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THE INFLUENCE OF ADHESIVE JOINT CHARACTERISTICS OF THE BONDED SAMPLES OF PUR-FOAM

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Abstract

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Upholstered chairs and upholstered furniture in general, is largely produced primarily using PUR-foams, and it largely in the form of gluing several types of foam and himself on a firm surface - usually plywood or the agglomerated material – for the qualitative increase of upholstered furniture (including seating). Work deals with properties of the bond in connection with the influence on the final properties of the finished product, or even a change of functional properties in use over time. This work deals with: The influence of the characteristics of the adhesive used on samples bonded polyurethane foams. This work deals with properties of the bond in connection with an influence on the final properties of the finished product, or changes in functional properties when used at the time. The work is focused on: Effect of glue applied to the characteristics of the bonded samples of PUR foam. To determine the effects observed were used as the basis for the methodology based on the standard EN 1957, which was further modified as necessary. The results of the tests and conclusions can be stated that the incidence of bonded joints, ultimately, has a negligible effect on the resulting observed characteristics and therefore can cut and paste samples of smaller sizes into larger blocks without a fundamental change of the original features.

bonded foam, PUR-foam

PUR-foam, as inputs are well known in the production of upholstered furniture in general, as well as resting furniture, quite a long time and has undergone many developments. So far, no one did not look deeper bond properties in connection with an influence on the final properties of the final, or change in use of performance over time.

The subject of the work was therefore to determine:

- The influence of adhesive used on the characteristics of the bonded samples of PUR-foam.

1 MATERIAL AND METHODS

1.1 Samples

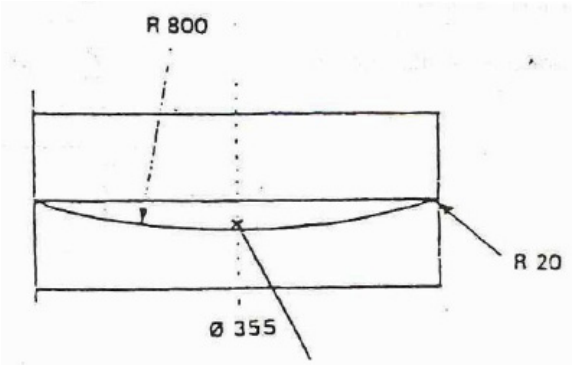
To explore the samples were used made of polyurethane foams from the same production batch and the samples were made by cutting a large block into smaller. Each sample and was then taped in two equal parts, which together form one test sample of desired size and in the middle of the bonded joints. Sample dimensions were 450 mm × 610 mm × 116 mm was used, solution-component adhesive based on chloroprene for combined injection.

1.2 Test Equipment

The test device was used in accordance with the requirements of EN 1957.

1.2.1 Press plate

Solid, round object with a diameter 355 mm, the compression surface is convex, spherical curvature radius of 800 mm outside radius of 20 mm side. Press plate must be smooth and must be mounted with the ball joint on the load tester system as possible to the thrust plate surface (EN 1957).



Dimensions in mm

1: *Press plate*

Figure 1 taken from EN 1957.

1.2.2 Equipment for obtaining the load / deflection curve

Equipment for obtaining the load / deflection curve consisted of a pusher plate and the test apparatus, developed under the direction perpendicular to the power of 1 000 N. The speed of loading and unloading was (90 ± 5) mm / minute. Load and height are measured in relation to a fixed point, which was the point at which the first change was the acting force. Accuracy of the measurement of standards meets the requirement of ± 0.5 mm – the calibration certificate verifying the device. Accuracy of measurement system strength meets the requirement standards ± 1% of the maximum load (1 000 N). The device is such that the horizontal forces do not affect the measurement (EN 1957).

