AUTEX 2022 Conference Proceedings 978-83-66741-75-1 

**DOI: 10.34658/9788366741751.90**

# ANALYSIS OF THE HEAT TRANSFER PROPERTY WITH THE SANDWICH FABRICS BASED ON ANSYS WORKBENCH AND ALAMBETA

**Dan Wang[1(*)], Shi Hu[1], Yordan Kyosev[2], Dana Kremenakova[1], Jiri Militky[1]**

[1] Technical University of Liberec, Studentská 1402/2, 46117 Liberec, Czech Republic
[2] Technical University of Dresden, Hohe Str.6, 01069 Dresden, Germany
(*) Email: dan.wang@tul.cz

## ABSTRACT

As more and more attention is paid to the thermal comfort of clothing, academic research on the heat transfer properties of textile materials is becoming more and more important. In recent years, the application of simulation software to analyze the heat transfer properties of fabrics has become a research hotspot. In this paper, the ANSYS workbench simulation software is used to simulate the heat transfer property of a kind of sandwich fabric. The results obtained by establishing different models show that the application of single-layer fabric with different thermal resistances in the sandwich fabric will lead to greatly different thermal resistances of sandwich fabric; the same material has different thicknesses, and its thermal resistance will increase with the thickness; the same single-layer fabric with different combination positions will cause the thermal resistance of the sandwich fabric to change. At the same time, the software simulation values are compared with the actual measured values. It can be found that the two sets of data have the same trend, but the data of the former is significantly higher than the latter. The reason is that the model's porosity is much smaller than the actual sample.

## KEYWORDS

Sandwich fabrics, heat transfer property, thermal resistance, ANSYS workbench, Alambeta.

## INTRODUCTION

With the improvement of living standards, people begin to pay attention to the comfort of clothing, among which the thermal comfort of fabrics has an important impact on the wearing comfort of fabrics [1]. Traditionally, textile design and its basic performance analysis are mainly optimized through a large number of experiments. The disadvantage of this method is that the process is complicated, the cycle is long, and the process cannot be controlled. Based on the continuous progress and development of numerical simulation research, the application of relevant software to simulate and analyze the heat transfer performance of fabrics has become a research hotspot in today's textile field. In addition, this is also one of the important research methods to save resources, reduce production costs and realize intelligent products [2]. This paper uses the simulation software ANSYS workbench to simulate and analyze the heat transfer performance of a kind of sandwich fabric, which will be a material for winter clothes and has an anti-electromagnetic radiation function. The simulation software was used to explore the influence of different fabric thicknesses, different fabric materials, and different fabrics position changes on the heat transfer performance.

## MATERIALS AND METHODS

### Material of sandwich fabrics

From Table 1 presents the basic information of the sandwich fabrics. It has different layers, including anti-electromagnetic inference layer (Meftex10 [3]), insulation layer (Nonwoven1 and Nonwoven2), surface layer and lining layer (Woven1 and Woven2).

**Table 1. Basic information of single-layer fabrics.**

| Name | Sample description | | Area density [g/m$^2$] | Thickness under 200Pa [mm] |
|---|---|---|---|---|
| Meftex10 | 100% polyester with copper and nickel coating | nonwoven | 13 | 0.05 |
| Woven1 | 100% polyester | woven | 52 | 0.06 |
| Woven2 | 80%cotton/20%polyamide | woven | 88 | 0.2 |
| Nonwoven1 | 100% polyester with acrylic binder | nonwoven | 100 | 5 |
| Nonwoven2 | 100% polyester with acrylic binder | nonwoven | 300 | 15 |

### Method for Alambeta

Alambeta is used to measure the heat transfer properties of fabrics, including thermal conductivity, thermal resistivity, thermal diffusivity, thermal absorptivity and sample thickness under 200 Pa pressure [4]. The equipment has two test boards with heat flow sensors located at the top and base of the instrument. When testing, the sample will be placed on the measuring plate at the base, and then the top plate measuring head will descend and touch the sample. The equipment will measure the transient heat flow on contact and obtain different parameters of the sample through photoelectric sensors [5].

### Method for simulating heat transfer property by ANSYS workbench

This paper is based on simulating the heat transfer performance of textile materials, and the "steady-state thermal" module can be selected in the ANSYS workbench software [6]. The model of the sample is then designed in the "geometry" module, which is completely based on the different combinations of the samples (Figure 1). Then to define material properties for the designed model and perform mesh division. The next step is to set the boundary conditions, and this paper assigns the boundary temperature. Finally, the data and images of temperature distribution and heat flux distribution are obtained through the software's own simulation and the thermal resistance value is solved by using these obtained simulation values.

