SUITABILITY OF STANDARD FABRIC CHARACTERISATION EXPERIMENTS FOR THE USE IN VIRTUAL SIMULATIONS

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ABSTRACT

Today input parameters for the main mechanical fabric properties for virtual garment simulations can be obtained from objective fabric characterization methods. In this research the suitability of those characterization experiments for the derivation of precise fabric parameters for virtual computations is studied. Therefore, six different textiles, out of different fibre materials and structures have been measured with the two main standard measurement systems, FAST and KES-F. Both methods have been studied, compared and the main fabric input parameters for virtual simulations derived.
Depending on the complexity of the computation system, the mechanical properties, which are mainly responsible for the fabric behaviour, are modelled either linear or non-linear. KES-F measurements provide complete strain-stress profiles and therefore allow the assessment of the nonlinearity of fabric parameters. The FAST method uses simpler procedures and permits only the linear interpretation of the measured data. Both systems provide satisfactory information for the evaluation of linear bending characteristics. Non-linear tensile and shear parameters can be derived from the KES-F stress-strain curves. Both measurement methods do not reflect what actually happens during the wear of clothes, where multiple high and low forces act on the garment.

1 INTRODUCTION

Although to this day computation technologies for textiles and garments exist, those new tools are practically not used in the apparel industry. At a closer glance however it becomes clear that further research is still necessary. In order to bring important garment manufacturing processes to a higher technological level, the clothing and textile industry calls for virtual simulations, which do not only satisfy the human eye with a realistic representation of a garment, but also mimic precisely mechanical and physical characteristics of textiles. Only precisely simulated fabric characteristics enable people to truly judge a garment upon its virtual counterpart.
The accuracy of virtual garment simulations is on the one hand dependant on precise computational models and on the other hand on exact input parameters for a correct description of the fabric behaviour. Until today, computation algorithms have evolved to such a level that we are able to not only simulate simplified, static clothes, but also complex dynamically moving garments, in the time frame, expected by the clothing industry [1], [2], [3], [4], [5]. This evolution of the simulation systems brought along with it new challenges for the determination of fabric input parameters. Now, existing characterisation methods, which have not been designed for the purpose of deriving parameters for virtual simulations, need to be rethought as well.

2 FABRIC CHARACTERISATION EXPERIMENTS

Objective fabric characterization methods measure and relate the major mechanical properties, in order to obtain comparable information about textiles. The applied physical tests analyse and reflect the sensations felt during the subjective fabric assessment, where the textile is touched, squeezed, rubbed or otherwise handled and describe them with a numerical value [6]. Important physical and mechanical properties are flexibility, compressibility, elasticity, resilience, density, surface contour (roughness, smoothness), surface friction and thermal attributes. These characteristics are the result of a broad fundamental research on fabric properties [7] [8] [9] [10].
In the 1970’s Kawabata first standardized the objective handle assessment of textiles by introducing the “Kawabata Evaluation System for fabrics” (KES-f). Since, this method is widely used for the objective characterisation of fabrics, as well as for studies of fabric mechanical properties [9]. In the late 1980´s the CSIRO Association in Australia realised the importance of a commercial measurement for wool fabrics and tried to offer a simpler and cheaper alternative to KES-f, the “Fabric Assurance by Simple Testing” (FAST) method [10]. Both, KES-f and FAST measure the same parameters; however different measurement principles are applied. The FAST method uses simpler procedures than KES-f and permits only a linear interpretation of the measured data, whereas KES-f provides a complete stress-strain profile for all measured characteristics. The measurements of both systems are conducted in the low force area, what corresponds to loads which a fabric is likely to undergo during garment manufacturing.

