COMPARISON OF SINGLE AND TWIN SCREW EXTRUDERS FOR THE PRODUCTION OF GLASS AND CARBON REINFORCED HIGH DENSTIY POLYETHYLENE (HDPE) FILAMENTS

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ABSTRACT

HDPE is a newly used thermoplastic for additive manufacturing but there is some problem to overcome. They need to be strengthened with various micro size additives. The distribution of the fibers in the matrix is of vital importance. The production process is affected by many parameters such as temperature, extrusion speed, cooling rate, matrix, and fiber particle size. In this study, a comparison was made by using single and twin-screw extruders to produce 10% glass and carbon and reinforced HDPE filaments. Mechanical properties were evaluated based on tensile tests. Reinforcing fiber to the HDPE matrix increases the tensile strength. If the matrix and fiber particle size are reduced to 250µ before the extrusion, it is possible to achieve high tensile results close to twin screw extrusion with single screw extrusion, but homogeneous distribution of fibers in the matrix is not satisfactory.

Keywords: Single screw extruder, twin screw extruder, filament production, additive manufacturing

1. INTRODUCTION

In marine industry, for almost ten years, HDPE with its good resistance to environmental degradation effects such as UV, marine organism, and corrosion *(Rajeshwari & Dey, 2014)* has been care into prominence. Using HDPE in production of small marine craft by additive manufacturing techniques needs to overcome the difficulties of thermal defects. To improve mechanical performance of HDPE, it needs to be reinforced with various additives such as micro-sized glass and carbon fiber *(Guo, Finkenstadt, & Nimmagadda, 2019)*. During this reinforcement process, the distribution of the fibers in the matrix is of vital importance. The production process is affected by many parameters such as temperature, extrusion speed, cooling rate, matrix, and fiber size *(Grande & Torres, 2005)*. While the single screw extrusion process is easier, simpler, and less costly, it is more vulnerable to manufacturing errors.

2. MATERIALS AND METHODS

In this study, a comparison was made by using single and twin-screw extruders to produce 10% glass and carbon and reinforced HDPE filaments. Mechanical were evaluated based on tensile tests. PETILEN YY I668 product of PETKİM company was used as the matrix. For single screw extrusion, pellet sizes were reduced to 250 µ by grinding and the surface area was increased. The mixture is tried to be homogenized with an ultrasonic mixer in single screw extrusion. Recycled glass and carbon fibers with a diameter of 100-400 µ were used as filament with fiber sizes vary. 1,75 mm diameter filament was extruded. D638 ASTM type V size tensile specimens were printed, and mechanical properties were investigated. In addition, the homogeneous distribution of the fibers in the matrix was observed in SEM images.

3. RESULTS AND DISCUSSION

As can be seen in the table, adding fiber to the HDPE matrix increases the tensile strength. Carbon fiber resulted a significant increase as expected. If the matrix and fiber particle size are reduced, it is possible to achieve results close to twin screw extrusion with single screw extrusion, but homogeneous distribution of fibers in the matrix cannot be guaranteed. Considering the higher production and operating costs of the twin screw extruder, this method may be a good alternative for low-cost production.

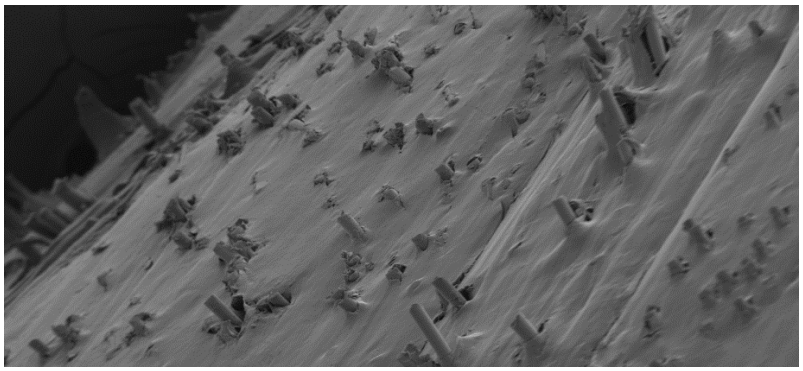


Figure 1. SEM images of twin screw extruded filament *(single screw will be added soon.)*

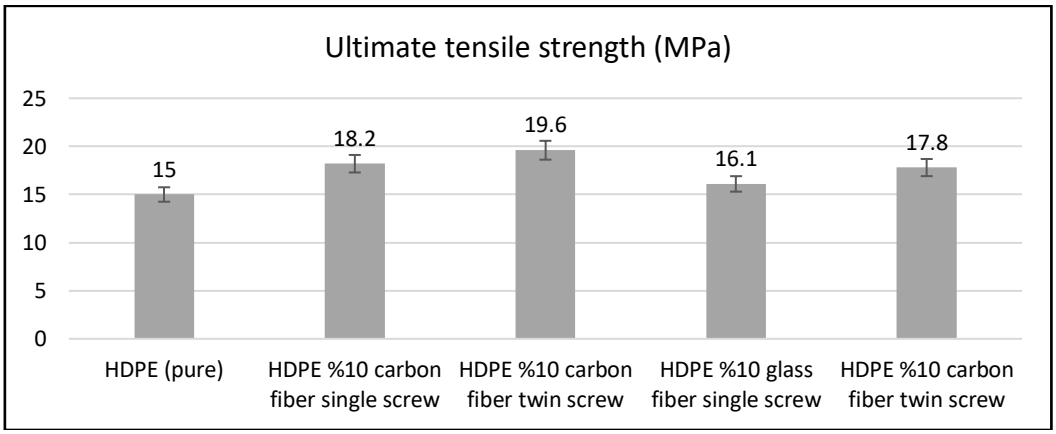


Figure 2. Tensile test results

4. CONCLUSIONS

Although fiber-reinforced HDPE composite filament production with single screw extrusion is low-budget, it is not suitable for industrial uses due to poor homogeneous distribution. HPDE composite filaments shows commercialization activities as new. HDPE is generally difficult to 3D printing due to its low surface adhesion and flexibility, but the addition of carbon and glass fiber increases tensile strength, brittleness to some extent but facilitates surface adhesion to the heated printing plate and allows printing on inexpensive entry level 3d printers.

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