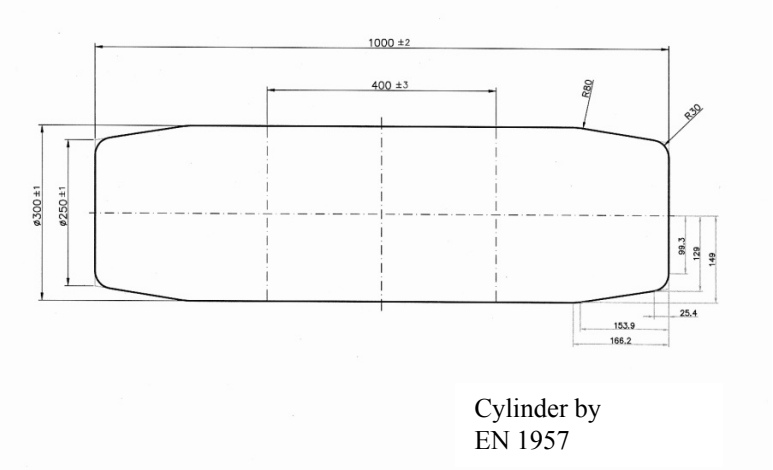
1.2.3 Equipment for measuring the durability

The device consists of a cylinder the size and shape, as shown in the figure (Figure 2) and the mechanism that pulls the cylinder horizontally back and forth across the surface of the test sample. The surface of the cylinder is hard, smooth without scratches and other surface damage. The overall system must develop a cylindrical power (1 400 ± 7) N, measured in a static state. The cylinder has a mass moment of inertia 0.5 kgm^2 ± 10%. The cylinder is free to rotate along its length and the lateral axis relative to horizontal. The cylinder is able to monitor the sample surface and freely after the move. The frequency is 17 cycles per minute.

1.3. Description of test methods

The test method is based on the standard EN 1957, but compared to the requirements of standard requirements have been modified and extended to better suit the characteristics under consideration.

Interval representation of 30 000 cycles was chosen simply. The first 30 000 cycles is considered in resting furniture for the state of his life. Twice the number of cycles, 60 000, was chosen because, in order to determine what the results would be achieved after twice this time and that would not have been any change from the required 30,000 cycles. If no change, or would be undetectable, it would have this situation can be explained by an amorphous samples after 30 000 cycles subject to change, and the fact that the double burden of time does not change the characteristics of the material is minimal and almost impossible. The second method takes into account the presumption of measurable changes in characteristics. However, it can come up with two options. Changing characteristics can be measured, but expected. It would show that its product has a lifetime, but even if this period to be doubled, it would still have the product kept the vast majority of its properties – which is the most frequent phenomenon. Another option would be that there would be a very substantial decrease in material characteristics in the tested samples, which could be due to an inappropriate type of material used and its properties. However, it was decided to accept the worst option for manufacturers and the most appropriate for the customer, it was decided in



Dimension in mm

2: *Cylinder*

that case – if it occurred – for the material considered unsuitable for a particular purpose.

A. Conditioning samples of 28 days

Upon acceptance of a sample seat is first necessary to have to condition the samples for at least 28 days in conditions (23 ± 2) °C/(50 ± 5) % relative humidity.

B. Durability test samples PUR foam blocks

It was first examined the behavior of samples produced only the very PUR foam. Immediately after the tests simple block polyurethane foams were tested further bonded polyurethane-foam blocks, each using a different adhesive.

All tests must be performed on the same test unit in the following order:

a) measuring height h_0 [mm]
b) corrective measure height and determine the actual amount h_0 [mm]
c) durability test: 100 cycles
d) measuring of hardness value after 100 cycles
e) measuring height h_{100} after 100 cycles and measuring of hardness value
f) conditioning
g) durability test: 29 900 cycles
h) measuring of hardness value after 30 000 cycles
i) measuring height $h_{30\,000}$ after 30 000 cycles [mm]
j) conditioning
k) durability test: 30 000 cycles
l) measuring of hardness value after 60 000 cycles
m) measuring height $h_{60\,000}$ after 60 000 cycles [mm].

C. Theory of data processing

After mechanical tests, there was a data processing.

a) the building a table of measured data
b) the calculation the change amount of the individual measurements
c) the calculation of surface under the curve (A)
d) the calculation guidelines
e) calculate the hardness values
f) calculated for the classification of hardness test unit
g) accommodate the calculated values in the summary table of samples
h) calculate the changes in their values and write the summary table of samples.

