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IMPROVING THERMAL COMFORT PROPERTIES FOR AUTOMOTIVE SEAT FABRICS USING PHASE CHANGE MATERIALS (PCMS)

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ABSTRACT

PHASE CHANGE MATERIALS (PCMS), THERMAL COMFORT, AUTOMOTIVE SEATS, FUEL ECONOMY, TAILPIPE EMISSIONS, TECHNICAL TEXTILES, CHENILLE YARNS

An operating air-conditioning (A/C) system is currently the largest ancillary load on automobile engines, negatively impacting both fuel economy and tailpipe emissions. Improving the comfort properties by using PCMs is an effective way to increase thermal comfort at little energy cost, resulting in reduced air conditioning needs and fuel use. Automotive seats fabric is well suited for effective use of PCMs due to their large contact area with and close proximity to the occupants. The thermal comfort improvement can be used to reduce the A/C heat capacity by 4 %.

The objective of this study is investigating the impact of fabrics made of chenille yarns containing PCMs on their properties that relate to comfort. These fabrics are mainly designed for seating in public transportation, including automotive.

Introduction

The automobile industry is the largest user of technical textiles, with about 20 kg in each of the 45 million or so cars made every year worldwide [1]. It is estimated that about 45 square meters of textile material is used in an average car and the percentage of textiles in a car is about 2 % of the overall weight of the car [2]. The weight of textile components in automobiles is expected to rise to 35 kg by 2020 [3].

The 20 kg of textiles in an average car is made up approximately from 3.5 kg seat covers, 4.5 kg carpets, 6.0 kg other parts of the interior and tyres and 6.0 kg glass fibre composites [4]. The seat is probably the most important item in the car interior. It is the first thing the customer sees when the car door is opened and he or she will probably instinctively touch it; there is only one opportunity to make the most of this first impression). The seat is also the main interface of man and machine and seat comfort is of paramount importance [3]. The car seat must be comfortable in all senses of the word; psychologically, physiologically and thermally [3].

An operating air-conditioning (A/C) system is currently the largest ancillary load on automobile engines, negatively impacting both fuel economy and tailpipe emissions. An up-to-date solution for thermal comfort control of a car seat is to use microcapsules containing phase change material (PCM) [5]. PCMs are materials that can absorb, store and release large amounts of energy, in the form of latent heat, over a narrowly defined temperature range, also known as the phase change range, while that material changes phase or state (from solid to liquid or liquid to solid) [5]. As shown in below fig.

