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ARAŞTIRMA MAKALESİ RESEARCH PAPER

Investigation of Thermal Conductivity of Wood Sandwich Panels with Aluminium and Polypropylene Core [*]

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Abstract: Sandwich panels are obtained by placing thick but rather light core material between two thin and rigid lower and upper surface layers. Sandwich panels, especially due to their light weight, high "strength / weight" ratio and durability compared to conventional materials have many use areas such as aviation and space industry, maritime, automotive and building industry. It is one of the biggest advantages that sandwich materials can be obtained from different materials and geometric structures by choosing the lower and upper surface layers and the core for various applications. The aim of this study is to investigate the thermal conductivity values of the sandwich panels, which are manufactured with different types of surface and core materials in sandwich panels. An aluminium and polypropylene as a core materials and alder, birch and scots pine wood veneers were used as wood species for surface panels for manufacturing of sandwich panels. A polyurethane modified epoxy- adhesive was used for binding of core layer to both surface layers. Thermal conductivity of sandwich panels was determined according to ASTM C 518 & ISO 8301. As a result of the study, the highest thermal conductivity values were obtained from aluminium core sandwich panels. The highest values were obtained from alder for the aluminium core panels and scots pine for the polypropylene core panels as wood species.

Keywords: Aluminium, core, polypropylene, sandwich panel, thermal conductivity.

Alüminyum ve Polipropilen Çekirdekli Sandviç Panellerin Isıl İletkenliklerinin Araştırılması

Öz: Sandviç paneller, iki ince ve sert alt ve üst yüzey tabakasının arasına kalın fakat hafif çekirdek malzeme yerleştirilerek elde edilir. Sandviç paneller, özellikle hafiflikleri, yüksek "kuvvet / ağırlık" oranları ve geleneksel malzemelere göre dayanıklılıkları nedeniyle havacılık ve uzay endüstrisi, denizcilik, otomotiv ve inşaat endüstrisi gibi birçok kullanım alanına sahiptir. Sandviç malzemelerin, farklı uygulamalar için alt ve üst yüzey katmanları ve çekirdeği seçilerek farklı malzemelerden ve geometrik yapılardan elde edilebileceği, en büyük avantajlardan biridir. Bu çalışmanın amacı, farklı yüzey ve çekirdek malzemeleri ile üretilen sandviç panellerin ısıl iletkenlik değerlerini araştırmaktır. Çekirdek malzeme olarak, alüminyum ve polipropilen; kızılağaç, huş ve sarıçam kaplamaları, sandviç panellerin üretiminde yüzey panelleri olarak kullanılmıştır. Çekirdek tabakanın her iki yüzey tabakasına yapışması için poliüretan ile modifiye edilmiş bir epoksi yapıştırıcı kullanılmıştır. Sandviç panellerin ısıl iletkenliği ASTM C 518 ve ISO 8301'e göre belirlenmiştir. Çalışma sonucunda, en yüksek ısıl iletkenlik değerleri, alüminyum çekirdekli sandviç panellerinden elde edilmiştir. Alüminyum çekirdekli paneller için kızılağaçtan en yüksek değerler elde edilmiş ve polipropilen çekirdekli paneller için çam ağacından elde edilmiştir.

Anahtar sözcükler: Alüminyum, çekirdek, ısıl iletkenlik, polipropilen, sandviç panel.

[*]This article was presented at ORENKO 2018 congress.

INTRODUCTION

Sandwich panels are used for variety of structural applications, including building construction, transportation, decking, marine and aerospace because of their high energy absorption ability, high bending stiffness and light weight (Li et al., 2014; Aslan et al., 2017). They are favoured for their high specific strength and stiffness, corrosion resistance, tailor ability, and stability. Sandwich panels are very suitable for lightweight structures requiring high in-plane and flexural stiffness (Gustin et al., 2005). Additionally, they are usually based on two thin face sheets with high stiffness and strength, and a compliant and light-weight core that maintains the distance between the faces and sustains deformation, often with insulation properties. By varying the material and thickness of core and face sheets, it is possible to obtain sandwich panels with different properties and performance (Steeves and Fleck, 2004). The properties of interest for core materials include, among others, low density and good thermal and acoustic insulation characteristics. Commonly used core materials are honeycombs, foams and balsa wood, but other alternatives of cellular core structures are being proposed (Lakreb et al., 2015).