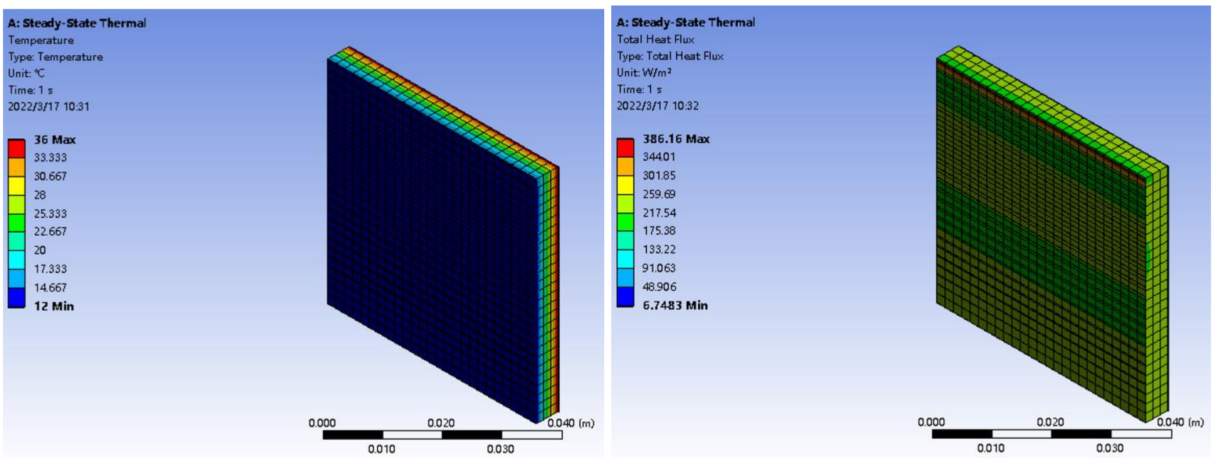


**Figure 1. Data and image of temperature (left) and heat flux (right) by ANSYS workbench.**

## RESULTS AND DISCUSSION

The thermal resistances of sandwich fabrics with different combinations by Alambeta and ANSYS workbench can be seen from the table 2. In general, the two sets of data show the same trend. However, it can be clearly seen that the actual test data is lower than the simulated data, because the porosity of the actual samples are much larger than that of the simulated models. In addition, the following conclusions can be drawn from the comparison of different groups of samples: (1) The higher the thermal resistance of the single-layer fabric obtained from the comparison of sample 1 and sample 2 will directly lead to the higher thermal resistance of the sandwich fabric; (2) It can be seen from the comparison of sample 2 and sample 3 that the thicker the thickness of the fabric, the higher the thermal resistance of the fabric; (3) The comparison of sample 3 and sample 4 shows that the same single-layer material placed in different position will also lead to the sandwich fabric's thermal resistance is different.

**Table 2. Thermal resistance of different sandwich fabrics by Alambeta and ANSYS workbench.**

| Name | Sample description (Fabrics sequence is from human body to external environment.) | Thermal resistance by Alambeta ($K.m^2/W$) | Thermal resistance by ANSYS workbench ($K.m^2/W$) |
|---|---|---|---|
| Sample 1 | Woven1+Meftex10+Nonwoven1+ Woven1 | 0.11639 | 0.14341 |
| Sample 2 | Woven2+Meftex10+Nonwoven1+ Woven2 | 0.12367 | 0.15241 |
| Sample 3 | Woven2+Meftex10+Nonwoven2+ Woven2 | 0.26101 | 0.33508 |
| Sample 4 | Woven2+Nonwoven2+Meftex10+ Woven2 | 0.26444 | 0.37649 |

## CONCLUSION

Based on the actual measurement of Alambeta and the simulation software using ANSYS workbench, this paper analyzes the influence of different fabric types, different fabric thicknesses, and different fabric positions on the heat transfer performance of sandwich fabrics by establishing different fabrics models. The specific research conclusions are as follows: The thermal resistance data from Alambeta and ANSYS workbench show the same trend, but the actual test data are lower than the simulated data because the porosity of the actual samples is much larger than that of the simulated models; The application of single-layer fabric with different thermal resistances in the sandwich fabric will lead to greatly different thermal resistances of sandwich fabric; The same material with different thicknesses will bring about its thermal resistance will increase following the thickness; The same single-layer fabric with different combination positions will cause the thermal resistance of the sandwich fabric to change.

## ACKNOWLEDGMENT

This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic and the European Union - European Structural and Investment Funds in the Frames of Operational Porgramme Research, Development and Education - project Hybrid Materials for Hierarchical Structures (HyHi, Reg. No. CZ.02.1.01/0.0/0.0/16_019/0000843). And many thanks to the Bochemie company for providing Meftex 10 samples.

## REFERENCES

[1] Tadesse M.G., Loghin C., Dulgheriu I., Loghin E., *Comfort evaluation of wearable functional textiles*, Materials (Basel) 2021. vol.14, no 21, doi: 10.3390/MA14216466.
[2] Akankwasa N.T., Veit D., *Advances in modeling and simulation in textile engineering : new concepts, methods, and applications*, Woodhead Publishing, Cambridge 2021.
[3] *Meftex 10*, online, https://www.meftex.cz/cs/meftex-10/p-1/ [access: 2.03.2022].
[4] Matusiak M., Kowalczyk S., *Thermal-insulation properties of multilayer textile packages*, Autex Res. J. 2014 vol. 14, no 4, pp. 299–307, doi: 10.2478/AUT-2014-0030.

[5] Hes L., Dolezal I., *Indirect measurement of moisture absorptivity of functional textile fabrics*, J. Phys. Conf. Ser. 2018, vol. 1065, no12, doi: 10.1088/1742-6596/1065/12/122026.
[6] Ansys Workbench, *Simulation Integration Platform*, online, https://www.ansys.com/products/ansys- workbench [access: 21.03.2022]