

THERMAL INSULATION FOR APPAREL

FIELD

This invention relates to thermal insulation for apparel worn in low temperature environments.

5 BACKGROUND

Apparel worn by persons in low temperature environments to reduce heat loss from the person to the environment typically comprises three layers: an inner lining worn against the skin or another layer of clothing, an outer layer typically referred to as the shell, and a thermal insulation layer provided between the lining and the shell. The layer of thermal insulation
10 serves to reduce heat loss from the person via irradiation, thermal conductivity and convection.

Reduction of convection heat loss may be realized by creating air traps and minimizing pore size in the thermal insulating layer and also making the thermal insulation layer denser. While it is possible to reduce heat loss by convection almost to zero, comfort to the wearer will be
15 compromised as the apparel will be not breathable.

Reduction of irradiation heat loss is important as a major part of heat from the human body is lost by this channel. All irradiated heat passing through a barrier is divided into three parts: reflected, absorbed and transmitted. Application of heat absorption materials in thermal
20 insulating apparel is a known approach to reduce heat loss by trapping heat in the garment. For example, different nanoparticles of zinc, aluminium or stainless steel have been known to be added in small proportions (e.g. 0.05-0.1%) for heat absorption. Laminated fabrics with functions of accumulating heat and preserving heat are also known. Carbon micro powder is a popular additive to make fibres/fabric heat accumulating. However, while heat absorption
25 certainly improves thermal insulation, the absorbed heat will still be transmitted through the clothing layers or simply dissipated. Moreover, added particles in insulating fibres quite often increase thermal conductivity of such fibres, and as a result the absorbed heat is being lost via conduction instead. Heat reflection is another perspective for development of advanced thermal insulating materials. Different methods of heat reflection have been known for use in
30 thermal insulation of apparel, such as incorporating glass microbeads or providing metallic dots or net to reflect infrared radiation. However, such methods would naturally increase the cost of the garment.

Thus, while existing thermal insulating apparel are able to sufficiently reduce heat loss from

their wearers, there is still a demand for reduced garment cost and bulk while retaining or improving thermal insulation of such apparel.

SUMMARY

5 According to a first aspect, there is provided a thermal insulation for apparel worn in a low temperature environment; the thermal insulation comprising a non-woven composite comprising a mixture of fibres with multi-lobal cross-sections and fibres with circular cross-sections, the non-woven composite reducing heat loss from a wearer of the apparel to the low temperature environment.

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Weight percentage of the fibres with multi-lobal cross-sections may range from 2% to 90%.

Linear density of the fibres with multi-lobal cross-sections may range from 1 denier to 60 denier.

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Length of each of the fibres with multi-lobal cross-sections may range from 20 mm to 100 mm.

Specific density of the non-woven composite may range from 40 g/m² to 300 g/m².

20 The fibres with multi-lobal cross-sections may be made of polyester.

The fibres with circular cross-sections may be made of polyester.

25 The non-woven composite may further comprise fibres of at least one of: polyethylene fibres, polypropylene fibres, biocomponent fibres and natural fibres.

According to a second aspect, there is provided apparel to reduce heat loss from a wearer of the apparel to a low temperature environment, the apparel comprising the thermal insulation of the first aspect.

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BRIEF DESCRIPTION OF FIGURES

In order that the invention may be fully understood and readily put into practical effect there shall now be described by way of non-limitative example only exemplary embodiments of the present invention, the description being with reference to the accompanying illustrative
35 drawings.

FIG. 1 is a schematic cross-sectional illustration of possible air flow around a fibre of multi-

lobal cross-section and a fibre of circular cross-section.

FIG. 2 is graph of reflection fibres of multi-lobal cross-sections and fibres of circular cross-sections.

FIG. 3 is a schematic cross-sectional illustration of possible light movement around fibres of multi-lobal cross-sections.

FIG. 4 is a schematic cross-sectional illustration of exemplary embodiments of fibres with multi-lobal cross-sections.