A detailed description of the principal points in the data processing:

c) the calculation of surface under the curve (A)

To calculate hardness values needed to calculate of the surface under the curve (A) with payloads from 0 to 450 N. During loading press plate should be recorded indentation depth and strength. Standard EN 1957 page 11 in the note to paragraph 7.3 states:

When obtaining data for the load / deflection curve must be recorded at least 250 points from 0 to 1 000 N between 0 and 450 N may be the distance between two successive points more than 2 N.

To ensure greater accuracy of the chosen method of double reading on the device. First it was on the device using the control software is set to the first change in compressive force plate to reset all the values (particularly the depth of indentation), and that this first change will be recorded next couple values. This equipment was paired value recorded in two ways. The first method was set to every 2 N were recorded in current values, regardless of where exactly (meaning in what part of the curve) measurement of progress. The second way to record the change was based on the indentation depth so that between consecutive measurements should be no difference distances greater than 0.04 mm. Between these two relationships was due to a logical OR relationship. In this way it was achieved that in the worst case would be obtained "only" 500 pair of values that would be unacceptable to the evaluation were also satisfactory. Thanks to our relationship or not obtained the number of paired values in the 1 077–1 635 only under the curve of the load in the 0 N and 450 N in individual measurements, so it was a requirement of at least 4.78 × more exactly.

Load curve of individual values can not express a clear formula equation of the curve. For this reason, it was necessary to accept a version of definite integrals, but only on the basis of gross mathematical calculation. Since it was acquired enough pair of values, it can proceed to calculate the area under the curve thanks to them. Since the difference of the indentation depth was set at 0.04 mm, it might be considered for our calculation is already small enough. On the basis of this difference was using the software MS Excel 2007 calculation prepared table. As input values were entered values obtained from measurements. These have been imported and adapted to be used for administrative units and decimal numbers. He was then analyzed using the formula, the calculation of the individual items was summed to each other. The whole calculation, however the sum of all areas of geometric shapes.

In this way, it was a specific procedure for each recorded curve of load compiled a table to calculate the actual area. The use of the above-mentioned MS EXCEL 2007, compiled a table of area calculation. After importing the data into columns, was first checked the continuity of values. It was then, an additional column which was estimated length of the interval on the X axis (meaning the difference of the x-axis and the readings were far from the beginning of the axial cross from the value closest to her, but closer to the beginning), which recorded the depth of indentation in mm. It was then inserted another column which was estimated length of the interval Y (as an analogy to the X-axis), where the recorded values of power. Subsequently, the column was inserted, which were calculated triangle area (to simplify the calculation) using the following formula: (length x length x interval Y)/2. As the last column was introduced for calculating the area

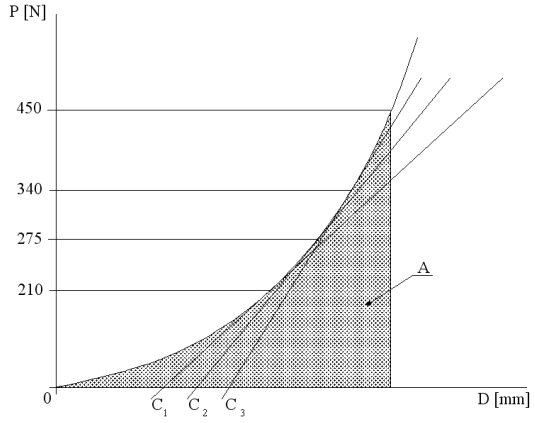
under the rectangle relationship. Finally, the column was inserted in which he adds the third and fourth column. For each of these totals, then gradually adding the other was the intervals of the resulting area under the load curve.

e) calculation the hardness values

The values thus obtained with the directives of MS Excel 2007 were calculated using the hardness value of the mathematical relationship borrowed from EN 1957 p. 12:

$$H_x = \frac{C_1 + C_2 + C_3}{3} \quad \text{[N/mm]},$$

where:
C_1 .. is the value of directive of the load curve 210 N after $_X$ cycles
C_2 .. is the value of directive of the load curve 275 N after $_X$ cycles
C_3 .. is the value of directive of the load curve 340 N after $_X$ cycles
H_X . the resulting hardness value after $_X$ cycles (this is an average load of the slope at a load 210 N, 275 N and 340 N (see Figure 3).



