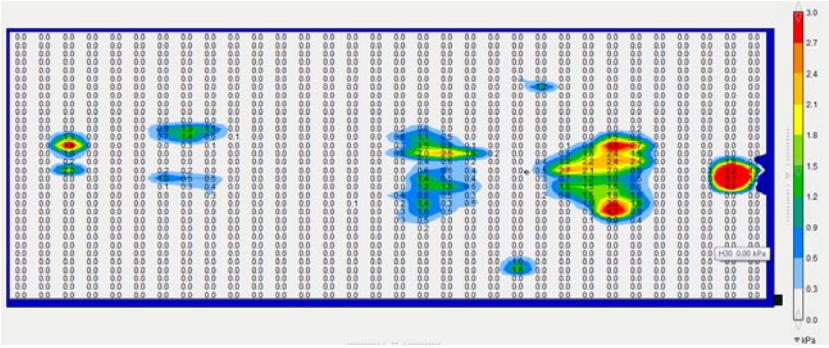

Figure 5. Map of pressures formed on mattress B, used by chosen woman

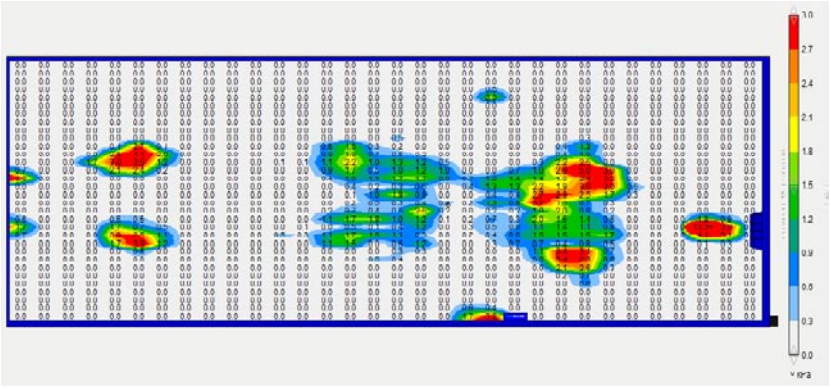

Figure 6. Map of pressures formed on mattress A, used by chosen man

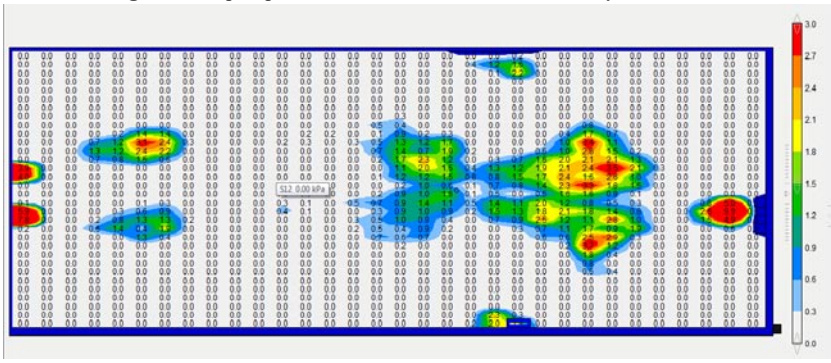

Figure 7. Map of pressures formed on mattress B, used by chosen man

Survey methodology was conducted amongst 43 persons. Men comprised majority and represented 77% of surveyed (Figure 8). Assessing the softness of mattress A, 37% of respondents determined it as hard, 52% as half-soft, and 11% as soft. For comparison, mattress B was determined by 19% of respondents as hard, by 53% as half-soft and 28% as soft. Next replies concerning the comfort of mattresses were presented on Figure 9 and 10. A decisive question about purchase of the mattress confirmed laboratory tests in which 53% of

respondents chose the mattress B as more comfortable (Figure 11). A price of the product didn't affect the choice of mattress.

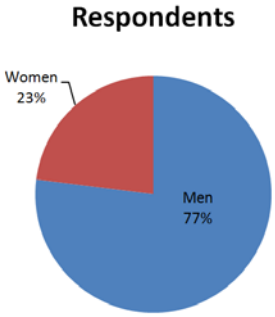

Figure 8. Percentage of Women and Men participation in the study

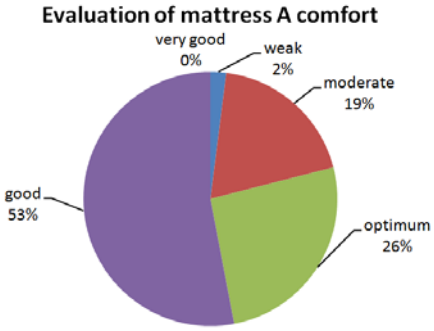

Figure 9. Evaluation of mattress A comfort while short use but by all users

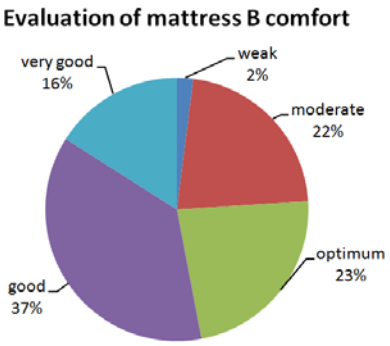

Figure 10. Evaluation of mattress B comfort while short use by all users

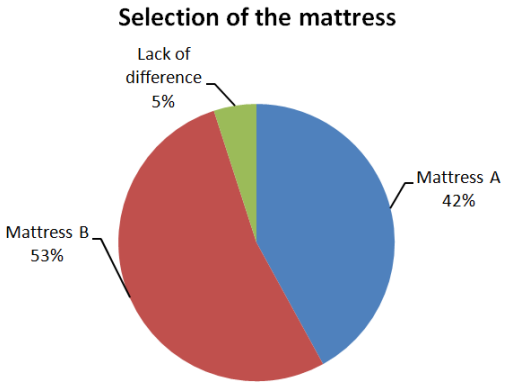

Figure 11. Respondent replies concerning purchase of mattresses

CONCLUSIONS

There is a clear impact of the polyurethane foam shape on the elasticity of mattresses. Profile cuts in the shape of chocolate cube showed a greater elasticity. The value of comfort rate was greater in case of profile cuts in mattress B, which is consistent with survey results and volunteers feelings. Compliance from the image readings of contact pressures and volunteers indications, based on questionnaire forms was 53% with 5% who didn't feel the difference between mattresses.

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Streszczenie: *Wpływ konstrukcji materacy piankowych na ich sztywność i komfort użytkowania.* Głównym celem pracy było określenie wpływu konstrukcji dwóch materacy na ich sztywność i komfort podczas krótkiego użytkowania. Badania przeprowadzono przy użyciu maty sensorowej FSA z odczytem naprężeń kontaktu. Pomiary z udziałem 43 wolontariuszy, którzy wypełniali ankiety w celu określenia odczuć komfortu. Analiza badań przeprowadzonych przy użyciu maty sensorycznej pozwoliła określić wpływ konstrukcji na komfort użytkowników, ustalić rekomendowany materac i porównać go z wyborem wskazanym w ankiecie przez użytkownika podczas krótkiego ich użytkowania. Na podstawie przeprowadzonych badań laboratoryjnych i ankietowych stwierdzono, iż zgodność wyboru wystąpiła u 53% ankietowanych. Jednocześnie potwierdzono, iż profil konstrukcji ma wyraźny wpływ na zmianę wartości naprężeń kontaktowych.

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