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Core Material Manufacturing Study On Aluminum *Composite* Panel (ACP)

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Abstract. An aluminum composite panel (ACP) is a flat panel with aluminum plates/sheets that are rigid and strong but relatively lightweight. Between the two plates, the core material content is generally made of polyethylene and polyurethane. However, the two core materials are not resistant to high temperatures/heat. They are flammable, so it is urgent to make variations of other core materials resistant to high temperatures. This study aims to provide variations for ACP core materials using polymer materials resistant to high temperatures, namely Low-Density polyethylene (LDPE) and Polyoxymethylene (POM). The method used is experimental/fabrication of ACP making. The high-temperature test was carried out in a furnace with a temperature of 300^0C, 350^0C, and 400^0C, each with a holding time of 1 hour. The results obtained from observing the microstructure using an Optical Microscope before and after the test damaged the core material while the Aluminum metal was still intact. The mass of ACP before and after testing also changed. Overall, at the three temperatures above, the LDPE core material does not withstand this temperature because the temperature is above the melting point of the LDPE material.
Keywords: Aluminum Composite Panel, core material, Low-Density Poly Ethylene, Polyoxymethylene, high-temperature test

INTRODUCTION

Law Number 28 of 2002 and Regional Regulation of the DKI Regional Government No. 7 of 2010 regulate the rules for constructing high-rise buildings. One *point* regulated in the law is the use of fire-resistant building materials, especially in high-rise buildings. But in reality, almost all of these buildings are lined with artistic and magnificent colorful wall layers made of ACP *Aluminum Composite Panel* (ACP) panels. ACP is two materials that are joined together (by pressing) between two aluminum plates/sheets (top and bottom layers) and between them in the *core* of the material/material of the polymer (the standard material used is generally polyethylene (PE) or polyurethane (PU). The combination of aluminum and this core material is called composite material. So the shape of ACP is a flat panel with a rigid, strong, but relatively light aluminum plate/sheet. While between the two plates is filled with a core of polymer material (Figure 1). ACP is usually produced with

specifications: standard size width (1000, 1250, 1500, 1570)mm, length: customize, maximum length up to 6000mm, and ACP thickness: 2mm,3mm,4mm,5mm,6mm.

ACP material is generally used as an exterior wall cladding (Figure 2) to highlight the artistic and magnificent impression on the façade, meaning the exterior of a building placed in a commercial building such as a shopping center, business center, hotel, or shophouse. It is commonly combined with glass, billboards, or canopy panels [1]. In addition, ACP is also used in the interior. Usually, ACP is used for partitions, column covers, and also for artistic ceilings of interior walls (Figure 3).

ACP core material, which is made of polyethylene or polyurethane, is not resistant to heat and is flammable, so it significantly affects the combustion power and spread of fire outside or inside the building. Currently, the use of ACP with a polyethylene composition of more than 30% has been banned as building cover panels in developed countries in Australia and Europe.

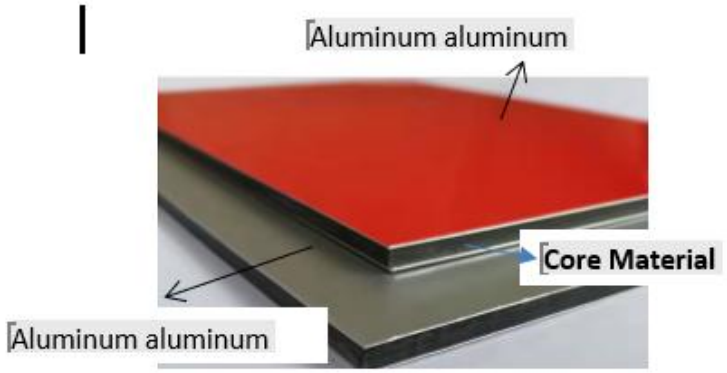
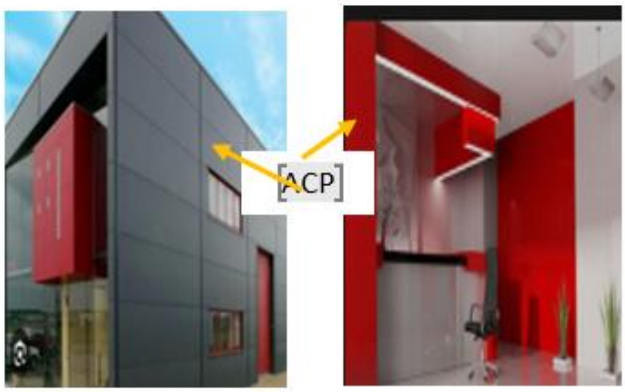


