



The correlation between natural and artificial ageing of upholstery leather

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Ageing is an irreversible change occurring in a product over a period time. A major problem for any manufacturer is that a guarantee period for the product must be taken into account although the precise conditions of use are unknown. Test methods are therefore required which simulate the conditions of use, and the changes which occur naturally over a number of years. However, it is possible that the test procedures used cause changes in the sample which do not occur in actual use, together with poor correlation between artificial and natural ageing⁽¹⁾. In practice, the ageing conditions used for upholstery leather provide examples of such occurrences⁽²⁾.

This means that test methods are required that correlate with normal usage and are sufficiently sensitive to determine the

micro changes on ageing. A likely method is the determination of bending-stiffness, as developed in LGR, and tested on artificially aged specimens^(3,4).

To determine if this test could provide information on the long term ageing character, leathers were exposed to artificial conditions and natural ageing within a room for 18 months. The samples were then assessed to check if the changes in bending-stiffness showed a correlation between the two types of exposure. Six different leathers were chosen for comparison as shown in *Figure 1*.

Test procedures

NATURAL AGEING

Samples were pinned to both sides of wooden frames of size 50x150 cm. One set of leathers was exposed to sunlight (south facing window), whereas the set on the other side faced inwards (i.e. without exposure to the sun), both sets being exposed to the conditions within the room. This enabled a direct comparison under room conditions concerning the effect of exposure to sunlight.

Using an on-line temperature measuring device⁽⁵⁾, the surface temperature on the leathers exposed to the sun, and the samples protected from this exposure were measured every 12 minutes. The temperature changes based on monthly averages over the whole of the 18 months were recorded, and are given in *Figure 2*.

Figure 1: Leather specification

Sample	Tannage	Technology
Leather 1	Chrome	Unfinished
Leather 2	Chrome	Semi-aniline finish
Leather 3	Chrome-free	Unfinished
Leather 4	Chrome-free	Pigmented finish
Leather 5	Chrome	Semi-aniline finish. Standard fatliquor.
Leather 6	Chrome	Semi-aniline finish. Modified fatliquor.

