

**FACTORS AFFECTING GARMENT'S THERMOPHYSIOLOGICAL PROPERTIES IN TROPICAL WEATHER COUNTRIES**

**Reviewer: Prof. Lubos Hes, PhD, DSc, Dhc, TU Liberec, Faculty of Textiles**

**1. Summary**

The objective of the submitted PhD Thesis (Dissertation) is the analysis of the factors affecting thermophysiological properties of garments worn in tropical weather countries. The range of the studied textile materials involves cotton, viscose, wool and synthetic polymers. The instrumental testing was carried out at varying levels of temperature of the samples and air relative humidity.

The results were statistically treated, multiple regression models were established and 3-dimensional diagrams were presented. The already published (foreign) mathematical (structural) model of evaporation resistance of a fabric was in this Thesis modified towards its use for the knitted fabrics and experimentally verified.

**2. General remarks**

- List of symbols and their dimensions is missing.
- Many equations are presented without their dimensions (like Eq. 36, 37, 38), in order to substitute the missing list of symbols and their dimensions.
- In the presented equations, the bottom indexes are correctly presented in smaller size, but they should be also written partly under the basic line.
- The author did not analyse deeper the heat transfer effects in fabric by radiation (fortunately, these effects are low).

**3. Imperfections of the Dissertation (P = page)**

P X: instead of REFERENCE and PUBLICATION, it should be written REFERENCES and PUBLICATIONS.

P 47: the Permetest Skin Model does not work according to the BS 7209, but according to the modified ISO 11092.

P 52, Eq. (33): watt should be written correctly as Watt.

P 57: when the author presents the measured „effusivity“ levels of the studied samples, he should also present his reason for doing it. The main reason for determination of this effusivity or by another name „thermal absorptivity“ of textile fabrics is the study by Hes [1] in which he proved, that the levels of thermal absorptivity of fabrics correspond well (with Spearman rank correlation coef. higher than 92%) with the subjectively determined levels of the „warm-cool feeling“ of fabrics. This primary source ought to be mentioned in the References.

P 67, P 84, paragraph 4.1.21 and 4.3.2.: the dimension of thermal conductivity should not be written as W/mK, as it indicates the temperature degree in milikelvins mK. The correct form is W/m/K, or  $Wm^{-1}K^{-1}$

P 77, P 85, paragraph 4.2.3., 4.3.3.: the dimension of thermal resistance should not be written as  $m^2Kw^{-1}$ , but as  $m^2KW^{-1}$ .

P 110, Table 4.6: the diffusivity levels are not correct, they should be divided by  $10^6$ . Ret numbers should be divided by  $10^3$ . Fortunately, these values are correctly presented in the Figures 4.85 and 4.86.

P 118, Table 4.7. The diffusivity levels are not correct, they should be divided by  $10^6$ .

P 118: the use for K as the symbol for thermal conductivity is unfortunate, as it can cause confusion with K for the Kelvin temperature degree.

P 139: the calculation of the Imt index is useless, it presents an artificial relative index which is not used in the recent communications.

P 141: the author describes very positively the antibacterial properties of the Bamboo viscose fibres, but Prof. Hauser from NCSU proved recently, that all these declared positive properties were not confirmed by the respected US scientists. Thus, garment manufactureres, who base their marketing on the mentioned positive properties of the Bamboo viscose fibres, are brought to justice in the USA.

P 142, Fig. 4.136: the results of the infrared thermography are often overestimated: due to strong effect of the fabric color and moisture on the fabric surface emisivity, the areas with apparently higher temperatures can be just areas with higher emisivity.

P 152: the Fick's law is not presented correctly: the negative sign (-) in the right part of the Eq. 125 is missing.

P 153: What is the meaning of the parameter  $\gamma$  in the Eq. 126?

P 154: in the Eq. 128 the diffusion coefficient  $D$  should be written, instead of the porosity  $\varepsilon$ .

P 155, Fig. 55: what is the meaning of the „y“ axis?