Figure 1. Aluminum plate/sheet *Composite Panel* (ACP) [2]

The condition of the building fire that used ACP as a layer to cover the indoor walls, ceiling, and exterior of the building façade approximately four years ago was the Attorney General's Office (Kejagung) building in Kebayoran Baru, South Jakarta [3] (Figure 4). The core material of ACP used is polyethylene, which is not heat/fire resistant, so when it burns, this polyethylene drips on other flammable materials in the building, so that in a short time, the red jago is very mighty to destroy the building which is the asset and pride of the Adhyakasa corps and all Indonesian people, has burned down in a short time.



Picture. 2 ACP for Figure 3. ACP exterior for interior

Figure 4. Prosecutor's Office Building Burned Agung (Attorney General) in Kebayoran Baru, South Jakarta

ACP core material before dripping due to burning; when exposed to high temperatures, the core layer can bubble, resulting in an uneven aluminum surface that can reduce beauty. On the other hand, the force against wind pressure is not strong enough, so in poor construction, it will be a risk to safety,

The research aims to make ACP with core materials made of *Low-Density polyethylene* (LDPE) and Polyoxymethylene (POM). LDPE is a thermoplastic that can be processed by heating and cooling it. Its white characteristics have a melting point between 110 ^{0}C-137 ^{0}C, and it is relatively thin, flexible, clear, and light, so it is easy to use as a variety of materials or products. LDPE tends to be insensitive to light changes, so it is easy to change color due to sunlight's influence, producing black material [4]. The dimensions of the LDPE sample for the high-temperature test are 25 cm long, 24 cm wide, and 10 mm thick.

Figure 5 Chemical structure of Polyoxymethylene (POM)

POM materials known as acetal, polyacetal, or polyformaldehyde are engineering plastics first developed in the late 1950s. The sample dimension scheme used for ACP is 25cm long, 25cm wide, and 5 mm thick. The chemical structure of POM is in Figure **5**. Polyoxymethylene is a kind of linear polymer without side chains, with high density and crystallinity and excellent comprehensive properties. It is a hard and dense material with a smooth and shiny surface, light yellow or white in color, which can be used for a long time in the temperature range of 40-100 ^{o}C. Its wear and lubrication resistance is also superior to most engineered plastics, and it has good oil and peroxide resistance. Highly resistant to acids, alkalis, and the sun's ultraviolet radiation.

Polyoxymethylene has a tensile strength of 70MPa, small water absorption, stable size, and luster, which is better than nylon. It also has high heat resistance, bending strength, fatigue resistance, excellent wear resistance, and electrical performance. It burns slowly and smokes slightly.

METHOD

The research method is shown in the *flow chart* presented in Figure 6. The core materials used are LDPE and POM. Before temperature testing, high observation of microstructures was done using an optical microscope (MO) and weighing. ACP samples.

The glue for ACP adhesion is aluminum-core aluminum material using the OCI N193 Aluminum glue type. Meanwhile, the fire-retardant coating *is a form of* fire-retardant liquid (671^{o}C) mixed with thinner.