3: *Determination of hardness values*

Legend
P .... Force [N]
D ... indentation depth [mm]
A ... surface under the curve [mm^2]
1 load/deflection curve
C_1 .. is the value of directive of the load curve 210 N
C_2 .. is the value of directive of the load curve 275 N
C_3 .. is the value of directive of the load curve 340 N
Figure 3 taken from standard EN 1957.

f) calculation for the classification of hardness test unit

After calculating the hardness value was calculated for the classification of hardness test drive using the mathematical relationship:

$$H_{Sx} = 10(1 - \exp^{-(Ka+b)})^2 \quad \text{and} \quad K = \frac{A}{Hx},$$

where:
A ... surface under the curve under load from 0 N to 450 N [mm^2]
H_X . the resulting hardness value past $_X$ cycles
a .... is 5,92*0,0001 (constant)
b..... is 0,148 (constant)
H_{Sx} the value of the classification of hardness test units after $_X$ cycles.
The mathematical relationship taken from standard EN 1957 p. 12.

1.4. Samples

All samples were made from a single batch of PUR-foam (N 3038) and the samples were made by cutting a large block into smaller. The Samples A were glued on each of two equal parts, which together form one test sample of desired size and in the middle of the bonded layer.

Samples A

Dimensions: 450 mm × 610 mm × 116 mm;
Glue – Two component chloroprene adhesive, solution-based compound intended for injection, coating 74 g, namely approximately 250 g/m^2 both sides.

I: *Measured and calculated values of Samples A*

No. Action	The length of time evaluating	Functional properties					
		Height of the test unit [mm]	transformation of height [mm]	hardness value [N/mm]	transformation of hardness value	firmness rating	transformation of firmness rating
1	Before testing the durability	115.83	–	–	–	–	–
2	Initial measurements after 100 cycles	110.57	–5.27	9.46	–	3.67	–
3	Continuous measurements after 30 000 cycles	105.77	–4.80	6.86	–2.60	6.19	2.52
4	final measurement after 60 000 cycles	106.47	0.70	5.41	–1.45	7.45	1.25