Figure 2: Temperature variations during the period of natural ageing

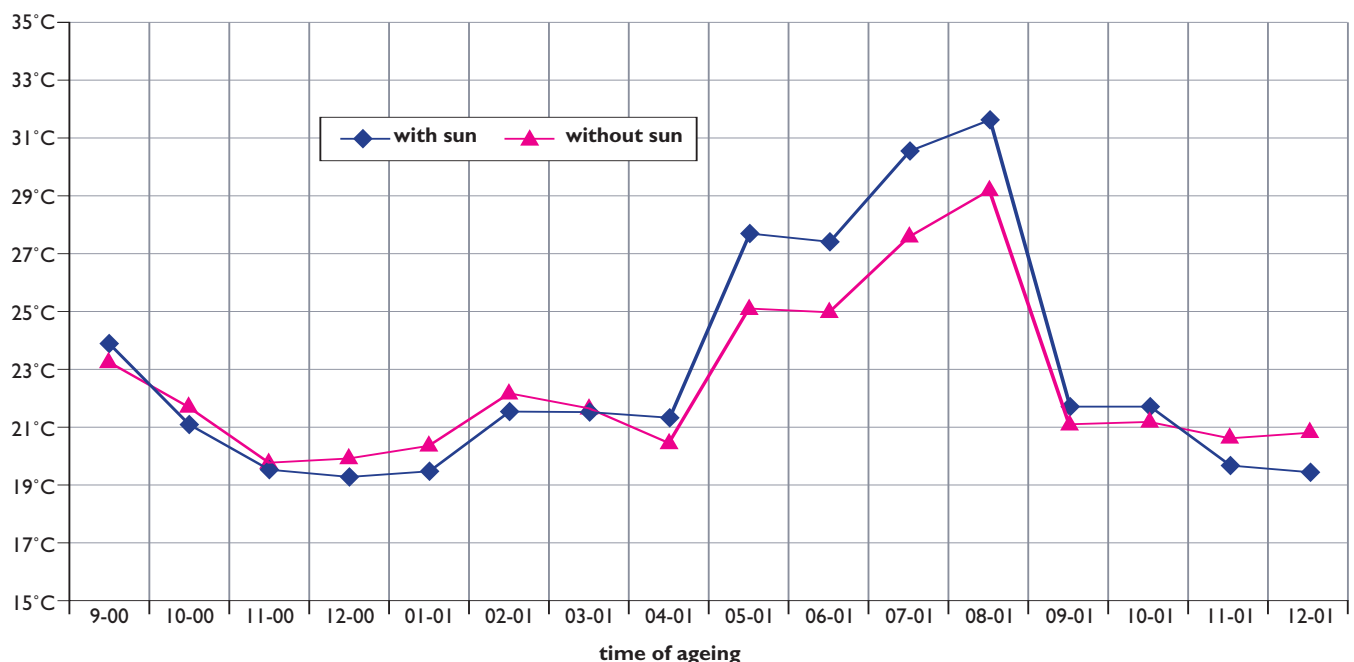




Figure 3: Changes in bending-stiffness, moisture and area caused by 18 months natural ageing

Sample	Tannage	% increase in bending stiffness		% reduction in moisture		% area loss	
Leather 1:	Chrome	42.5	9.2	4.6	2.6	5.0	2.1
Leather 2:	Chrome	13.4	-1.1	3.5	1.6	2.2	0
Leather 3:	Chrome-free	27.6	26.9	1.4	1.0	0	0
Leather 4:	Chrome-free	31.4	32.6	1.7	1.1	0	0
Leather 5:	Chrome	77.8	40.6	3.4	1.8	1.3	0.2
Leather 6:	Chrome	62.5	18.8	3.2	1.5	3.4	0.2

■ with sun ■ without sun

In addition, a test piece was taken every 2-3 months, reconditioned, and, in addition to bending-stiffness, the following properties determined: *tensile strength, tear strength, adhesion, flexometer, rub fastness, lightfastness (DIN EN ISO 105-B02), fat content.*

ARTIFICIAL AGEING

The artificial ageing consisted of a heat treatment at 80°C in an oven for up to 144 hours in steps of 24 hours. The leathers were reconditioned for at least 24 hours, then tested before the next 24-hour treatment. The tests used were those that had shown meaningful changes in the natural ageing and to establish the correlation between the two types of exposure.

Bending stiffness for natural ageing

Samples were bent using a calibrated force sensor. This enabled the bending force to be determined in mN. As the test was non-

destructive, this test could be repeated, followed by further exposure to periods of ageing.

From previous experience of leather ageing, the hardening and embrittlement indicated by changes in bending-stiffness are accompanied by loss of moisture and reduction in area. These changes are presented in *Figure 3*.

It can be seen from *Figure 3* that the chrome-tanned leathers exposed to sunlight show a greater increase in bending-stiffness than those not subjected to the influence of the sun. However, with reference to *Figure 2*, the surface temperature differential between the two sides of the frame is not large.

The differences therefore cannot be directly due to the warming effect of the sun, but must be due to the effects of light.

These differences between exposure to the sun and non-exposure are only significant on the chrome-tanned leathers. The chrome-free leathers show an increase in bending-stiffness, but the differences due to 'sun' effects under dry conditions are very small. Averaged over two to three month periods, these changes are shown in *Figure 4*.

However, comparison data for artificial ageing indicate that changes in bending-stiffness closely correlate with changes in temperature of the surroundings i.e. lower temperatures give lower rates of change with increases at higher temperatures (see *Figure 5*).

In addition, these changes associated with natural ageing may also relate to moisture content. As shown in *Figure 3*, despite reconditioning, the moisture content of the leather shows an irreversible moisture loss.