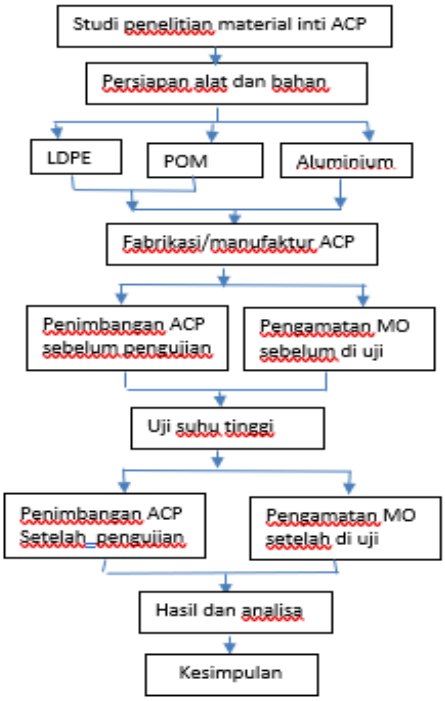


Figure 6. Flow chart research

DISCUSSION

The schematic of the ACP results is shown in Figure 7.

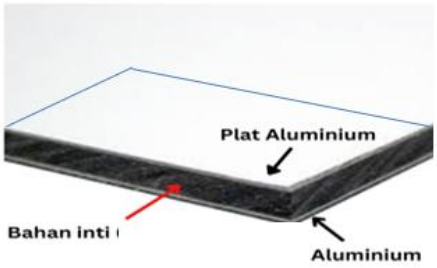


Figure 7. Aluminium Composite Panel (ACP) Schematic. The Result were obtained after the ACP material was presed to become very sticky to each other (red circle) (Figure 8)

Figure 8 Material results after doing Bonding by pressing

The complete ACP material for the LDPE core material is shown in Figure 9a,b,b1, and the ACP material for the POM core/*core* material is shown in Figure 10a,b.

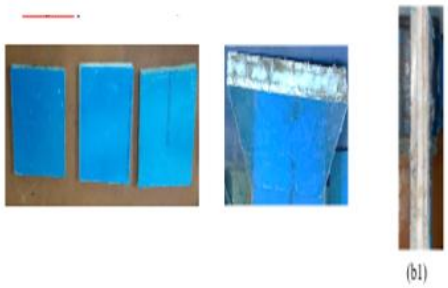


Figure 9a,b,b1 ACP material with the core material being LDPE

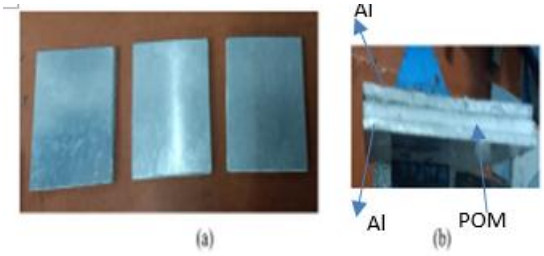


Figure 10 a,b ACP material with material core POM

High-temperature testing by means that all samples (3 ACP samples with LDPE core material and 3 ACP samples with POM material) are put into a furnace heated at 300ºC, 350ºC, and 400 ºC respectively, at *a holding time* of 1 hour. The results after the high-temperature test, ACP material with LDPE and POM core materials are shown in Figure 11a,b,c for LDPE and Figure 12a,b,c for POM core material.

All the core materials of LDPE melted and evaporated, leaving only the alumni. This happens because the melting point of LDPE is only around 150ºC, while the high-temperature test is above that temperature.

(a)

(b)

(c)

Figure 11a,b,c ACP with core material LDPE that melts and evaporates during the test High temperature

(a)

(b)

(c)

Figure 12a,b,c ACP with core material POM that melts and sticks during the test High Temperature

After heat resistance tests, all POM core materials become melted and sticky with aluminum (Figure 12a). The side view is shown in Figure 12 b,c). The melting point of POM is about 260^{o}C. The mass of ACP with LDPE and POM core materials before and after testing is shown in Table 1 and Table 2.

