QUANTITATIVE JUDGEMENT OF WEARING COMFORT OF HAND-FOOT-WEAR USING A HAND-/FOOT-MODEL

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INTRODUCTION

The wearing comfort of military clothing directly influences the capacity performance of the soldier. Biophysical aspects must, therefore, be considered during the development of clothing systems. Optimization of materials used for clothing with respect to their biophysical properties requires efficient test methods. In some cases sophisticated models must be employed to receive the desired information.

Because of constructive features of shoes and gloves a final judgement of the wearing comfort cannot be achieved by determining the biophysical paramaters of the applied materials alone. The shoe or glove has to be investigated as a whole. Up to now suitable testing devices are not available. A so called hand-/foot-model therefore has been developed for this purpose.

METHOD

The hand-/foot-model measures the dry and humid heat transfer through gloves and shoes.

It consists of a computer controlled air conditioner, a heated transfer line and exchangeable hand and foot dummies, made of fibre reinforced plastic (1,2). The specifically designed perforation of the surface of the dummies corresponds as closely as possible to the distribution of perspiratory glands on the human hand and foot (3).

The model can be operated in two different ways:

In the fixed value mode a specified rh/T-level is set up inside the hand (foot) dummy and the resulting humidity and temperature values are measured by two sensors, located in the palmar (medial) region and at the thumb (big toe) on the hand (foot) dummy. This way, prototypes of shoes and gloves can be judged with respect to the applied materials and constructive details influencing the heat and moisture exchange.

In the dynamic mode a dynamic change of temperature and humidity according to real life microclimatic conditions in hand- and footwear can be simulated. This mode is mainly used for comparative studies. The database for the dynamic mode results from tests with different (weak/normal/strong) sweating types of volunteers walking on an ergometer at three different levels of tilt in a climatic chamber at -16, 0, +16 and 32°C. The three levels of tilt represent energy conversion rates of 209,418 and 627 W (3). The volonteers were wearing clothing suited for the corresponding temperatures. During the tests temperatures and relative humidities were recorded by means of rh/T-sensors mounted in the same places like those attached to the dummies.

The dynamic mode allows to follow the change of temperature and humidity levels inside the shoe/glove at different energy conversion rates, i.e. different amounts of heat and humidity created by the dummy. In a reference test with the dummy the rh/T-level inside the glove (shoe) is controlled by either the thumb (toe) or the palmar (medial) sensor according to the rh/T-values from the database while recording the resulting control parameters of the air conditioner at the same time. In the target test the control Parameters are adjusted according to the reference test and the rh/T-values of the two sensors are recorded. A comparison of the rh/T-curves of the reference and the target tests shows the influence of differences in the glove (shoe) design and/or manufacture on the rh/T-level, i.e the wearing comfort.

RESULTS

Using the hand-/foot model comparative studies have been carried out on different types of military hand- and footwear. The effect of membrane materials used inside gloves and shoes has been evaluated with respect to their cold/wet behaviour.

As an example Figs. 1 and 2 show the results of a comparative test of field boots designed for tropical weather conditions. The test was carried out in the dynamic mode. Microclimatic wearing comfort can be expected, when a *boot* has good heat and moisture exchange capabilities, i.e. low internal values for relative humidity and temperature. Fig. 1 shows considerably higher rh-values for boot A compared to boot B, whereas the slopes of the temperatures for both boots in Fig. 2 are nearly identical. Therefore, boot B would be the better choice for tropical weather conditio=.

Fig. 1: Tropical Field Boots:
Relative Humidity at 16°C Ambient Temp.

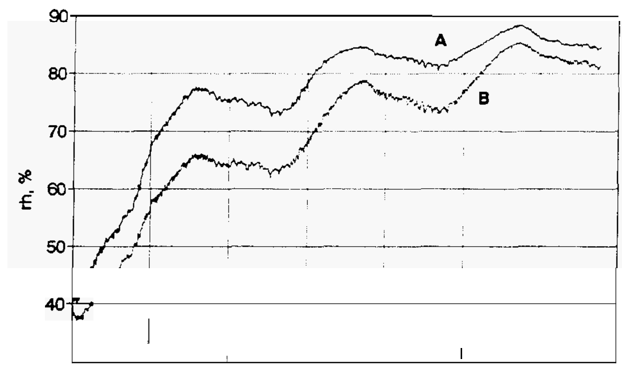
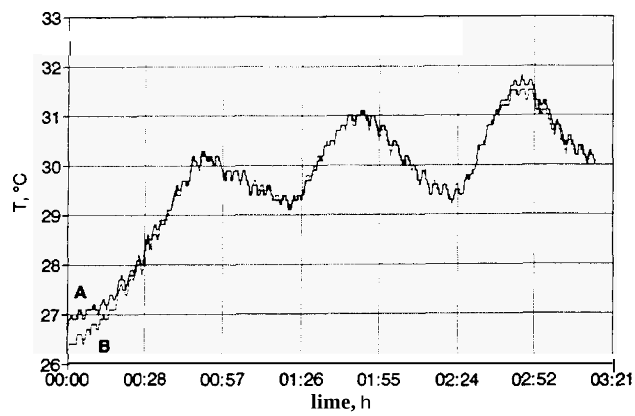


Fig. 2 Tropical Field Boots:
Temperature at 16°C Ambient Temp.



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