3 MEASURED PROPERTIES AND THEIR VIRTUAL COMPUTATION

For virtual garment simulations not the calculated standard fabric hand value, but the actual measured empirical data is of interest, as therefrom important input parameters can be derived. For this study six different textiles, composed of different fibre materials and structures, have been measured with the KES-f and the FAST method. The recorded data of both systems has been compared and corresponding virtual parameters derived. Based on simulation experiments, both methods have been rated regarding their suitability for extracting precise input parameters for virtual computations. The six tested fabric materials are: Linen (100% LI, plain weave), flannel (100% WO, twill), gabardine (100% WO, twill), light silk (100% SE, plain weave), single jersey (100% PES, weft knit) and satin (100% PES, sateen).
Depending on the complexity of the implemented computational model, mechanical properties are modelled linear or non-linear. For this work, a state of the art simulation model is used, suited for the computation of dynamic simulations with high accuracy. Elastic properties, except bending, are non-linear modelled.

3.1 Tensile

Tensile tests are designed in a way to return the correlation between applied forces and corresponding fabric elongations. The FAST method measures the tensile property at one load of 100 N/m along warp and weft direction and the corresponding elongations are returned. The KES-f test determines the tensile behaviour with an increasing force of up to 500 N/m also along weft and warp direction. After the tensile load attains the maximum force, the recovery process is recorded and the complete strain-stress profile is returned.

A direct comparison of the measured data from both methods is only possible at 100 N/m force and indicates a good match for five samples (linen, gabardine, silk, flannel and satin). The correct tensile measurement of the elastic single jersey fabric with FAST was not possible, as the system already exceeded its measurement limits (21% of elongation).

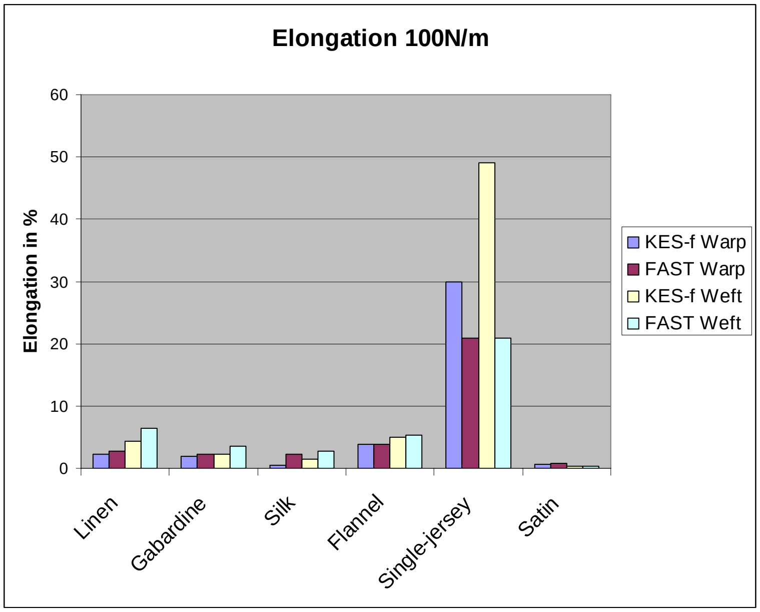

Figure 1: Elongations at 100N/m from KES-f and FAST

For the actual derivation of fabric input parameters for the virtual simulation application, a mathematical description of the measured data is needed. Depending on the computation system and the available amount of measured data, this mathematical interpretation can be linear (Figure 2, FAST) or non-linear (Figure 3, KES-f). However, the derived virtual fabric parameter can only be as precise as the range of the measured data.

