ABOUT THE CUTTING RESISTANCE MEASUREMENT OF TEXTILES

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ABSTRACT
To estimate textiles, for example tarpaulin fabrics, which are applied against vandalism, beside the cut and stich resistance also other properties must be considered. Goal of this work is, to analyze which tests should be considered. Also is important to find out, if the test of cutting resistance is significant enough, to give information about the resistance against damaging of fabrics. So the protection will depend not only on the type of material, but as well on the density and the friction surface. As result of the analysis is found, that additionally to the cutting resistance as well the tearing strength and seam slippage should be tested.

Key Words: cutting resistance, protective textiles, textile testing, reproducibility

1. INTRODUCTION
The cutting resistance of textiles is a very important property - both from the technological and customer point of view. Textiles with higher cutting resistance cause several problems during the production of clothes, require special cutting equipment in the companies and do not allow the cutting of large number of layers. From the application point of view, there are several areas, especially the protective clothes, where a good cutting resistance has to be presented and is the main parameter for evaluation of the functionality of such products, like safety gloves, safety vests etc. Independent of that, if the cutting resistance is wished or not, for both situations it has to be measured and no optimisation of the properties of the textiles can be done without reliable testing methods.
This paper gives an overview about the available testing methods, which are related to the cutting resistance of textiles.
All important parameter and their variance during the testing will be evaluated. The cutting force for instance can be measured with some accuracy, which depends on the accuracy of the force measuring unit.
Additionally, the deviations of the hardness and the angle of the knife influence the cutting force. The variations in the unit, which fixes the sample, have as well influence on the cutting force. All these variances have to be considered.
2. STANDARD TESTING METHODS FOR CUTTING RESISTANCE

The standard DIN EN ISO 13997-1999 [1] defines the conditions for the performing cut resistance testing as following:
The cut resistance of a material is tested by a device, where a sharp blade is pulled over a material. The cut length is between 3mm and 50 mm by using different cut forces and the device must be able to cut a material with a constant force by measuring the cut distance.
It is mentioned, that currently only the device TDM-100 Tomodynamometer of the Company RGI Industrial Products [5] satisfies these conditions. The development of the device is reported in [3], [4] and some results about protective gloves are presented in [2].
The method uses some correction coefficients to take into account the abrasion of the knife. The result is mentioned by the force, which is needed to cut a distance of 20 mm of the sample.

Another method uses rotational knife [7] is named Couptest, according to EN 388. The measurement is based on a comparison of known test samples and those, which should be tested. A circular blade is put on the known test sample with a force of 5N, till the blade gets in contact with a conductive layer under it. The number of cycles will be counted. This standard is just used for testing gloves. Additionally to the cut resistance, also the abrasion, the tearing strength and the stitch resistance is measured.
Open is the question, how the two standards can be compared. The EN 388 gives an idea of a comparison of the results of the two standards, but it is not checked, if this assumption is right [9].

The European Union has special directive 89/686/EEC [6] on personal protective equipment (PPE). Point 3.3 of this directive defines "Protection against physical injury (abrasion, perforation, cuts, and bites) - under the foreseeable conditions of use."
As the review demonstrates, there are only two types of devices on the market, which can be used under industrial conditions. There are known as well several investigations about the cutting resistance, using same or similar methods with modified standard testing machines. Actually in the most sources the principle of the testing methods is described, but the data about the accuracy of the measurements is difficult to find.
Table 1 gives an overview about the testing methods of cut resistance, to show the different parameters, which makes it difficult to compare the results.
Table 1  Comparison Standards for Cut resistance

<table>
<thead>
<tr>
<th>Application</th>
<th>COUPTEST according to EN 388</th>
<th>TDM, according to EN ISO 13997</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of knife</td>
<td>Just for gloves</td>
<td>Protective clothing</td>
</tr>
<tr>
<td>Size of knife</td>
<td>45 +/- 5mm</td>
<td>65 x 18 mm</td>
</tr>
<tr>
<td>Thickness of knife</td>
<td>3 +/- 0.3 mm</td>
<td>1.0 +/- 0.5 mm</td>
</tr>
<tr>
<td>Measured distance</td>
<td>50 mm</td>
<td>From 3 – 50 mm / measurement reading at 20 mm</td>
</tr>
<tr>
<td>Measurement speed</td>
<td>Max 10cm / s</td>
<td>2.5 +/- 0.5 mm/s</td>
</tr>
<tr>
<td>Force on knife</td>
<td>COUPTEST according to EN 388</td>
<td>TDM, according to EN ISO 13997</td>
</tr>
<tr>
<td></td>
<td>5 +/- 0.05 N</td>
<td>Between 1.0 and 200 N (+/- 5%)</td>
</tr>
<tr>
<td>Cut angle</td>
<td>32.5 +/- 2.5°</td>
<td>90 +/- 2°</td>
</tr>
<tr>
<td>Length of sample</td>
<td>100 +/-10mm</td>
<td>25 mm</td>
</tr>
<tr>
<td>Width of sample</td>
<td>60 +/- 6mm</td>
<td>100 mm</td>
</tr>
</tbody>
</table>

