Structural and machine development for processing high volume weft material and its integration in multilayer weave structures for thermal insulation applications

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Abstract: To date, thermal insulating multilayer structures have been fabricated through a multi-stage process involving the production of individual layers followed by a connecting sewing procedure. Typically, these structures consist of an upper and lower layer with insulating material sandwiched in between. The enclosured air volume within these structures provides significant insulation potential. However, the sewn joints introduce cold bridges, which substantially diminish this potential [1, 2]. The weaving technology offers the opportunity of integral woven complex and multimaterial structures. By using this technology the different layers of thermal insulating structures are woven and joined in on process step with avoiding cold bridges. This technologie offers a high insulating potential hand in hand with sustainable use of material as a main target of the textile industrie [3].

The advancement of rapier weaving technology as an integrated production solution for thermal structures aims to circumvent the aforementioned cold bridges and the associated complex adaptive process. This entails replacing separate upper and lower layers with a chambered multi-layer fabric. The layers are interconnected via a binding warp system, obviating the need for sewing. Additionally, an integrated heating structure ca be incorporated to enhance performance if deemed necessary.

The integration of thermal insulating nonwoven material in the weft direction presents two primary challenges. Firstly, there is the consideration of structure and pattern design due to jacquard technology [4]. This entails accommodating the differing cross-sections of conventional weft yarns and functional elements, ensuring synchronization of insertion cycles and weave patterns. The research objective thus revolves around developing tailored bindings for multi-layer structures, considering variations in weft dimensions and the integration of the binding warp system.

Moreover, individual thread courses and resulting structural consequences exert varying influences on the thermal performance of the structure, affecting heat transfer to differing extents. Consequently, there is one focus on customizing cover layers to meet the specific requirements of end-users, individualisation and applications [5].

A further challenge lies in incorporating nonwoven material as a weft element, necessitating the ability to withstand high forces during insertion without sustaining damage. Additionally, adaptations to weaving machines designed for conventional threads or alternative insertion methods are required. Technological and mechanical engineering interventions are essential of the preparation of nonwoven fabric, including assembly and reinforcement, as well as for the insertion process itself.

Keywords: *thermal insulation, multilayer woven structure, cold bridges*

Figure 1 Chambered insulating multilayer structure

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