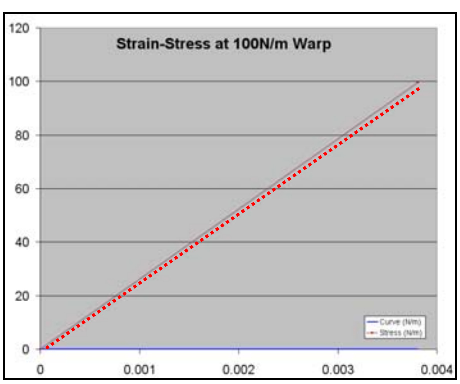

Figure 2: Linear derived data from FAST

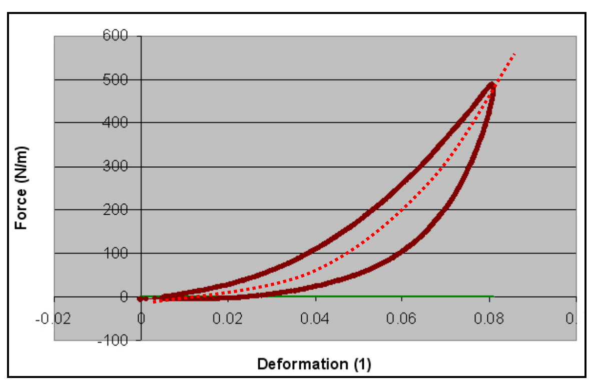

Figure 3: Non-linear interpreted data from KES-f

The superposition of the derived virtual fabric parameters from FAST and KES-f show that both mathematical descriptions differ in the low and the high force area (Figure 4). Although differences in the low force area are small, deviations for higher forces, which likely occur on a worn garment, are more significant. The linear derived parameter from FAST is incorrect, as referring to it much lower loads are sufficient to achieve large fabric elongations. Moreover, used in virtual garment fitting processes, the FAST parameter returns a wrong feedback about the garments comfort (Figure 5 and 6).

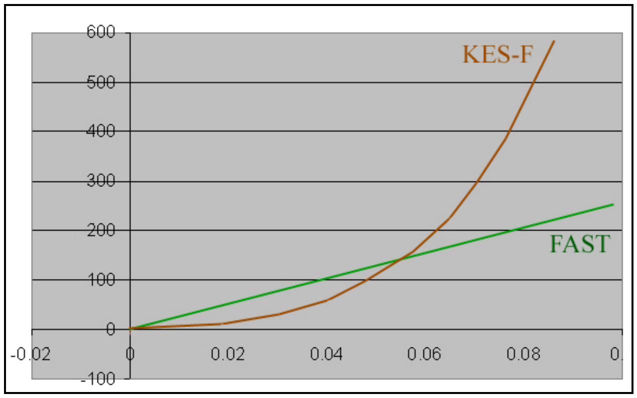

Figure 4: Comparison of KES-f and FAST parameters

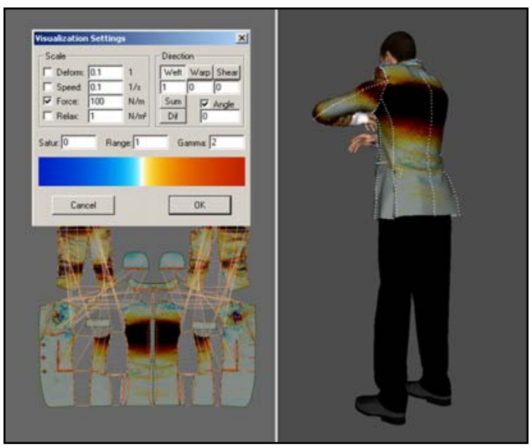

Figure 5: Simulation with KES-f parameter

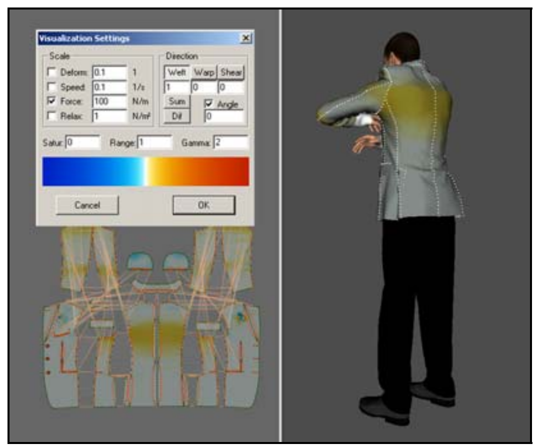

Figure 6: Simulation with FAST parameter

3.2 Shear

For the shear assessment, different measurement principles are used by FAST and KES-f. Within FAST, the fabrics bias extensibility at 45° is measured at one small load of 5 N/m and the shear rigidity is calculated. KES-f measures the shear by applying opposite forces to shear the fabric specimen until an angle of 8° degree is reached. After the maximum angle is attaint, the specimen is sheared in the opposite direction. Corresponding forces are recorded and a complete strain-stress profile is returned.
A direct comparison of the shear data from KES-f and FAST was only possible for four fabrics. The FAST measuring force of 5N/m was not reached during the KES-f experiment for two fabrics, as the maximum angle of 8° was attaint with lower loads (silk at 1.8 N/m and single-jersey at 3.2 N/m). However, the comparable fabrics showed a good correlation for both measurement methods.