Figure 4: Changes in bending-stiffness due to natural ageing

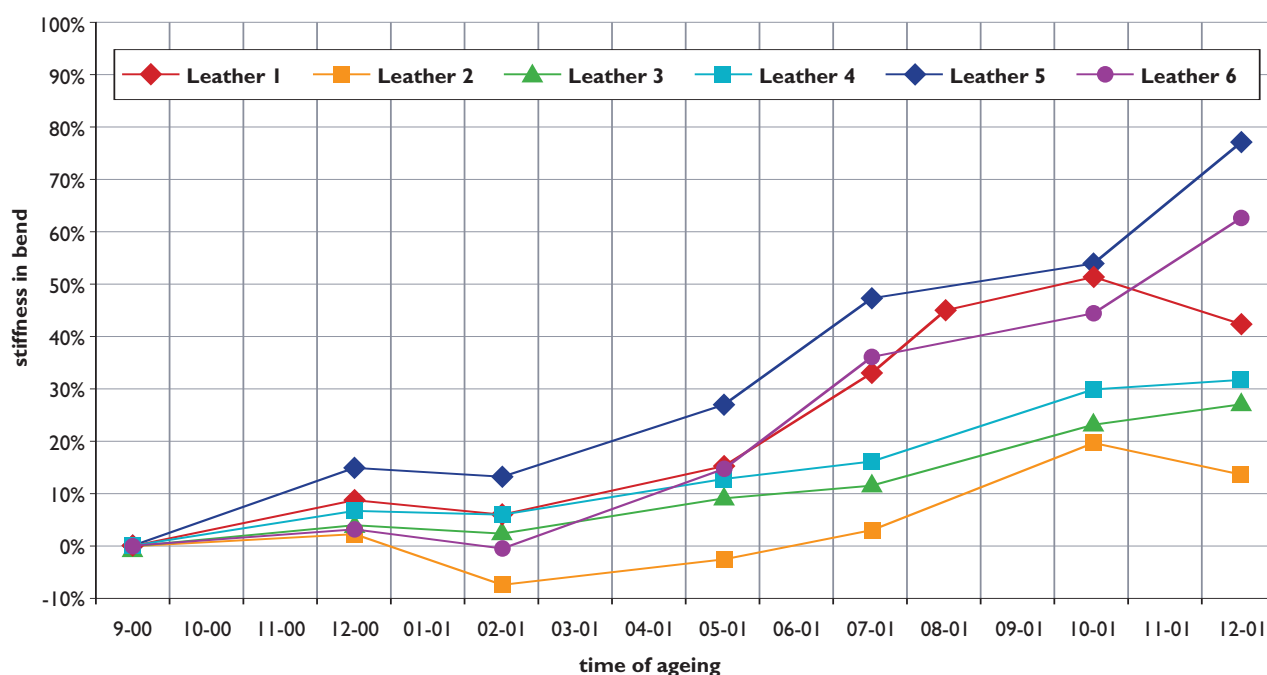
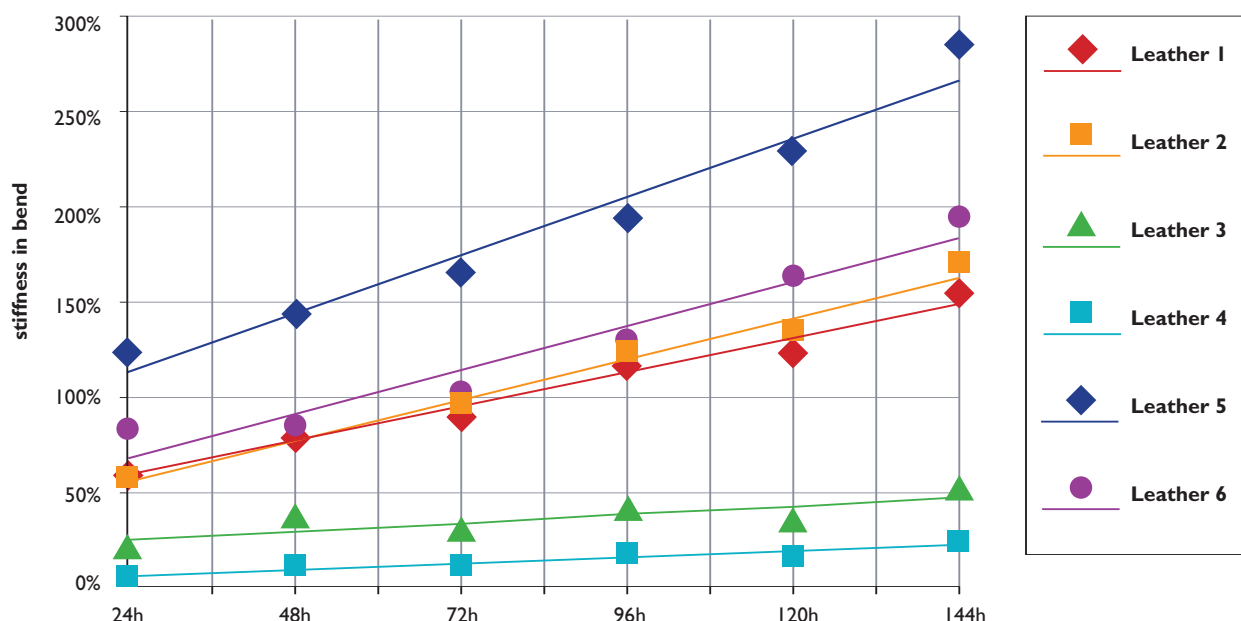