Most of the sandwich panels are made of honeycomb and foam cores with surface materials (Pan et al., 2008; Vaziri et al., 2006; Qin & Wang, 2013). Especially, the sandwich panel composites that have open cells provide the multifunctional benefits to composite such as the high stiffness strength and high specific strength (Xiong et al., 2010; Joo et al., 2011; Xiong et al., 2016). Honeycomb sandwich structure consist of a thick layer (core) intercalated between two thin-stiff surface layers (skin). Honeycomb sandwich core is cellular solid that used void to decrease mass, while maintain qualities of stiffness and energy absorption. Honeycomb sandwich composite are widely used to replace traditional material in highly loaded application such as automotive and aviation industry (Newstead et al., 2008; Forsberg et al., 2006; Aslan et al., 2017).

With the increasing adversity of climate changes from global warming, discussions within the international community for establishing an appropriate response policy have become more urgent (Seo et al., 2011). In facing the global warming trend, there is a dire need for more effective measures to sustain comfortable temperatures in living environments. To sustain an indoor temperature that is independent of outdoor temperature fluctuations, materials need to be developed that have superior thermal insulation abilities (Kawasaki & Kawai, 2006). Thermal conductivity is a very important parameter in determining heat transfer rate and is required for development of thermal insulation of materials (Sahin Kol & Altun, 2009). Several studies about thermal conductivity of composite materials showed that thermal conductivity was influenced thickness of composite materials, density, moisture content, temperature, material space ratio and flow direction of heat (Suleiman et al., 1999; Bader et al., 2007; Sonderegger & Niemz, 2009; Aydin et al., 2015).

The aim of this study is to investigate the thermal conductivity values of the sandwich panels, which are manufactured with different types of surface and core materials in sandwich panels. An aluminium and polypropylene as a core materials and alder, birch and scots pine wood veneers were used as wood species for surface panels for manufacturing of sandwich panels.

MATERIAL and METHODS

In this study, aluminium and polypropylene (PP) as honeycomb core materials and alder, birch and scots pine veneers as face sheet materials were prepared in 30 × 30 dimensions for the manufacture of sandwich panels. The polyurethane modified epoxy- adhesive was used for binding of core layer to both surface layers. The hardener was added in the adhesive at 20%. Figure 1 shows a sandwich panel production.

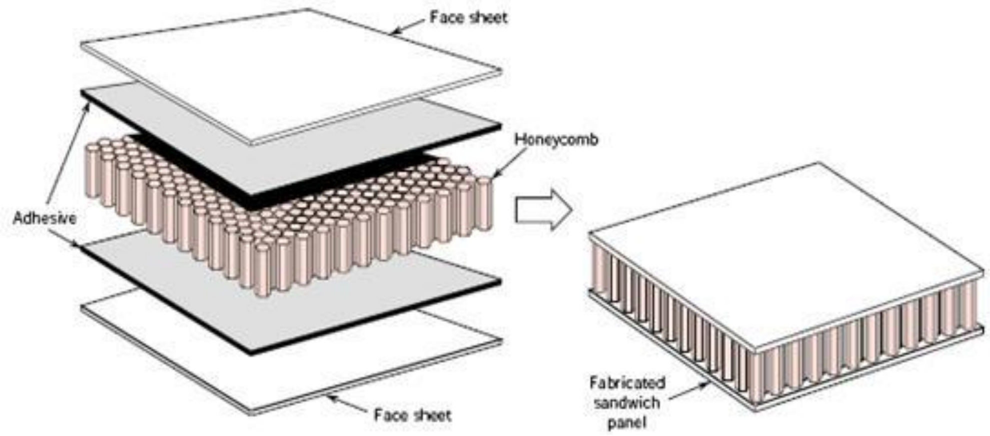

Figure 1. Sandwich panel production.

