High Density Polyethylene (HDPE) as a Prominent Marine Small Craft Building Material: Opportunities and Obstacles.

Ayberk Sözen [1,2], Gökdeniz Neşer [2]

[1] Dokuz Eylul University,
The Graduate School of Natural and Applied Sciences,
Izmir, Turkey

[2] Dokuz Eylul University,
Institute of Marine Sciences and Technology,
Izmir, Turkey,
(E-mails: ayberk.sozen@deu.edu.tr, gokdeniz.neser@deu.edu.tr)

Keywords: *High Density Polyethylene (HDPE), marine small craft building, manufacturing methods for thermoplastic boat building.*

Abstract: The existing and potential uses of HDPE in marine industry have been introduced in detail, in this study. The methods of manufacturing with HDPE have been compared in terms of usage characteristics such as design approach, cost, time, and performance by experts and users opionions. Apart from these conventional methods, additive manufacturing methods (AMMs) has come into prominence today's small craft industry and HDPE has been considered as a potential material for this method in spite of its obstacles. The ways of improvement of HDPE for AMMs such as "reinforcements with glass or carbon fibres" has been also introduced based on early experimental results.

1. INTRODUCTION

HDPE, as the most used plastic material, with low moisture absorption, good resistance to chemicals, marine organisms and corrosions, sufficient mechanical performance, reasonable cost in structures pipes, cables, plates and geo-membranes has been attracted the attention of the marine industry for decades [1]. Chronologically, in 1970s HDPE small marine crafts with relatively complex forms up to 5 meters of length overall produced by means of rotation moulding method in which a heated mould rotates in a fixed orbit, plastic granules adhere to the mould under the influence of centrifugal force and are reshaped by cooling [2]. To reach larger boat with the same material, the plastic welding method were developed starting from 2010s. By using this method which does not allow designers to study complex form, patrol boats, passenger vessels and even fishing boats over 20 meters of length overall were produced. Another method emerged from 1980s, additive manufacturing, has been gained a popularity in marine small craft building from the late 2010s [3,4]. However, apart from the other thermoplastics, using HDPE in this method is still problematic due to thermal deformation and weak layer adhesion [5,6]. To solve these problems new glass and carbon fibre reinforced composite materials based on HDPE matrix have been investigated in today's naval architecture research field.

2. METHODOLOGY

The usage characteristics of HDPE due to the production method have been evaluated by the expert studied in small marine craft building area as designer, manufacturer, supplier and researcher. Their evaluations have been analysed by Analytical Hierarchical (AHP), which is a decision-making process included in the hierarchical analysis developed by Saaty in the early 1970s. This method helps decision makers to systematically prioritize many alternatives by effectively implementing a multi-criteria decision-making process, which includes the measurement criteria of various features and decision factors.

3. RESULTS AND DISCUSSION

AHP results have been given in in the Table 2. Efficient production method changes according to boat type, preference, and priority.

Table 1. AHP results and rank of the production methods

	Dinghy (n>=10)	Fishing Boat (n<10)	Passenger boat (n<10)	Patrol Boat (n<10)	USV (n<10)	Yacht (n<10)
Rotational moulding	1 (42%)	2 (29%)	3 (23%)	3 (19%)	3 (22%)	3 (18%)
Sheet welding	2 (30%)	1 (56%)	1 (50%)	1 (62%)	2 (38%)	2 (30%)
Additive manufacturing	3 (27%)	3 (15%)	2 (28%)	2 (%20)	1 (40%)	1 (%51)

4. CONCLUSIONS

HDPE is a quite prominent material in the whole marine industry. For its use in small craft building, it is advised that deciding a particular method should be on a case-by-case basis by considering above mentioned characteristics.

References:

[1] Siswandi, B., Aryawan, D., HDPE vessel of Pompong as a fishing vessel for Bengkalis Fisherma, IPTEK Journal of Proceeding Series, 2, 2017, pp. 108-113.

[2] Garces, J.M., Moll, D.J., Bicerano, J., Fibiger, R., McLeod, D., Polymeric nanocomposites for automotive applications, Adv Mater., 23, 2000, pp. 1835–1839.

[3] Aloyaydi, B., Sivasankaran, S., Mustafa, A., Investigation of infill-patterns on mechanical response of 3D printed polylactic-acid. Polymer Testing, 87. 2020

[4] Strickland, J., Strickland, D., Applications of Additive Manufacturing in the Marine Industry. Practical Design of Ships and Offshore Structures, 2016

[5] Ge, Q., Qi, H. J., Dunn, M., Active materials by four-dimension printing, Applied Physics Letters, 103, 2013,

[6] Ding, Z., Yuan, C., Peng, X., Wang, T., Qi, H. J., Dunn, M., Direct 4D printing via active composite materials, Science Advances, 34, 2017