The KES-f shear strain-stress envelopes allow again a more detailed study of the non-linearity of the shear property. Hereby, three of the tested fabrics, such as silk (Figure 7), flannel, and single-jersey show more linear shear behaviour, whereas the shear comportment of the three other samples, such as linen (Figure 8), gabardine and satin is more non-linear.

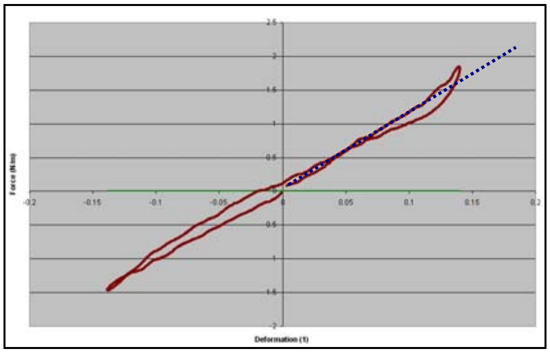

Figure 7: KES-f shear data for silk

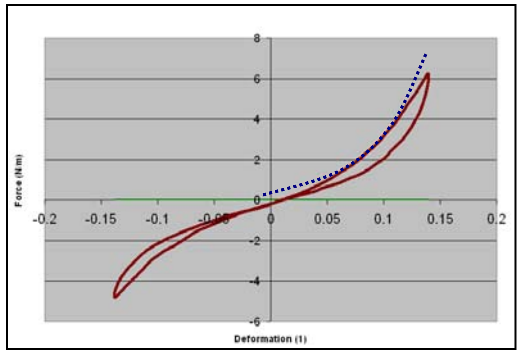

Figure 8: KES-f shear data for linen

Virtual parameters for the three fabrics showing linear shear behaviour have hence been linear derived from both testing methods and a good correlation of their derived values has been found (Figure 9).

