Description:	• *Metal Substitution* • *Cost reductions*
Date:	Oct 4th, 2016
Authors:	Karl Schnetzinger, Advanced Polymer Compounds (APC), Austria Gernot M. Wallner, University of Linz (JKU), Austria
Download possible at:	http://task54.iea-shc.org/

Introduction

Due to the specific characteristics of polymeric materials (e.g., variety of property profiles, ease of processing, mass production capability, freedom of design) this material class has been used to replace metal parts and components in various industrial sectors. In this case study the cost reduction achieved by material substitution is described and discussed exemplarily for industrial pumps.

Centrifugal pumps for industrial applications

The overall energy demand in a pulp&paper plant is dominated by electrical energy needed for centrifugal pumps with specific hydraulic designs. State of the art pumps are made of duplex steel. While such pumps are casted and post processed in China, engineering and service takes mainly place in Europe. The main disadvantages of the current steel based design are low abrasion and corrosion behaviour, high costs for post processing and storage and long delivery times. Schematic drawings of such pumps and the main components are depicted in Fig. 1.

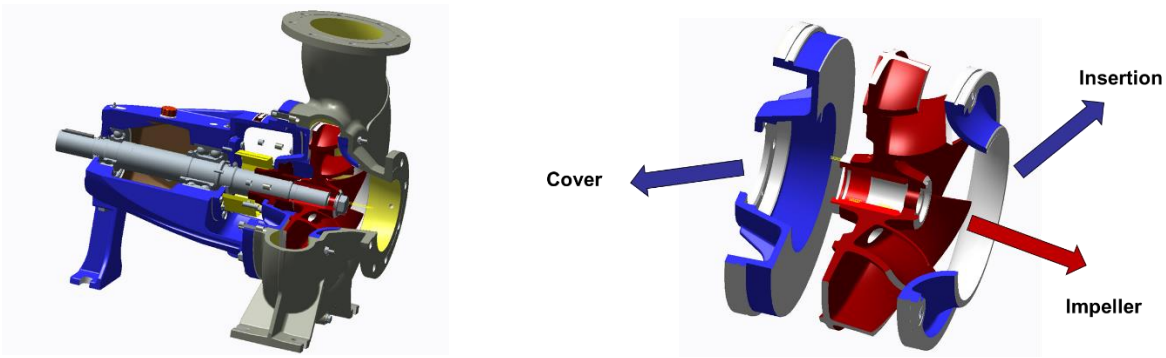

Fig 1. Overall view of centrifugal pumps (left); exploded view with main hydraulic components (right)

Material replacement for the cover of centrifugal pumps

In a first step the steel cover of the centrifugal pump was substituted by engineering plastics. Because of the demanding load profile (mechanical, thermal and environmental loads) and the current production numbers (~ 1000 pieces/year/type), a blend of aromatic+aliphatic polyamides as well as direct long fibre thermoplastic (D-LFT) moulding processing were chosen (s. Fig. 2), allowing a production of moulded parts

in simple designs without undercuts. The required undercuts next to the impeller are milled in an additional post processing step (s. Fig. 2).

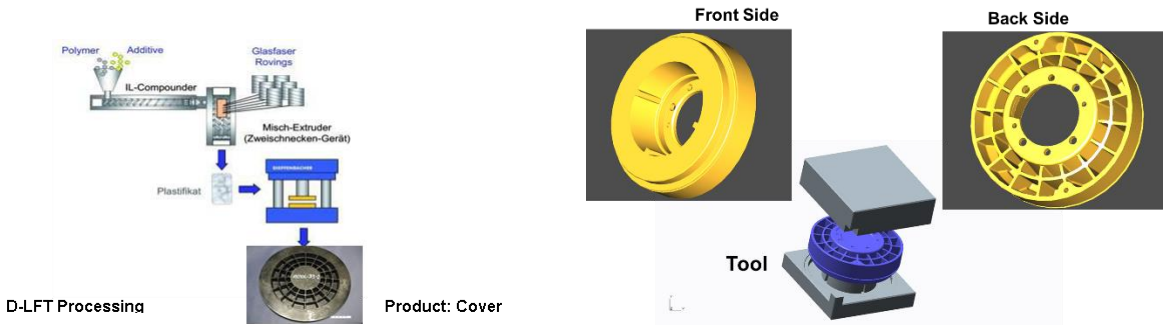

Fig 2. D-LFT moulding (left) and post processing of cover parts (right)

Cost reduction by material substitution

The main cost drivers for the cover part in steel or engineering polymer design are described as follows. Equal costs are indicated by 0, higher costs by + and lower costs by -.