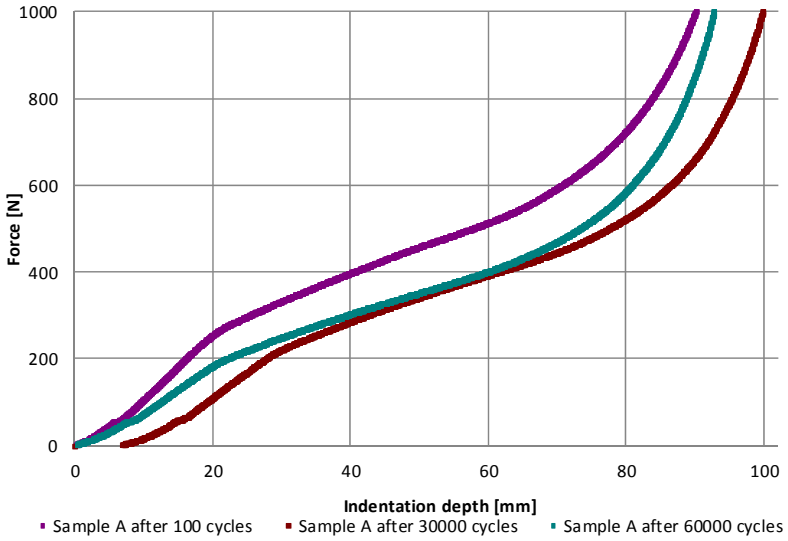
2 RESULTS

Summary view

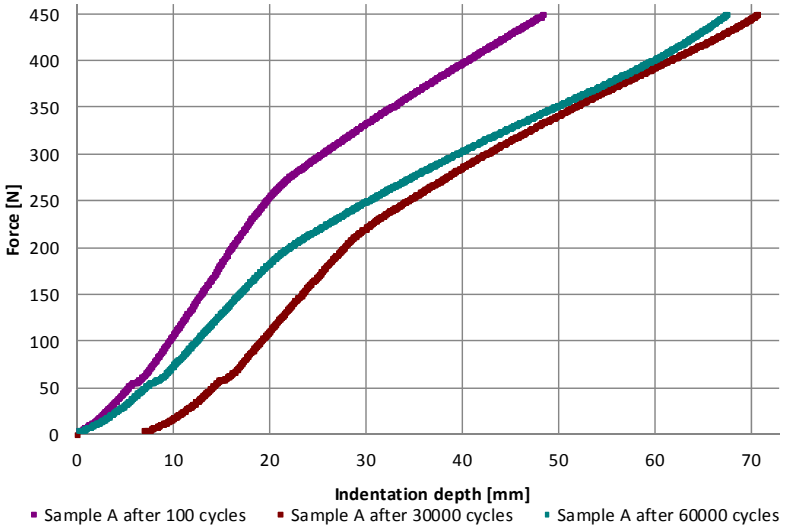
The images (Figure 4 and Figure 5) are shown samples of the load curve A. After the first 100 cycles occurred in the samples to settle the internal stresses within the material due to the maturation of the production, but the results could come, albeit in a limited extent, the result interaction with the surrounding material. Firstly, there are always the full load curve in the range of 0 N to 1000 N and then an equal representation of curves, but only to a load of 450 N. In this partial representation of the curve are noticeable differences.

3 DISCUSSION ON THE ABOVE RESULTS

The results obtained can be evaluated at two levels. The first plane was to determine changes in the properties block the occurrence of bonded joints, whether and how it can affect the effort to conserve materials, gluing blocks of polyurethane foam-shaped clusters of favorable characteristics. At this level, because the samples are treated with bonded joints compared with the reference block (samples without glued joints). The second plane was then peer review samples of the bonded joints in order to determine whether the adhesive used has a major (or measurable) effect on the bonded joint. Both planes can be really seen as an influence on the adhesive joint, or the influence of bonded joints, since other effects of virtually any way not to affect



4: *Display of load curves for a fixed number of cycles for Samples A*



5: *Display of load curves for a set number of cycles to calculate the surface when reaching 450 N for Samples A*

the results and can be neglected, or cancel out each other. This is followed by a graphical representation of the load curve of the samples and then set out more detailed representation of the curve (from 0 N to 450 N), which was needed for calculating the area under the curve. The individual images is possible to see the curve of the individual samples and illustrate the point more curves shown in the picture - this way, the most noticeable difference is measured. Self-image also shows the progress curve itself. This is to some extent influenced by the test equipment, or the shape of the pusher plate. Since the plate is pushed round the curve, it is clear that the force acting through the push plate in the first stage of compression is only active in the area of the plate. The entire area of the plates to the sample began to operate around the load of 400 N Therefore, in this area of the curve (0 N to 450 N) is obvious and sigmoid course, which, it is believing, just give them the shape of a pusher plate and a growing share of its operating area to test sample. During the trials it was possible to trace the dependence of the resulting hardness values of test samples on the shape of "S" curves, respectively, at AUC, calculated load values in the range of load (0 N to 450 N). For a given load range was demonstrated interdependence resulting hardness values of the "S" curve. The higher the resulting hardness value, the smaller the area "S" curve, which is in the range of more direct course. This also applies vice versa, so smaller is the resulting hardness value, the greater the area under the "S" curve, which is in the range of values steeper. The resulting interpretation of the results is highly dependent on the actual accuracy of that load curve constructed.

In this case, since the test samples of the same material except for equitable glued joints should not occur in any one element or another element to denoted decline in the value of force was needed to prevent and deal with this occurrence.