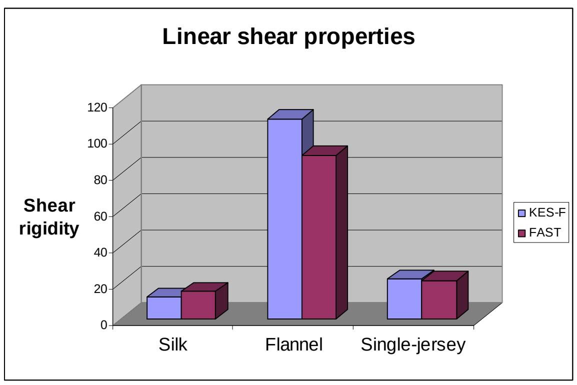

Figure 9: Comparison of linear shear parameters derived from KES-f and FAST

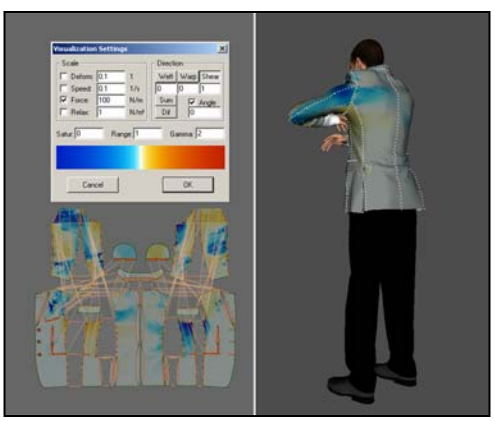

Figure 10: Simulation with KES-f parameter

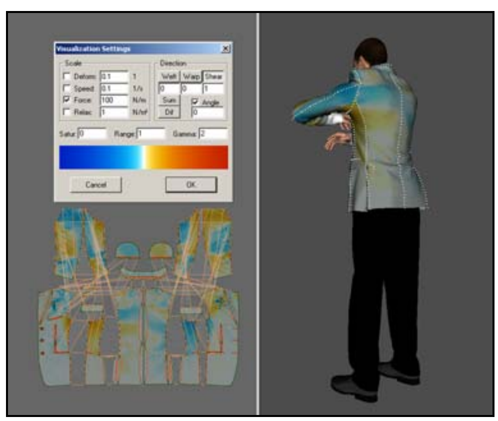

Figure 11: Simulation with FAST parameter

Fabrics exhibiting non-linear shear behaviour are more accurately derived from the KES-f strain-stress envelopes. However, in contrast to the tensile property, the error in the comfort feedback for the non-linear shear characteristics is smaller. This is related to the fact that regarding shear, generally lower forces are concerned (Figure 10 and 11).

3.3 Bending

For the assessment of the bending characteristic, FAST and KES-f employ different measurement principles as well. FAST uses the cantilever principle, where a material bends under its own weight. KES-f measures the bending property by recording the moment-curvature relationship. The fabric is fixed between two clamps and the specimen is bent in an arc of constant curvature (up to 150°) while the curvature changes continuously. Applied forces are recorded and a complete strain-stress profile is returned.

In the computation system, the bending property is linear modelled. Thus, a simple mathematical interpretation for the bending behaviour is sufficient. Both measurement methods return the bending rigidity as characteristic value. As this measure is a description of the slope between two major points of the measured data, it is suited to be directly taken as linear bending characteristic. The comparison of the bending rigidity from both measurement systems shows a good correlation for the gabardine, silk and satin fabric. The medium correlation of the three other fabrics can be related to the quite different measuring ranges of both applied principles.

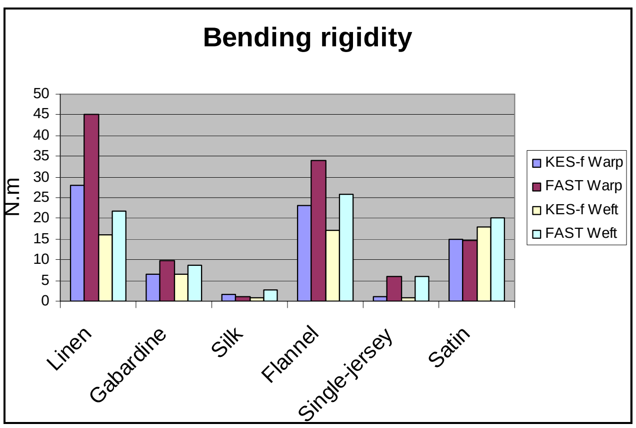

Figure 12: Bending rigidity FAST and KES-f

Figure 13: Virtual drape of the flannel fabric

The precision of the bending property can be visually controlled by draping tests. The virtual simulated drape of the flannel fabric using derived data from FAST and KES-f showed similar drapes for both cloths.

5 DISCUSSION

At a first glance, the KES-f method seams to be better suited for the measurement of the tensile and shear property. However, the KES-f method is limited as well, as it measures the fabric behaviour at only one load. During dynamic garment simulations, different intense forces occur. For that reason, derived parameters from KES-f are accurate for the one specified measured force (500 N/m), but not for various loads. For a correct input parameter, multiple load/unload experiments with different applied forces, which

reflect what actually happens during the wear of a garment, are needed for an accurate derivation of mechanical properties. Forces and deformations which have not been measured will not be imitated correctly in the simulation system.
During dynamic garment simulations, plasticity and time related parameters such as viscosity of fabrics become important input factors as well. However, viscosity properties are not assessed by FAST and KES-f.

4 CONCLUSION

Both measurement methods have been studied, compared and rated on six different types of fabrics. Both systems are suited for the derivation of bending parameters. The tensile and shear properties are more complex and non-linear modelled. The FAST systems is limited to only one measured load and therefore less suited for the derivation of tensile and shear parameters. KES-F tests provide a complete stress/strain profile and are more suited for studying the non-linear tensile and shear behaviour. KES-F measurements are also not sufficient for the derivation of fabric parameters for dynamic garment simulations.

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