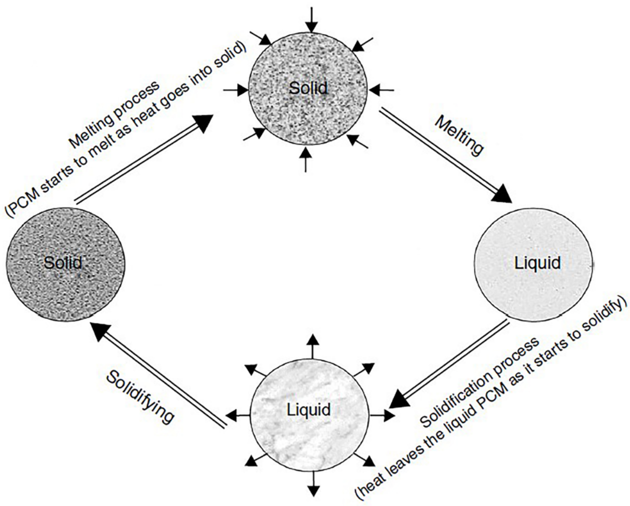


Figure 1 − Schematic of phase cycle of phase change material

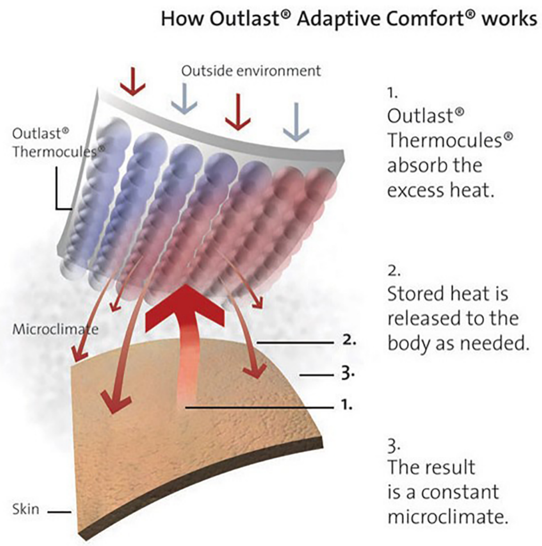


Figure 2 − Functioning principle of PCM in a fabric

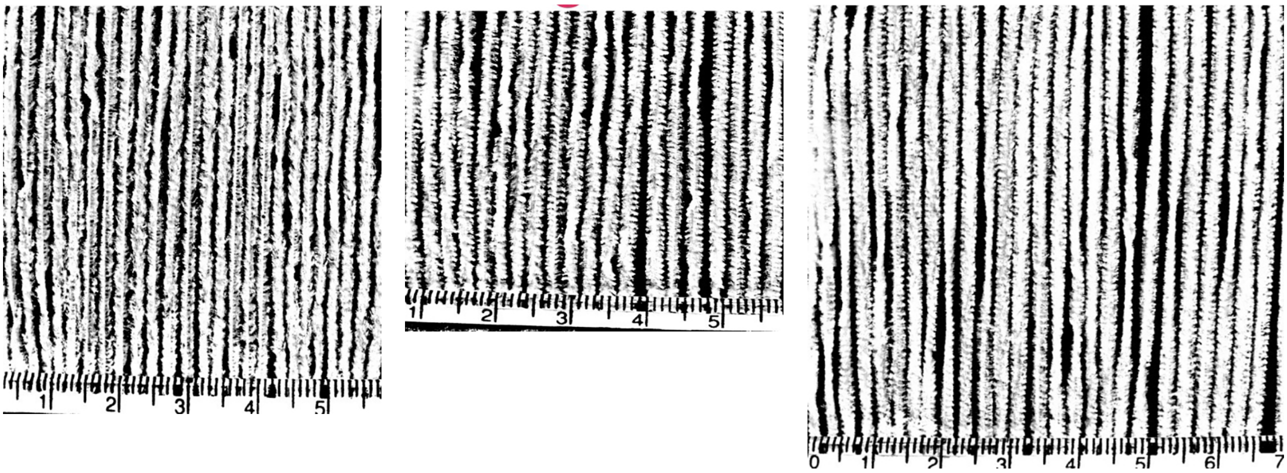
Materials and Methods

The main purpose of the present study is to achieve optimum thermal comfort properties for automotive seat fabrics through these parameters: (Chenille's pile yarn material, Pile length, Weave structures and Auxiliary weft materials).

As a starting point, the methodology of using Chenille yarns for automotive car seats fabric was based on these facts

- Chenille yarns are fancy yarns with aesthetic, soft and fuzzy surface. They have become the choice of designers for many items.
- In this research, our objective is to use the largest percentage of PCMs materials in produced fabrics, this cannot be achieved by using Traditional yarns, so fancy yarns offered a big deal in this issue, especially chenille yarn.

Chenille yarn consists of short lengths of spun yarn or filament that are held together by two ends of highly twisted fine strong yarn. The short lengths are called the pile and the highly twisted yarns are called the core or lock yarn.



2 Ply 3 Ply 4 Ply

Figure 3 – Produced chenille yarns (initial samples)

The previous 3 chenille yarns were used for producing the three chenille fabrics.

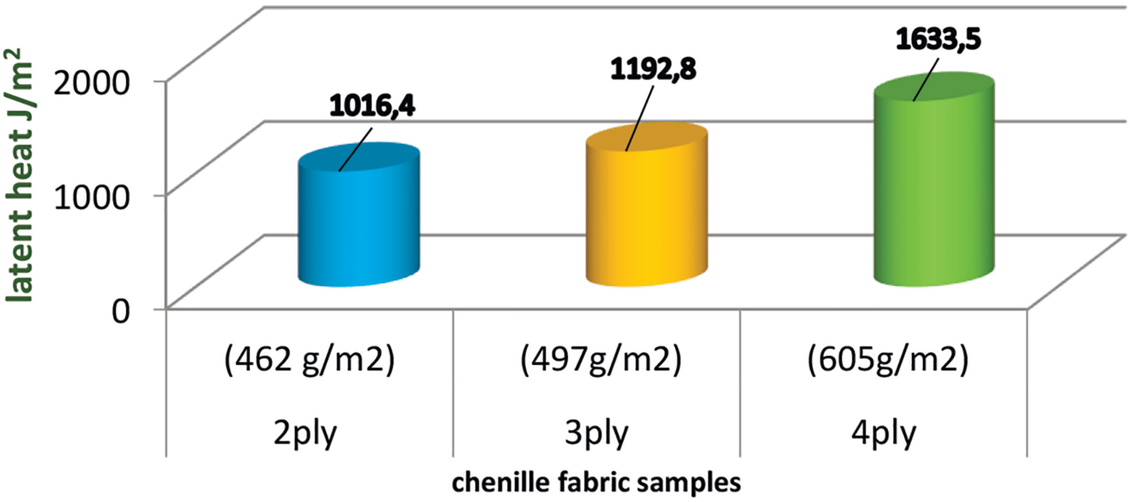


Figure 4 – Preliminary Work (initial samples) DSC test result: produced chenille yarns & fabrics