Table 1. Mass of ACP with material core LDPE before and after being tested

LDPE (for High Temperature Test)	Mass before testing (grams)	Mass after testing (grams)
	2251	1756
	2314	1686
	2302	1885

The mass of ACP with LDPE core material increases after the heat resistance test compared to before the test. This condition occurs because the LDPE core material melts and evaporates completely due to the heat test above its melting temperature. While for the core material of POM, melted and sticky into one with the aluminum, so that the mass becomes large, which is 4925 grams.

Table 2. Mass of ACP with material POM core before and after being tested

POM (for High Temperature Test)	Mass before testing (gram)	Mass after testing (gram)
	2259	4925
	2479	
	2313	

Observation of the microstructure before testing, for LDPE and POM core materials in Figure 13a,b. Figure 14 showed the microstructure of the POM core material (1000x magnification) after heat resistance testing. The observation of the microstructure of the LDPE core material after the heat resistance test is not present because the LDPE core material is not present (because it melts and evaporates is all gone).

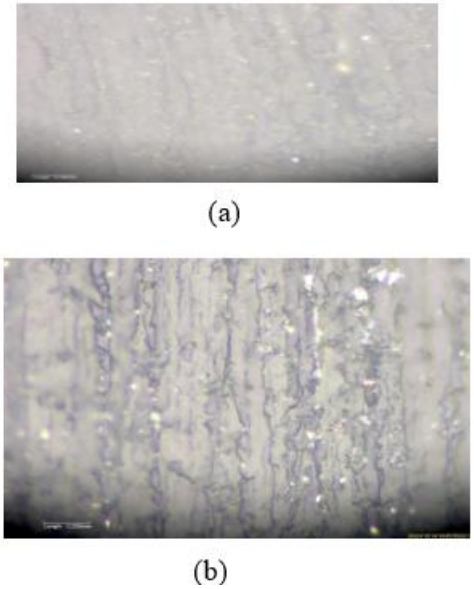


Figure 13 (a) Microstructure of LDPE core material, (b) Microstructure of POM core material (1000x magnification) before heat resistance test.

CONCLUSION

This study concluded that Aluminum Composite Panels (ACP) can be made with LDPE and POM core materials. The results of the heat resistance test show that POM material is more heat resistant than LDPE material.

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BIBLIOGRAPHY

M. Selvakumar, Dr.D. Jafrey Daniel James M.E.,Ph.D, Dr.K.R. Thangadurai M.E.,Ph.D, 2021, *A Deep Study on Aluminum Composite Panel: Applications, Merits, and Demerits*, International Journal of Mechanical Engineering, Vol. 6 (Special Issue, Nov.-Dec. 2021) ISSN: 0974-5823.

Alfari, S, 2016, Getting to Know Aluminum Composite Panel (ACP). (https://www.arsitag.com/article/mengenal-alumunium-composite-panelacp). Retrieved December 31, 2023.

.https://www.idntimes.com/news/indonesia/lia-hutasoit-1/material-acp-jadi-biang-kebakaran-cepat-merambat-gedung-kejagung, "ACP Material Becomes the Cause of the Fire Quickly Spreading to the Attorney General's Building".

Sriwijaya State Polytechnic, Journal of Kinetics Vol. 9, No. 03 (November 2018): 1 - 6 1 Issn: 1693-9050 E-Issn: 2623-1417 Https://Jurnal.Polsri.Ac.Id/Index.Php/Kimia/Index Processing of Low Density Polyethylene (Ldpe) and Polypropylene (Pp) Waste into Alternative Liquid Fuel Using The Prototype of Pyrolysis Thermal Cracking Processing Of Low Density Polyethylene (Ldpe) And Polypropylene (Pp) Waste Into Alternative Liquid Fuel Using The Prototype Pyrolysis Thermal Cracking Yohandri Bow1,A), Zulkarnain1 , Sutini P. Lestari1 , Steven R.M. Sihombing1,b), Siti A. Kharissa1 , Yosirham A. Salam or Zotero

Handayani S, Purwanto WW, Dewi EL, Roekmijati D, Soemanto W. Synthesis and Characterization of Sulfated Ketone Polyether-Ether Electrolyte Membranes (Sri Handayani).