[1] Hes, L., Araujo, M., Djulay, V., Effect of Mutual Bonding of Textile Layers on Thermal Insulation and Thermal-Contact properties of Fabric Assemblies, *Textile Res J.* 66, 245-250 (1996)

#### 4. Positive features of the submitted Thesis

1. The analysis of the State of the Art (Literature survey) is exhausting and systematic and demonstrates the very good knowledge of the Phd candidate of the studied problem.
2. The scope of the executed measurements of thermal comfort parameters of the tested fabrics is very large. These measurements are quite original, as they involve both the effect of varying sample temperatures (3 levels) and the varying relative humidity of the surrounding air (3 levels as well). These measurements cannot be found in the available scientific literature.
3. Mathematical treatment of the above results, including creation of the multiple regression models and presentation of 3dimensional diagrams, satisfies the requirements of good scientific study.
4. The modification of the already published (foreign) mathematical (structural) of evaporation resistance of a fabric for the knitted structures is quite original.
5. The list of presented references exceeds the common requirements.

#### 6. Conclusions

Despite of certain above mentioned (mainly formal) imperfections present in the submitted PhD Thesis, which consist of many well treated original measurements and of modified physical (structural) model of fabric evaporation resistance, the candidate Mr. Motawe MSc convinced the reviewer about his ability for serious and creative scientific work, and that is why his **PhD Thesis is recommended to be accepted and candidate to be awarded by the PhD scientific degree.**

Prof. Lubos Hes

In Liberec, on Jan. 15th, 2013



Review of PhD thesis of Mr. M.H. Motawe, MSc. submitted to  
Technical University of Liberec, Liberec, Czech Republic

Thesis title: Factors affecting Garment's thermo physiological  
properties in tropical weather countries

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**Description of the thesis:**

The dissertation consists of 180 pages, divided to 6 chapters, references and list of publications.

Chapter II entitled theory, in fact this chapter is a good review about characterization of thermal comfort of textile clothing, including definitions, basics of heat transfer through fabrics, relationship between different factors characterizing heat and water vapour transport.

Chapter III. Includes experimental work, includes material, instruments, and methods used for evaluation of the measured data. Chapter IV presents the results and discussions.

Chapter V, theoretical background and analysis, and chapter VI, conclusions.

**Formal remarks:**

- The arrangement of the thesis is not standard; for example chapter II should be literature review, Chapter V is actually a part of discussion of results, and verifying the theoretical calculation with the measured values.
- Missing list of symbols
- Typing the equation is very bad, and many times leads to confusion.
- Fonts inside graphs of contours are very small
- Evaluation of Comfort Index (page 143) title, sometimes missing axis titles (p.155).
- Thermal photos (page 142) without comment...etc.

**Comments:**

- The author applied the multiple regression technique for evaluating the effect of temperature and humidity on the different parameters characterizing thermal comfort. Lot of contour lines and response surfaces have been plotted. He described well the curves, but the **physical meaning is missing**. A comparative study of the different parameters should be presented for different materials used in the experimental work.
- The **comfort index** is somehow not fully presented and discussed.
- Poor description/evaluation of **photos from the thermal camera**.
- Conclusions are not well formulated, it is general remarks and not specific to the work. Is it justified to include UV in this work to be included in conclusions?

Although the present work has many negative formal faults, but it includes lot of positive features. The literature review is very good provided, showing the deep knowledge of the candidate.

The experimental work is very large and covers wide range of different materials and blends. Measurements of comfort parameters are provided on many up to date instruments. Evaluation technique of the experimental data is quite well.

Applying the comfort index gives a meaningful value for characterizing the thermal comfort.

Modification of evaporation resistance equation of knitted fabric is appreciated. Verifying the theoretical calculated values with the experimental data shows very good agreement.

**Conclusion:**

Mr. Motawe shows deep knowledge about the theme of thermal comfort of textile clothing, has provided a wide range of experiments, and data analysis, modified theoretical equation for characterization of evaporation resistance.

The submitted work fulfills the requirements for granting the PhD degree from the technical university of Liberec after **successful defense**.