Depending on the adhesive and surface materials used in this method, the sandwich composite panels were pressed at 80°C, under pressure of 10 kg/cm^2 and for 15 minutes and then are waited 24 hours in the press without temperature and pressure.

The thermal conductivity of the sandwich panels was determined according to ASTM C 518 & ISO 8301 (2004). Sample size required is 300x300xpanel thickness mm. Two specimens were used for each group. The tests were made at laboratory of Forest Industry Engineering in KTU. The Lasercomp Fox-314 Heat Flow Meter shown in Figure 2 was used for the determination of thermal conductivity.

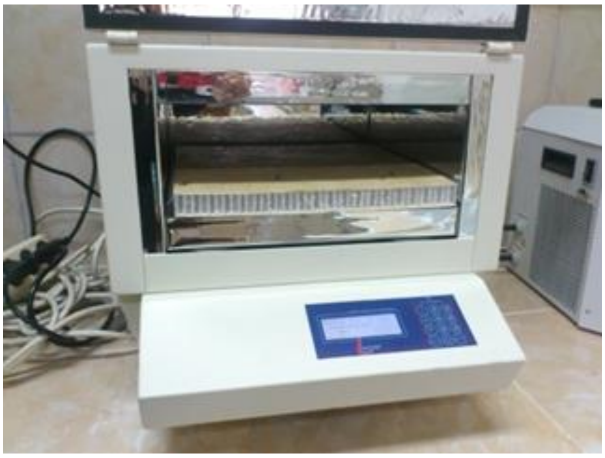

Figure 2. Lasercomp Fox-314 Heat.

RESULTS and DISCUSSION

The thermal conductivity values of the sandwich panels compared to other building materials (sand, gravel, cement, glass, concrete) are given in Figure 3 according to wood species and core materials.

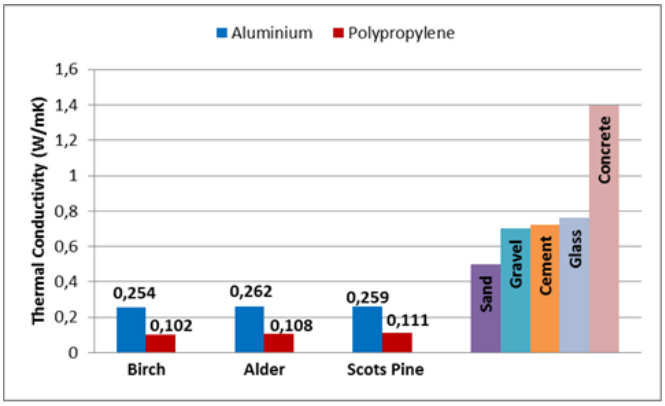

Figure 3. Thermal conductivity values of the sandwich panels and other materials (W/mK).

As can be seen that Figure 3, the highest values were obtained from alder for the aluminium core panels and scots pine for the polypropylene core panels as wood species. The highest thermal conductivity values were obtained from aluminum core sandwich panels. The thermal conductivity values of all sandwich panels were lower than the thermal conductivity values of other building materials. Thermal conductivity of wood based materials is vary according to wood species, direction of wood fiber, resin type, addictive members, impregnate materials and processes used in the manufacturing of wood based composite panels (Kamke et al.,1989; Sahin Kol et al.,2010; Kol et al., 2010; Demirkir et al., 2013). Also, several studies about thermal conductivity of composite materials showed that thermal conductivity was influenced thickness of composite materials, density, moisture content, temperature, material space ratio and flow direction of heat (Suleiman et al., 1999; Bader et al., 2007; Sonderegger & Niemz, 2009; Aydin et al., 2015).

CONCLUSIONS

The aim of this study is to investigate the thermal conductivity values of the sandwich panels, which are manufactured with different types of surface and core materials in sandwich panels. The thermal conductivity values of all sandwich panels were lower than the thermal conductivity values of other building materials. The thermal conductivity values of alder and scots pine sandwich panels were higher than those of birch sandwich panels as similar as density values. This study showed that sandwich panels produced from aluminium and polypropylene as core materials and alder, birch and scots pine wood veneers can be used as an alternative insulation material.

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