Plavčić P. Polieter eter keton u vodenom okolišu [Internet]. Available from: https://urn.nsk.hr/urn:nbn:hr:149:626502

Wang P, Zou B, Xiao H, Ding S, Huang C. Effects of printing parameters of fused deposition modeling on mechanical properties, surface quality, and microstructure of PEEK. J Mater Process Technol. 2019 Sep 1; 271:62–74.

Dipak G. Vamja, G. G. Tejani, 2013, *Experimental Test on Sandwich Panel Composite Material*, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 7, July 2013 (IJIRSET), Vol. 2, Issue 7, July 2013, ISSN: 2319-8753.

Bahari, Choirul Anam, 2019, *Utilization of Aluminum Composite Panel (ACP) Pieces as Work Station*, Seminar on Planning, Design, Environment, and Infrastructure Technology, ISSN (Print): 2715-4513, FTSP ITATS - Surabaya, August 28, 2019 ISSN (Online): 2715-4599

Ajun Hariono, Azhar Pangarso Laksono, Rahmandia Prasetia, Muhammad Firhand Agustio, 2023, *Fire Safety Performance of the Use of Aluminum Composite Panel (ACP) In Building*, Journal of Settlements, Volume 18 Number 2, pp. 92 –102, November 2023 ISSN: 1907 – 4352, E-ISSN: 2339 – 2975

Prantasi Harmi Tjahjanti, Iswanto, Edi Widodo, Sholeh Pamuji, 2023, *Examination of Thermoplastic Polymers for Splicing and Bending*, Nano Hybrids and Composites, (Volume 38) Pages:87-97, ISSN: 2297-3400, DOI: https://doi.org/10.4028/p-8myjhn, https://www.scientific.net/NHC

Prantasi Harmi Tjahjanti, Rachmat Firdaus, Iswanto Iswanto, Ahmad Nova Irfian, 2022, Corrosion Protection Of Low Carbon Steel By Coating Of Graphene Oxide Nanoparticles And Galvanization Process, Journal of Nanostructures (Abbreviation: J Nanostruct), Articles in Press, Accepted Manuscript, Published 01 January 2022, https://jns.kashanu.ac.ir/issue_15362_15363.html, Volume 12 (2022), Issue 1.

Prarantasi Harmi Tjahjanti, Rachmat Firdaus, Iswanto, Rizky Nurcahyo, Sofia Ariyani, Andita N.F.Ganda , 2020, *Utilization of Graphite Bars on Used Batteries Become Coating Material for Steel*, International Journal of Emerging Trends in Engineering Research, Volume 8. No. 6, June 2020, Pages: 2481-2485, ISSN 2347 – 3983, https://www.academia.edu/43635512/Utilization_of_Graphite_Bars_on_Used_Batteries_Become_Coating_Material_for_Steel

Prantasi Harmi Tjahjanti, Darminto, Wibowo Harso Nugroho, Andita Andita N.F.Ganda, 2019, *Study of Corrosion Penetration Rate on Composite Materials EN AC-43100 (AlSi10Mg (b)) + SiC**, International Journal of Integrated Engineering (IJIE), Vol 11 No 6 (2019), Publish: 2019-09-05, ISSN : 2229-838X, e-ISSN : 2600-7916
https://publisher.uthm.edu.my/ojs/index.php/ijie/article/view/2795

Prantasi Harmi Tjahjanti, Mulyadi, A. Zubaydi and S.H. Sujiatanti, 2019, Finite element analysis of material AlSi10Mg(b) and AlSi10Mg(b)+SiC*15p, Journal of Engineering Research, October 2019, pp. 50-56, Published: 2019-10-28, ISSN : 2307-1877 ,e-ISSN : 2307-1885 https://kuwaitjournals.org/jer/public/journals/special_issue_1/6.pdf]