According to the thermal test result of previous produced chenille yarns and fabrics (initial samples), the research team decided to make some changes in the construction of chenille yarns & fabrics. Chenille yarns (five samples) were produced by using two parameters (pile material & pile length) on the same machine, then these yarns used for producing fifteen chenille fabrics.

Results:

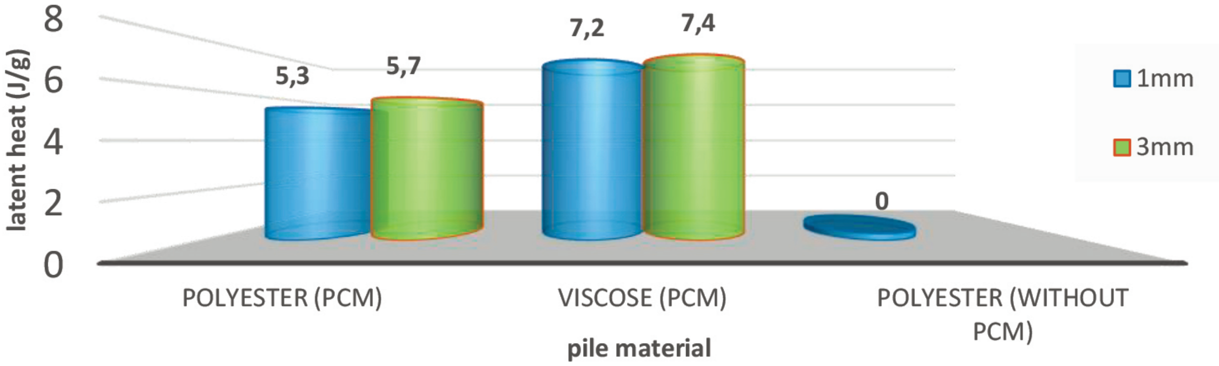


Figure 5 – Yarn thermal capacity (DSC test)

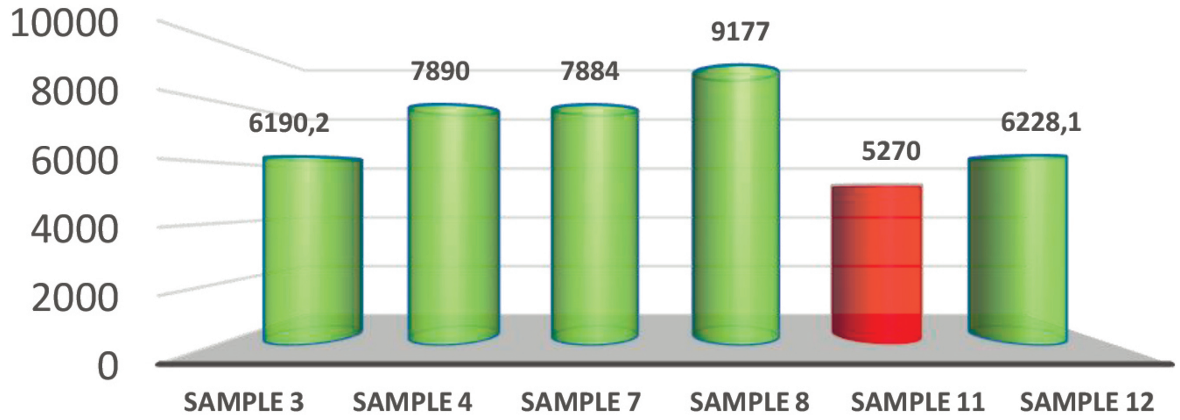


Figure 6 – Samples with the Best heat capacity

Conclusion:

1. Chenille yarns containing phase change materials (PCMs) were achieved overcoming several technical production procedures.

2. Our findings show that there is a tendency to an increase in latent heat readings with the increase in number of Chenille's pile yarn. That's to say Chenille yarns number plays a critical role in holding latent heat within the structure.

3. We also conclude that increasing PCMs percentage in the produced fabrics lead to an increase in thermal comfort of car seat fabrics (latent heat %)

4. Improving the comfort properties by using PCMs is an effective way to increase thermal comfort at little energy cost, resulting in reducing air conditioning and fuel consumption.

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