DETAILED DESCRIPTION

Exemplary embodiments of a thermal insulation for apparel worn in low temperature environments will be described below with reference to Figs. 1 to 4. By low temperature environments, it will be understood that the environment is at a temperature lower than 22°C, more likely lower than 15°C.

In the present application, the thermal insulation for apparel worn to reduce heat lost from a wearer of the apparel to a low temperature environment comprises a non-woven composite. The non-woven composite comprises a mixture of fibres with multi-lobal cross-sections and fibres with generally circular cross-sections. Examples of fibres with multi-lobal cross-sections are shown in FIG. 4. As can be seen, such fibres may have three or more lobes that extend along a length of each fibre. The multiple lobes of each fibre may be symmetrically or asymmetrically distributed around a longitudinal axis of the fibre.

The non-woven composite thermal insulation was found to possess lower air permeability compared with prior art composites made of fibres having only circular cross-sections. A sample of the non-woven composite having a density 100 g/m² obtained using a carding machine and bonded using glue web fixation was tested and found to have air permeability varying from 250 to 320 cm³/s×cm² [ASTM D737-96 Standard test method for air permeability of textile fabrics]. By contrast, a common composite having common circular cross-section fibres was found to have air permeability ranging from 320 to 400 cm³/s×cm². As a rule, reduction of air permeability is known to always correlate with an increase in thermal insulation of a material. It is suggested that the multi-lobal structure of some of the fibres used in the present non-woven composite thermal insulation created more hurdles for air flow compared to fibres having circular cross-sections, as illustrated in FIG. 1. Such a phenomenon may reduce heat loss via convection through the non-woven

composite thermal insulation.

An interesting phenomenon relating to light reflection was observed when comparing polyester fibres 10 with multi-lobal cross-sections and fibres 100 with circular cross-sections. As can be seen in FIG. 2, for both types of fibres 10, 100 having the same linear density of 1.5 denier, the fibres 10 with multi-lobal cross-sections exhibited higher reflectance. This may possibly be explained by the fact that the multiple lobes 20 of the fibres 10 with multi-lobal cross-sections form barriers for light passage, as shown in FIG. 3, thereby serving to trap light over a large range of wavelengths due to increased reflection between the multiple lobes 20 of the fibres 10 having multi-lobal cross-sections.

It is also suggested that the multiple lobes 20 create quasi air pockets between adjacent fibres 10 having multi-lobal cross-sections, so that air movement or exchange is made more complicated when compared to air movement or exchange between adjacent fibres 100 having circular cross-sections, thereby contributing to improved thermal insulation in the non-woven composite thermal insulation.

The non-woven composite thermal insulation comprising a mixture of fibres 10 having multi-lobal cross-sections and fibres having generally circular cross-sections may be prepared by first mixing the desired amounts of each type of fibre to form a web of the mixture of fibres, using known methods in existing dry-lay or wet-lay processes to form non-woven materials. The fibres are preferably provided as staple fibres of length ranging from 20 mm to 100 mm and having linear density ranging from 1 denier to 60 denier. The fibres 10, 100 may be made of any material as may be desired, such as polyester, polypropylene, polyethylene, natural fibres, biocomponent fibres and so on.

After formation, the web is bonded by known methods such as passing the web through conventional glue spraying machines or needle punching machines and so on, depending on which equipment is desired to be used to bond the web. Where biocomponent fibres are included in the non-woven composite, after formation of the web, the web may be heated in an oven for thermal bonding of the fibres to take place if necessary.

Samples of the non-woven composite formed with different weight percentages of polyester fibres having multi-lobal cross-sections and polyester fibres having generally circular cross-

sections were prepared and their clothing insulation (clo) values determined, where 1 clo = $0.155 \text{ K}\cdot\text{m}^2\cdot\text{W}^{-1} = 0.88 \text{ R}$ (where R means $\text{ft}^2\cdot^\circ\text{F}\cdot\text{hr}/\text{Btu}$, R being a measure of thermal resistance or ability of heat to transfer from hot to cold through a material such as a layer of insulation). The higher the R or clo value of a material, the more the material can prevent heat transfer, i.e. better insulation. The fibres used to prepare the samples had a linear density of 1.5 denier and 38 mm cut length. As a control, a sample non-woven fabric of polyester fibres all having generally circular cross-sections was also prepared and its clo value determined. Table 1 below gives the clo value of the non-woven fabric samples that were all prepared to have a specific density of 100 g/m^2 .