Table 2  Comparative value according to EN 388 [9]

<table>
<thead>
<tr>
<th>Cut resistance value EN 388</th>
<th>Cut resistance EN ISO 13997</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>≥ 13 N</td>
</tr>
<tr>
<td>5</td>
<td>≥ 22 N</td>
</tr>
</tbody>
</table>

Both standards are mentioned for protective clothing, respectively for protective gloves. In practice, there are a lot of other applications, where the knowledge of the cut resistance and accordingly other parameters is really important. To estimate the protection of tarpaulin fabrics against cut, most times it is tested according to the standard for protective clothing. But the additional tests, which can give overall information about the resistance against vandalism, for example the tearing strength or the seam slippage is missing in the evaluation of this.

3. CUTTING INSTRUMENTS AND GEOMETRIES IN THE PRAXIS

Another problem, which causes the test, according to the standard is the different character type of blades and knives. In reality, the causer of vandalism does not use standard conditions for cutting. The force, which is necessary to damage a tarpaulin fabric, depends on the kind of tool, which is used.
Figure 1. Common devices for cut resistance

Not just the kind of cut is different, also the distance between the cutting surfaces vary and in practice, the textile often is just pressed between the knifes, if it is not cut. In this case, a force is measured, but the fabric isn’t cut.

Figure 2. Common devices where not only the cut resistance is important

To damage a fabric, the cut resistance is important, but in case of seam slippage, the structure can be opened, without damaging the surface by stich or cut. By using an ice pick, there will be normally just pure seem slippage - the structure will be opened without damage the surface by cut. The not good enough resistance again seam slippage can lead as well to easy destroying of the fabric before cutting – because first the warp and weft yarns can be shifted and then the resistance against cutting will be lower.

Also a problem to get reproducible tests, which are related to real life, is the geometry of the cutting zone.
Figure 3. The geometry of the knives according to the tests—goal is the repeatability of the results.

Figure 3 gives a scheme, how the fabric is tested in the two standards. But in reality it can be really different, like Figure 4 shows. Using scissors the fabric is fixed between two knives which could make the cutting process easier. The question is, if there is a correlation between the cutting resistance according the Figure 4a and the measured one according to one of the standards. Using scissors make some additional damage on the material—often, if the material cannot be cut, it slides between the knives (Figure 4b) which already bends it and damages of the pressure and friction are occurring. After such damages, the cutting could become as well easier. Using metal wire for instance is in such geometry already problematic because after several bending steps it can become broken. To avoid it the brake, wires with lower bending rigidity should be used—such as "multifilament" wire ropes which can keep multiple bending cycles without break.

Figure 4. The geometry of cutting differs—depending on the application.

To evaluate such fabrics, which are designed for protection against vandalism and robbery, and as well to develop better structures, the following set of properties should be evaluated:
- cutting resistance, remains the most important
- cutting resistance against micro-jagged-profiles
- tear resistance
- seam slippage
- thickness
- bending rigid, or number of bending cycles before breaking.
This set of properties would allow one complete evaluation of the suitability of certain material for outdoor application, where the safety of the textile is important for its owner.

4. CONCLUSIONS
The analysis of the cut resistance tests demonstrate, that both standard devices are developed for testing purposes – to test and compare samples. The estimated resistance gives information about the pure cutting, but different then in real conditions in practice and in the case of protection of tarpaulin fabrics against cut. In real conditions the cut is not only done from the pressure and the surface, but as well from the small jags by sawing, not cutting. Often the structure is separated in the similar way like seam slippage. To give an overall result of protection against vandalism, other test results must be taken into account.

5. REFERENCES