**Figure 5: Increase in bending-stiffness on artificial ageing at 80°C****CHANGES WITH INDIVIDUAL LEATHERS**

Samples 1 and 2 show an absolute difference of 30% at the end of the exposure period, despite a similar variation in temperature. This can be explained by the fact that sample 1 was unfinished leather, whereas the leather taken for sample 2 received the protection of a semi-aniline finish so that the effect of the sun was less.

The two chrome-free leathers (samples 3 and 4), were subject to the same temperature changes, but with these leathers the effect of the sun was negligible.

Leathers 5 and 6 indicate changes as a result of different fatliquor offers. The modified fatliquor provides better protection, being confirmed by the lower change in bending-stiffness.

Bending-stiffness on artificial ageing

The changes in bending stiffness due to artificial heat ageing at 80°C were found to be linear and are presented in *Figure 5*.

These findings allow direct comparison between leathers, but there is no mathematical link with natural ageing. It is possible, however, to recognise a correlation between artificial and natural ageing, although it should be recognised that the sun factor is not present in the artificial ageing test. This makes the differences between the leathers more marked.

CHANGES WITH INDIVIDUAL LEATHERS

For chrome leathers (samples 1 and 2), the final values due to the leathers being respectively non-finished and aniline assisted differ by 15%. The chrome-free leathers (samples 3 and 4) show only small differences in bending stiffness compared with the chrome-tanned leathers. The chrome-tanned leathers (samples 5 and 6) show the positive effect of fatliquor modification.

Comparison of bending-stiffness values between natural and artificial ageing

As the natural ageing did not behave in a linear manner it is not possible to provide a mathematical relationship between the two forms of ageing. However, by comparing the bending-stiffness in *Figures 6* and *7*, one can compare the time in natural ageing with the values achieved by artificial ageing.

The approximate correlation between artificial and natural ageing is presented in *Figure 8*. These findings indicate that applying the bending-stiffness test to artificially aged leathers can provide a measurement of natural ageing.

ADDITIONAL FINDINGS

Other test methods showed that measurable changes occurred in resistance to flexing, lightfastness and fat content, but there was no correlation with the artificial ageing.