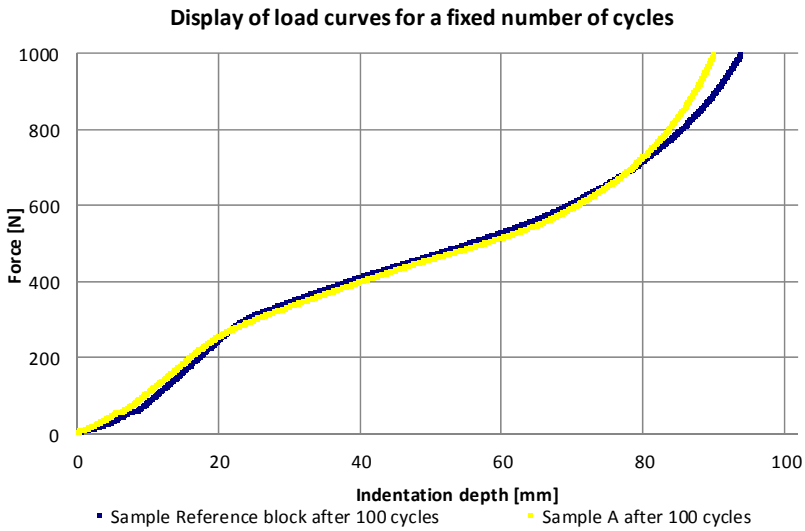
The values obtained surfaces were used to calculate the values of hardness classification (H_S) test samples according to the relationships.

For comparison, to see whether and to what extent the impact on test samples, the presence of bonded joints in the samples and to what degree, affect plays used glue, we use previous results (see Figure 6 to Figure 11 – compared to the reference block samples – samples without glued joints).

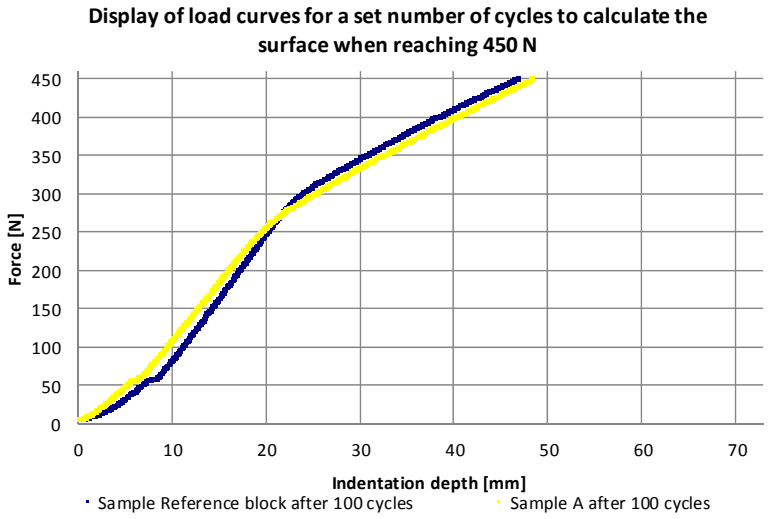
When compared with results of previous tests can be observed that the presence of bonded joints in the samples increases its resistance to compression, especially in the first stage of loading. With the number of load cycles is to reduce the difference in behavior of specimens with glued joints and without, and in some cases a certain number of cycles is almost the disappearance of this difference. Samples without glued joints in a certain field measurements behave similarly, as samples with glued joints. Influence attribute bond line gap because, as with different joints and adhesive properties of polyurethane-foam is there a different course load curves.

The representation of the images (Figure 6 and Figure 11) was shown to influence adhesive used on the characteristics of the bonded samples of PUR-foam, that after 60 000 cycles are much more similar to the sample load curves from samples tested after 100 cycles.

