ASK THE EXPERT: THERMAL INSULATION

The latest in our series of articles questioning textile experts focuses on the subject of thermal insulation.

Something in the air



An interesting development is the combination of thermal insulation and air impermeability, achieved by using fleece technology with breathable, flexible membranes.

Zimtstern/Dominic Zimmerman

In this series of asking fibre and fabric experts questions on key sports and outdoor subjects, Dr René Rossi, head of laboratory services for protection and physiology at Swiss interdisciplinary research and services institution for material sciences and technology, Empa, supplies the answers.

Question: Sportswear brands are experimenting with blown or shredded synthetic fillers, with little success up till now (The North Face recently suspended the launch of ThermoBall). What new breakthroughs do you expect in this area?

Answer: Air is the best insulator, apart from a vacuum. It has a thermal conductivity of about 0.025 watts per metre Kelvin (W/mK) in the physiological range (30°C). Textiles that insulate very well have a thermal conductivity of 0.03 to 0.04 W/mK. This means that the theoretical limit given by the insulation of air is nearly reached. However, if air moves within these textile structures, heat is exchanged by convection. Free convection can occur in air layers of 8 mm or above. The challenge is therefore to create large air layers but to prevent any air movement (for example, with down-like structures). This may be reached by 3D structures, which do not change their shape during use, but on the other hand are very flexible to avoid the reduction of the sensorial comfort of the garment. Another possibility is to add several wind-tight but water vapour-permeable layers between the insulation layers of multilayer clothing.

Q: Phase change materials or PCM-based thermoregulating fibres and fillers seem to have met their limit in apparel uses. What new research is there into new phase-change substances that could improve the performance of this type of product?

A: PCM may only be used for applications with large temperature changes. However, human

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thermoregulation usually keeps the skin temperature of the trunk nearly constant between about 28°C and 35°C. The temperature of the limbs can drop down to 15°C before we feel pain from cold. Therefore, the use of PCMs for sports applications often only makes sense in gloves, socks or shoes. The reason why PCMs have probably reached their limits is mainly that the effect is weight-dependent (the greater the effect, the heavier the clothing). Furthermore, with the classical microen - capsulating processing methods in fibres or foams, the weight percentage of PCM in the polymer composite remains limited. Improvements in the performance could probably be achieved with other manufacturing methods avoiding microencapsulation.

Q: Far infrared (FIR) reflecting ceramic or mineral-based alloys found in laminates, coatings and fibres are being promoted as efficient thermoregulating materials (in addition to other functions). What is your position regarding this group of products?

A: The efficiency of such products has apparently been demonstrated in different studies. To my knowledge, these studies only assessed subjective feelings like mental capacity or balance in the participants, but no thermal or thermoregulatory effects. During sports activities, blood circulation is already increased to feed the muscles or help thermoregulation. Under these circumstances, it is not certain if such materials are really needed to support blood circulation.

Q: In your opinion, how can new advances in body mapping be used in conjunction with thermal insulation technologies for best results?

A: The term body mapping is often used in conjunction with varying perspiration rates in different parts of the body. In terms of thermal insulation, this means that for body parts with high sweating rates—like the spine region—textiles should be used that keep most of their insulation even when wet in order to avoid a post-exercise chill. Varying the insulation of clothing depending on the part of the body can be tricky as the body's thermoregulation partly equalises varying insulations through blood circulation so that, for instance, if you have cold feet, it can help to put on another jumper.

Q: There appears to have been an increase in sales of insulated apparel. We accept that this has been for a combination of reasons, but if one of the reasons is that apparel brands have made improvements in incorporating insulation, which of those improvements have made the biggest impression on you and why?



Dr René Rossi, head of laboratory services for protection and physiology at Empa in Switzerland.

The Fiber Society

A: I think that one of the major developments of the last few years is the combination of thermal insulation and air impermeability by combining fleece technology with highly breathable, highly flexible membranes made, for instance, from nanofibres (or sub-micron fibres). The fleece ensures a high amount of air between body and environment and the membrane prevents air movements. This is an ideal combination.

Q: We know one of the most important questions during field-testing of thermal insulation technology in garments is the effect of wind chill. Feedback we have seen suggests that ingredient brands or apparel manufacturers find it hard to take wind chill into account because of the limitations of being able to imitate wind chill effectively in a laboratory. In your view, what is the best solution to this dilemma?

A: The simulation of wind in laboratory conditions is very complex because there are interactions between wind and garment. The sample to be tested influences air turbulence and, therefore, it is challenging to get reproducible results. The wind chill effect is very dependent on the position of the wearer and obviously also on the garment openings. The results of such measurements may be ambiguous and leave a certain freedom of interpretation. A test method for wind chill would have to take into account design features of the garment. As there are more and more thermal manikins in use to assess thermal insulation and water vapour transport of garments, such systems could be used to quantify the effects of wind.

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