Figure 6: % change in bending-stiffness on natural ageing

Ageing time	08 2000 - 12 2000	12 2000 - 01 2001	01 2001 - 05 2001	05 2001 - 07 2001	07 2001 - 10 2001	10 2001 - 12 2001
Leather 1	9.0	6.1	15.1	33.3	51.4	42.5
Leather 2	2.4	-7.6	-2.8	3.1	19.5	13.4
Leather 3	4.3	2.9	9.8	12.1	23.8	27.6
Leather 4	6.4	5.8	13.0	16.2	29.7	31.4
Leather 5	15.1	13.3	26.9	47.2	53.8	77.8
Leather 6	3.1	-0.3	14.7	36.0	44.5	62.5

**Figure 7: % change in bending-stiffness on artificial ageing**

Ageing time	4 hr	8 hr	24 hr	48 hr	72 hr	96 hr	120 hr	144 hr
Leather 1	17.0	34.5	56.7	83.6	90.6	117.0	124.0	155.0
Leather 2	14.5	27.8	56.8	81.1	96.5	123.3	134.8	170.5
Leather 3	7.5	17.5	20.0	37.5	30.0	40.0	35.0	52.5
Leather 4	0	0	5.2	10.3	10.3	17.2	15.5	24.1
Leather 5	35.7	54.8	123.8	145.2	166.7	195.2	231.0	285.7
Leather 6	22.5	42.5	82.5	85.0	102.5	130.0	165.0	195.0

Figure 8: Correlation between natural and artificial ageing

Sample	Natural ageing	Artificial ageing
Leather 1	approx. 10 month	4 hr
Leather 2	approx. 12 month	4 hr
Leather 3	approx. 8 month	4 hr
Leather 4	< 6 month	4 hr
	approx. 6 month	24 hr
Leather 5	approx. 11 month	4 hr
Leather 6	approx. 11 month	4 hr

Conclusions

The objective of this research was to establish if bending-stiffness measurement was sufficiently sensitive to be used to establish ageing over a period of time and, additionally, whether natural and artificial ageing correlated.

From the findings it can be stated that bending-stiffness is a most predictive method, and could be used in practical research on ageing. It was also evident that ageing occurred in small steps and additionally the flexometer, lightfastness results and fat content changed significantly.

An advantage of the bending-stiffness method was that the test was non-destructive and that measurements could be taken without altering the sample. This was particularly useful as changes were small, and because the moisture content and area

loss could be determined on the same sample.

By using this technique, it was possible to follow the effects of temperature variations on ageing. For example, in the colder times of the year, the leathers altered less than during warmer times.

Further changes in bending-stiffness related to the various tannages. Here the chrome-tanned leathers changed considerably more than the chrome-free leathers, and it was possible to establish benefits provided by stabilised fatliquor compared with the standard offer.

As the conditions of natural ageing were not constant - as in the artificial ageing - no time equivalents could be mathematically established between natural and artificial ageing. However, there are indications that 4 hours of artificial ageing at 80°C is approximately equal to < 5-12 months of natural ageing.

References

1. K. Thinius, *Stabilisierung und Alterung von Werkstoffen, Band II und III ff.* Akademie-Verlag Berlin, 1970
2. E. Doering, *Gebrauchs- und Alterungsverhalten von Automobilleder, Leder- und Haeutemarkt* 7 (2002), S. 30-31
3. H-J. Kellert, A. Hummel, H-P. Germann, *Das Alterungsverhalten von Leder, Leder- und Haeutemarkt* 3 (2000), S. 25-30
4. H-J. Kellert, A. Hummel, H-P. Germann, *The ageing behaviour of leather, World Leather, May 2000, page 48 - 53*
5. Ecomat 200 - DM (Data Monitor) 1100, ifm-electronic, Essen, More information, see <http://www.ifm-electronic.com/ifmnde/web/dsf/DM1100.htm>