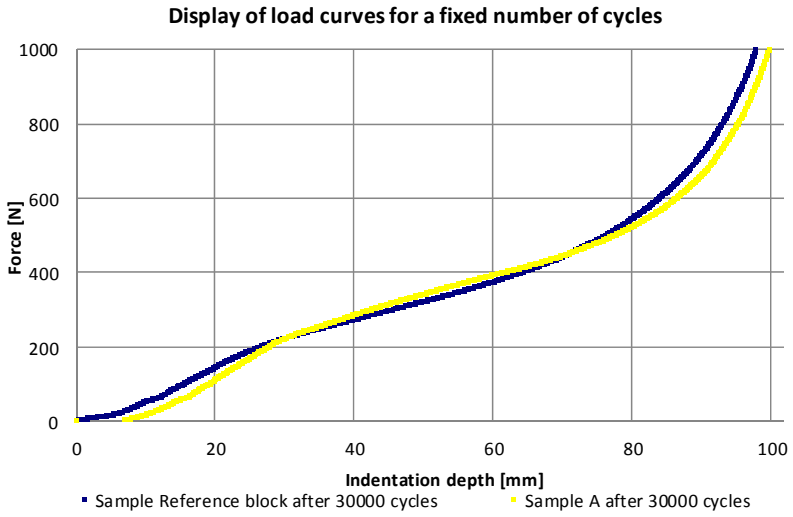
It can really only assume that the curve for samples after 60 000 cycles a course similar to the samples without glue joints. But it is generally possible to say that this particular type of polyurethane foams in the presence of bonded joints (any) effect of adhesive joints with an increasing number of load cycles decreases and approaches the material characteristics of the samples without glue joints.



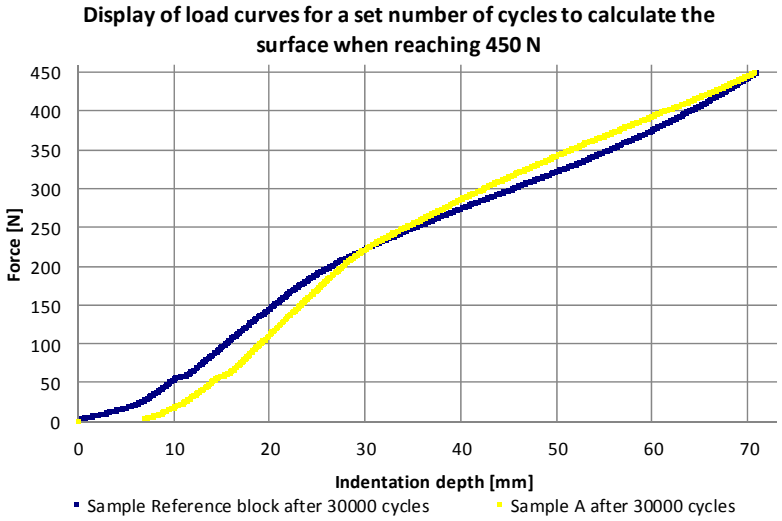
6: *The curves of samples of blocks after 100 cycles*



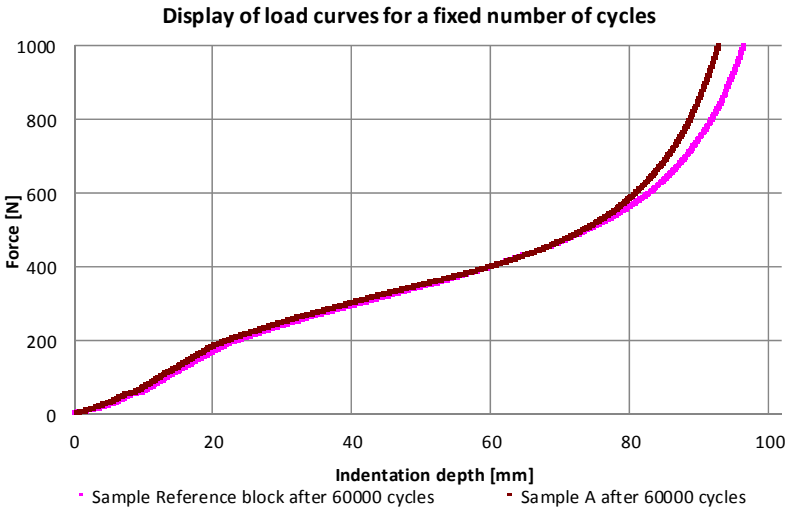
7: *Curves after 100 cycles, to calculate the surface in achieving 450 N*