	Steel Solution	Polymer Solution
Materials Costs	**0**	**0**
Tooling	**0**	**0**
Processing	**-**	**+**
Post Processing	**+**	**-**
Logistics	**+**	**-**
Personnel Costs	**0**	**0**

Regarding the material costs, the price for Duplex steel is about 10 €/dm^3 which is slightly higher compared to long glass fibre reinforced polyamides with about 8 €/dm^3, but the volume of the polymer part is slightly higher compared to the steel part, resulting in materials costs at the same level. Also the required tools for casting and D-LFT moulding are in the same range of about 20.000 EURO for a tool life of about 5000 parts. The investment costs for D-LFT machinery for part processing are significantly higher (about 3 mio €). However, the post processing for steel parts in China is by a factor of 2 higher. The dependency on the lot size is lower for the processing costs. Hence, the post processing costs have a big impact at higher lot sizes. The logistics costs (production in China and use in Europe) are also higher for the steel solution.

The overall relative costs for centrifugal pump covers made of steel or polymeric materials are plotted in Fig. 3 as a function of produced pieces/year (lot size). The relative costs for lower quantities (below 50 pieces/year) are higher for the polymer design because of the higher investment costs for the machinery. The costs for the polymer based solution are significantly lower for higher production volumes exceeding 50 pieces/year. For even higher production quantities (> 10,000 pieces) injection moulding of engineering plastics would be the most cost-efficient production technology.

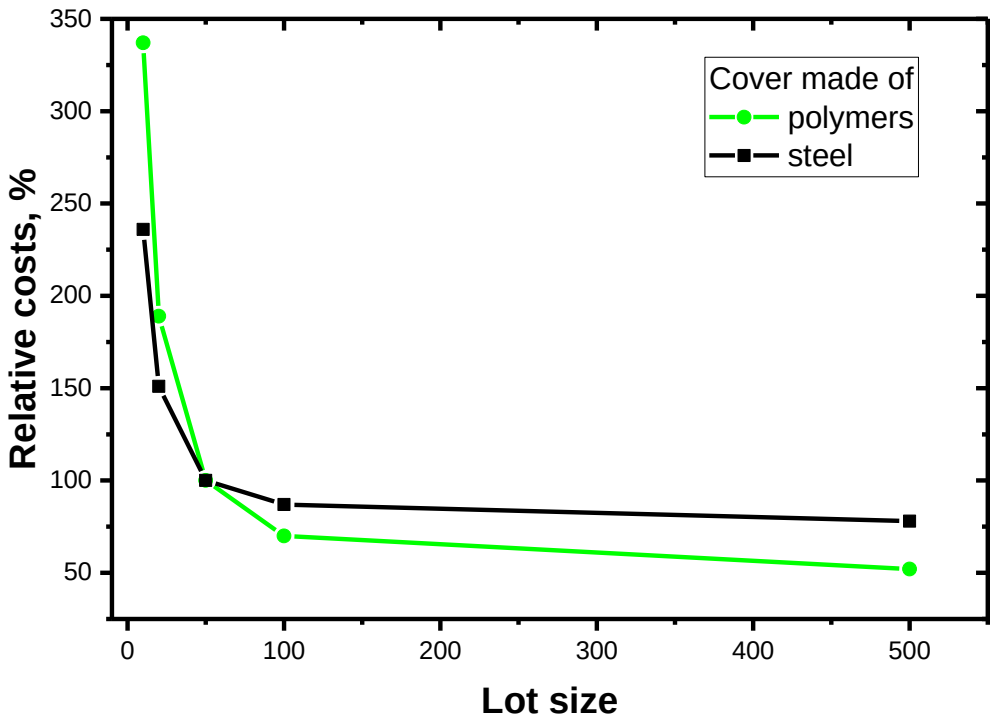

Fig 3. Relative costs for covers of centrifugal pumps for the pulp&paper industry made of polymeric materials (green) or steel (black)