

ENGINEERED PLASTICS – IMPROVING PROFIT MARGIN BY IMPROVING PROCESSING EFFICIENCY

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Current economic times require continuous improvement of manufacturing process efficiencies that will lead to improvements in profit margin for engineered plastics. Continuous improvement requires an understanding of Total Production Cost. Total production cost reduction includes elimination of off-line process steps, elimination of shut-downs and associated yield losses as well as examination and optimization of raw material costs. This presentation will examine ways in which improvements can be made to improve Total Production Cost – thereby increasing profit margin - while maintaining the quality of the resin and the functional characteristics of the molded part.

Introduction

Suppliers are continuously trying to improve their cost position to increase profitability, maintain market share and increase customer satisfaction. Evaluation of lowest total cost production of a thermoplastic composite material is a cross-disciplinary function which involves research and development, raw material suppliers, manufacturing personnel and the end user. Understanding the costs associated with each step of the engineered resin production process is a key factor in removing costs – while retaining the quality. In this paper, process and formulation changes and the subsequent effects on Total Production Cost will be examined for a filled polypropylene composite material.

Experimental

A Century 70 mm 40 L/D 10-barrel extruder was used for compounding all trials. Acrison gravimetric weight loss feeders were used for the introduction of liquid coupler and melt flow adjuster into the feed throat and introduction of filler into Barrels 4 and 6. The balance of the ingredients were placed directly into a ribbon blender, blended for 1-minute and then gravimetrically fed into the main feeder.

Base Formulation

Ingredient Number	General Class of Material	Formulation Percentage
1	20 MFR Virgin PP	20.01%
2	12 MFR Virgin PP	34.37%
3	PP Coupling Agent	3.00%
4	Heat Stabilizer Powder Package	1.00%
5	Liquid Coupler	0.22%
6	Melt Flow Adjuster	0.40%
7	Filler	41.0%
Total		100.00%

Experiment # 1: The heat stabilizer powder package (Ingredient 4) which consists of 4-ingredients that need to be pre-mixed prior to each run, was replaced with a purchased pelletized heat stabilizer concentrate.

Therefore, no costs were incurred for the pre-mixing step in this Total Production Cost calculation.

Experiment #2: The heat stabilizer powder package (Ingredient 4) was replaced with a purchased pelletized heat stabilizer concentrate and the liquid coupler (Ingredient 5) percentage was decreased from 0.22% to 0.11%. During processing, excess liquid coupling agent crystallizes and clogs the feed throat. With the current formulation, the extrusion line has to be shut down approximately every 6-hours to clean the feed throat. In addition, this coupling agent costs approximately \$11/lb. This loss in material and production time impacts the Total Production Cost.

Experiment #3: The heat stabilizer powder package (Ingredient 4) was replaced with a purchased pelletized heat stabilizer concentrate and the 20 MFR PP (Ingredient 1) was replaced with recycled 20 MFR polypropylene derived from carpet fiber.

Experiment #4: The heat stabilizer powder package (Ingredient 4) was replaced with a purchased pelletized heat stabilizer concentrate and the liquid coupler (Ingredient 5) was removed from the formulation to determine the impact on the finished product properties.

Experiment #5: The heat stabilizer powder package (Ingredient 4) was replaced with a purchased pelletized heat stabilizer concentrate, the liquid coupler (Ingredient 5) was removed and the 20 MFR PP (Ingredient 1) was replaced with recycled 20 MFR polypropylene derived from carpet fiber.

Resin samples were collected and molded into specimens. Specimens were evaluated using ASTM test methods after conditioning in a temperature and humidity controlled environment for 72-hours.

Results and Discussion

Five experiments were performed which could improve the Total Production Cost of the product by eliminating process steps, optimizing and/or substituting

ingredients in the formulation. Resin samples were collected and molded into test specimens to determine if the proposed process and formulation changes would alter the final resin physical property characteristics.

Table 1, Experimental Results Summary, presents the test results from molded specimens of the resin, as well as the calculated Total Production Cost.

Table 1 – Experimental Results Summary

Test Parameter	Units	Base	Exp #1	Exp #2	Exp #3	Exp #4	Exp #5
Ash	%	41	41	41	41	41	41
Density	g/cm ³	1.25	1.26	1.25	1.27	1.25	1.26
Tensile Strength	MPa	46	47	48	45	36	34
Tensile Elongation	%	1.7	1.9	1.7	2.0	1.5	1.4
Flex Strength	Mpa	65	63	66	63	46	46
Flex Modulus Tangent	MPa	7,700	7,600	8,000	7,600	7,500	7,700
Izod Notched Impact	Kg/m ²	2.2	2.3	2.4	2.4	1.7	2.0
Total Cost	Lb	\$0.914	\$0.916	\$0.894	\$0.842	\$0.882	\$0.809

The Total Production Cost was calculated using the following formula:

$$\text{Total Production Cost} = \text{Ingredient (Formulation Cost)} + \text{Pre-Blend Mixing Cost} + \text{Processing (Extrusion Toll) Fee} + \text{Scrap}$$

Conclusions

Experiment #2 was successful in reducing the Total Production Cost of the engineered resin by 2.2% without an impact on the quality of the final engineered resin. This improvement did not require a formulation ingredient change – but incorporated removal of a pre-mixing process step and optimization of current ingredient throughputs that resulted in better processing (less shut downs) conditions. This cost reduction for the current 3,500,000 lbs of this resin used on an annual basis this would result in a \$70,000/year increase in profit.

Experiment #3 was successful in reducing the Total Production Cost of the engineered resin by 8% without an impact on the quality of the final engineered resin. This improvement incorporated removal of a pre-mixing process step and substitution of a recycled polypropylene derived from carpet scrap for 20% of the formulation. This cost reduction of \$0.072/lb for the current 3,500,000 lbs of this resin used on an annual basis would result in a \$252,000/year increase in profit.

The next sensible step in this process and formulation optimization would be to combine the efforts of Experiment #2 & Experiment #3 by removing the pre-mixing step, substituting the recycled polypropylene and optimizing current ingredient throughputs. It is estimated that these changes would result in a cost reduction of approximately \$0.095/lb which would result in a \$332,500/year increase in profit.

Experiment #4 involved the removal of the liquid coupling agent. This substantially reduced the physical properties of the final resin and would most likely not be a seamless change for the end user.

Experiment #5 confirmed that the use of the recycled polypropylene as 20% of the formulation did not have a significant impact on the finished properties of the end product (comparing Experiment #4 results to Experiment #5 results). Therefore, use of recycled material as a portion of this formulation could result in substantial cost savings without a reduction in performance.

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