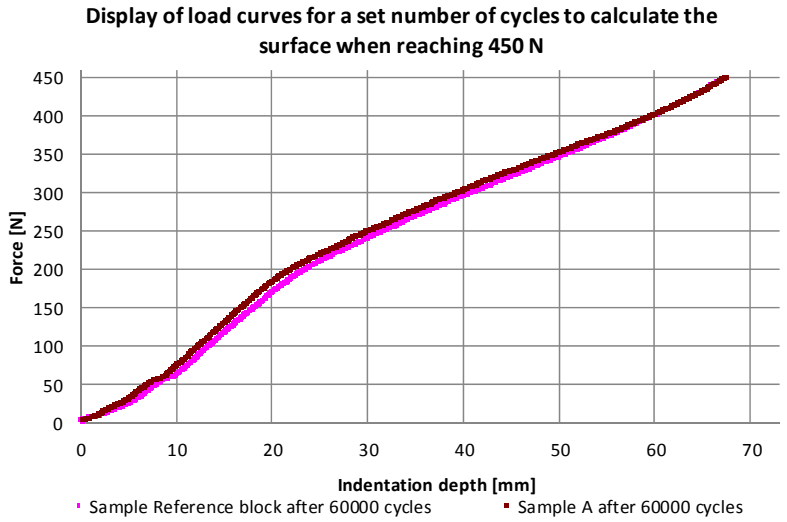
8: *Curves of samples blocks after 30 000 cycles*



9: *Curves after 30 000 cycles, to calculate the surface in achieving 450 N*



10: *Curves of samples blocks after 60 000 cycles*



11: *Curves after 60 000 cycles, to calculate the surface in achieving 450 N*

4 SUMMARY

In the end we tried to answer the aim, give recommendations for the future and also recommendations for future practice in:

- Effect of glue applied to the characteristics of the bonded samples of PUR foam with a focus on the upholstered seating furniture, *where the joint is the most stressed*.

Effect of glue applied to the characteristics of the bonded samples of PUR foam

From the measured, calculated and assessed values can be noted that the diversity of samples of blocks, which can be primarily divided into samples with glued joints and no glue joints can affect adhesive used to confirm and to some extent quantified. With regard to the impact load, it can be concluded that the change also affects the properties of the adhesive used; it is burdened by the bonding layer of adhesive used. You could say that the type of adhesive used and method of application also affects the final properties. When gluing the individual pieces together is a "composite" consisting of several types of materials that have different proportions. Each of these layers has its own characteristics, but the "hard" links do not constitute the sum of the individual parameters, but their mutual interactions occur with the modified materials, mostly improved properties. Assuming bonding different types of polyurethane foams, which is currently in production of upholstered furniture is common, may be

appropriate proportions of each types polyurethane foams and their numbers to obtain the required material properties, but it is necessary to take into account the number of bonded joints, and how their presence affect the resulting "composite ".
Change of H_S most characterizes the change of depth of indentation in the test unit change in its properties. Based on the results we can say that major changes in the test unit less stable and subject to faster wear.
The change in classification breakdown test unit values has an impact of several factors. Another important factor is the change in the properties of materials.
Has been shown the effect of glue to characteristics of the bonded samples of PUR-foam.

Recommendations for the future

- Expand the number of measurements on different types of glue to a larger number, which would verify the achieved measurement – and concerns itself no bonded bloc to broaden the basis for more specific types of PUR foams with those characteristics – will increase the variability of the experiment and the opportunity to further pursue a combination of different foam samples and adhesives
- determine the effect of loading on the durability of the change (increase) the ambient temperature to simulate the effects of human warmth to the finished product.

Using the influence of adhesive used for further practice

For these measurements show that the type and properties of the adhesives have a major influence on the change of properties of materials. It is therefore important to develop and introduce new practices into the adhesive with respect to ecology and the desired final properties and strictly observe the development and research in the field testing of new adhesives, including their interactions with various substrates. From an economic perspective is useful to apply the minimum amount of glue, but it is necessary to meet its minimum deposit to guarantee the strength characteristics, and therefore recommend to pay attention to the adhesive itself, as well as developing new ways of applying for both new species but also for existing. Unable to restrict development only on the adhesive, but also on their application, disposal, environmental impact and cost effectiveness.
Given the results can be concluded that the incidence of bonded joints in the block PUR foam has a negative impact on properties and can be recommended for the saving of raw materials to their bonding into larger units and more convenient shape.

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