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Prague January 31<sup>st</sup>, 2013

**Subject:** The opponent review report on the PhD. dissertation work by  
**Mohammed Hemaia Motawa, MSc.,**  
**“Factors affecting garment’s thermophysical properties in tropical weather countries“.**

The dissertation consists of 180 pages and 190 references. English text is written obviously though the reader may face some troubles in understanding sometime scattered information while ordering paragraphs. Anyhow the disserting author shows a good overview of the concept of the current state-of-art on solved problematic, which in the recent years acquired a considerable amount of theoretical work and moreover experimental results revealing the leading position of the university (TUL).

The work is written in acceptable English (which gives it the necessary internationalist character, which I do welcome in general), is suitably designed and straightforward readable though the text is somehow demandable to be fully understood in details, particularly concerning equations. At the dissertation work I am missing the list of symbols, and a Czech and English written summary, which (together with the front list of figures should be placed at the end). I would also welcome a separate explanation of some characteristic terms (though recognizable in textile engineering) such as esophagus (p.7), vasomotor (p.15), turtuosity (p.35), manikins (p.41) as well as an in-advance definition of exploit materials (Lycra, Coolmax – even if well defined on p.92). In conclusion I am missing discussion desirable toward possible spotlights of dissertant personal opinion for the processes optimization, including estimates of the prospects for further development.

At the review conception I have to admit that I am not an adequate expert in the entire field of textile engineering but I found some resemblance with my physics familiarity in the study of freeze-in of various materials and the activity of diverse surfaces as well as my personal experience as a mountaineer and explorer acting and employing various garments under both low (big mountains) and high (tropical) climate temperatures.



Let me present some further remarks and inquiries:

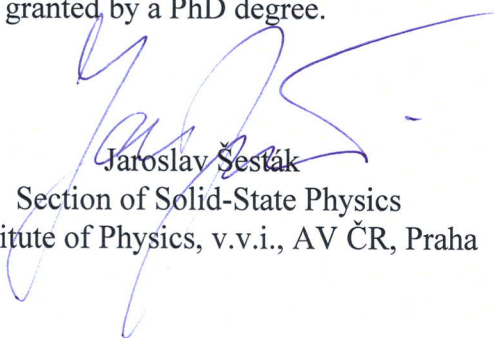
- 1) P. 7 - eq. 1. - the same letters manner should be maintained  $T_{nb}$  vs  $T_{nb}$  and symbols defined  $T_i$  ( $T_i$ ).
- 2) P. 12 – a portrayal figure would be appreciated showing inherent flows and comfort partition.
- 3) P. 15 what means the last term on the bottom equation –  $\ln$  ?
- 4) P. 16 – For radiation and convention an analogous equation should be presented!
- 5) P. 19 in the human factors the feeling of touch should added.
- 6) P. 24 – eq. (8) the unit factor is mixing with entire equation, standard processing is to place units in [brackets], which applies to equations throughout the dissertation (e.g. (17,24-31) etc.).
- 7) P. 30, though the capillarity is mentioned on the p. 33, its effect should be introduced even here.
- 8) Wearer trials are not well understandable, eqs. (17) to (23).
- 9) P. 57 – thermal conductivity as both:  $k$  and  $K$ !
- 10) P. 65 -  $\Phi$  in the table 4.1. is not defined, follows it is humidity.
- 11) P. 156 – Explain apparent discrepancy of theoretical and experimental data for  $15 \pm 180\% \Phi$  in Table 5.6, 5.7. and 6.8.
- 12) P. 161 - in conclusion you have a discrepancy; on one hand you recommend lower heat conductivity to protect environmental heat while on the other hand you disregard insulation when safeguarding overheating (bottom of paragraph 3).

In conclusion I am satisfied with the presented text and its scientific and expert contents ranking the dissertation in the standard average of comparable presentations within similar material specializations.

The work meets the requirements for a doctoral thesis specified both by the Ministry of Education, Sport and Young (MSMT) and the Technical University in Liberec, and therefore recommending the work for an appropriate support and positive defense realization as well as the dissertant to be granted by a PhD degree.

With best regards,

Yours sincerely

  
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