Amount of fibres having multi-lobal cross-sections, %wt	clo
0	2.73
20	3.02
40	3.12
60	3.45
80	3.35
100	2.97

Table 1

During industrial formation of the non-woven composite, it is noted that adding less than 2% by weight of fibres having multi-lobal cross-sections may give rise to problems with homogenous distribution of these fibres among the fibres having generally circular cross-sections. Thus, it is preferably that the amount of fibres having multi-lobal cross-sections in the non-woven composite should be greater than 2% by weight.

From Table 1 above, it can be seen that an optimum range of the amount of fibres having multi-lobal cross-sections in the non-woven composite is about 50% to 80% by weight, where a synergistic effect on clo is observable by mixing fibres of multi-lobal cross-sections and generally circular cross-sections. Although an increase in the weight percentage of fibres of multi-lobal cross-sections weight can be seen to generally increase insulation of the composite, it can be seen that when the amount of fibres having multi-lobal cross-sections exceeds 80% by

weight, insulation drops. This may be due to the composite becoming stiffer with straighter air channels that allow air flow through the composite. The same trend was observed regardless of whether the fibres having multi-lobal cross-sections were mixed with polyester fibres having generally circular cross-sections and linear densities of 3 deniers or 7 deniers, or whether the
5 fibres having multi-lobal cross-sections were mixed with staple fibres of other materials such as polypropylene or biocomponent fibers.

To overcome the problem of increased stiffness with increase in weight percentage of fibres having multi-lobal cross-sections, the fibres may be siliconized and or fibres of higher cut
10 length may be used. Siliconization was observed to result in an almost 25% decrease in stiffness, which is considered sufficient for fabrication of a desirable thermal insulation product.

In addition to synthetic fibres, natural fibres may also be mixed with the fibres having multi-
15 lobal cross-sections to form the non-woven composite thermal insulation. Furthermore, as the price of fibres having multi-lobal cross-sections is comparable with the price of fibres of the same material (e.g. polyester) having generally circular cross-sections, fibres having multi-lobal cross-sections may be readily added in large amounts to form the non-woven composite thermal insulation, as may be desired.

20 Whilst there has been described in the foregoing description exemplary embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations and combination in details of design, construction and/or operation may be made without departing from the present invention.

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CLAIMS

1. A thermal insulation for apparel worn in a low temperature environment; the thermal insulation comprising a non-woven composite comprising a mixture of fibres with multi-lobal cross-sections and fibres with circular cross-sections, the non-woven composite reducing heat loss from a wearer of the apparel to the low temperature environment.
2. The thermal insulation of claim 1, wherein weight percentage of the fibres with multi-lobal cross-sections ranges from 2% to 90%.
3. The thermal insulation of any one of the preceding claims, wherein linear density of the fibres with multi-lobal cross-sections ranges from 1 denier to 60 denier.
4. The thermal insulation of any one of the preceding claims, wherein length of each of the fibres with multi-lobal cross-sections ranges from 20 mm to 100 mm.
5. The thermal insulation of any one of the preceding claims, wherein specific density of the non-woven composite ranges from 40 g/m² to 300 g/m².
6. The thermal insulation of any one of the preceding claims, wherein the fibres with multi-lobal cross-sections are made of polyester.
7. The thermal insulation of any one of the preceding claims, wherein the fibres with circular cross-sections are made of polyester.
8. The thermal insulation of any one of the preceding claims, wherein the non-woven composite further comprises fibres of at least one of: polyethylene fibres, polypropylene fibres, biocomponent fibres and natural fibres.
9. Apparel to reduce heat loss from a wearer of the apparel to a low temperature environment, the apparel comprising the thermal insulation of any one of claims 1 to 8.