REPLACING STEEL IN AN ELECTRICAL MOTOR WITH TALC REINFORCED POLYPROPYLENE

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REPLACING STEEL IN AN ELECTRICAL MOTOR WITH TALC REINFORCED POLYPROPYLENE - A CASE STUDY

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ABSTRACT

The development of an electrical motor which won the 1988 SA Industrial design award is discussed as a case study of replacing steel with a reinforced material. Steel end pieces, housing the bearings of the electrical motor was replaced with talc reinforced polypropylene. Through steel replacement the final product was made economically viable by considerable savings on material and production time. Glass reinforced polypropylene was also used to produce the electrical cable connections. The parts which had to comply with specific dimensional and functional requirements were produced by injection moulding.

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INTRODUCTION

There are many applications in industry where steel can be replaced by plastic or composite materials to provide a product with specific properties which are not obtainable with steel. In other instanced steel is replaced to save cost. The savings can be either in material cost or production time. Engineering plastics and composites have to a variable extent substituted metal for housing and casings, movable parts in machinery, components in the motor industry - mainly body parts and generally in appliances, office machines, agricultural and industrial equipment. The rate of substitution with new plastics materials being developed daily is expected to increase to between 8 - 12% per annum through to the 21st century.

This paper presents a case study of steel replacement to provide a product which is corrosion resistant and which provides a considerable saving in material cost and production time.

REPLACING STEEL PARTS IN AN ELECTRICAL MOTOR

A project to design and develop a submersible electrical motor for application in boreholes was initiated in 1987. The research and development was performed by the Engineering Faculty at the Potchefstroom University and the industrialization was done by a private company.

Within a year the first prototype was successfully tested. The motor was however not economically viable. Especially the steel end pieces were very expensive to produce. The manufacturing of the top end piece included turning and welding processes and since the motor is used in water it also had to be plated. The cost of the top end piece amounted to approximately R60,00 of which R10,00 was for plating.

It was therefore decided to replace the steel end pieces before the motor was industrialized. The steel was to be replaced with a composite material, talc reinforced polypropylene. The Department of Mechanical Engineering designed the products and developed the injection moulds to produce them.

We were required to replace two engineering parts with plastic parts. In the case of the top end piece the challenge was to design a mould for the injection moulding of a part complying with specific functional and dimensional requirements such as:

- accurate dimensions with small tolerances
- withstanding stresses and strains
- withstanding thermal cycles
- acting as an electrical earth

The first step was to design the product. Its steel counterpart was cylindrical in shape. The outer diameter was 98,7 mm with a tolerance of plus 0,1 mm minus 0,0 mm. It houses a bearing for the rotorshaft of the electrical motor and has four stainless steel studs for bolting a borehole pump onto the motor. The sides of the component have to meet a parallel specification of 0,1 mm over a length of 99 mm. On the outside the component accomodates an O-ring groove 3,7 mm wide and 2,5 mm deep.

Special features were designed into the product to meet the specifications. Since the product was required to act as an electrical earth, house a bearing for the rotorshaft of an electrical motor and bolt a borehole onto the motor, stainless steel, mild steel and plastic were combined.

A steel plate is bolted onto the plastic part, using the stainless steel studs inserted in the moulding. The steel plate prevents the bearing from turning in its housing and at the same time acts as an electrical earth together with the stainless steel studs. The studs provide a means for bolting the pump onto the motor. The pump enforces a thrust on the motor through the bearing, the steel plate and via the studs back to the pump. The plastic part therefore fulfils its load bearing capacity by directing the load path away from the plastic and via steel parts. We believe that plastics and composites for that matter should be integrated with other materials to meet specifications that otherwise cannot be met.

Talc reinforced PP was chosen because of its stiffness and shrinkage properties. The product had to be stiff since it is pressed into a stainless steel tube which forms the outside of the motor. The shrinkage of the product during the injection moulding process had to be accurately controlable. The position of the stainless steel studs had to comply with international standards to universally fit all makes of borehole pumps. The tolerance on the specified distance of 76 mm between the studs is ± 0,1 mm. This tolerance had to be obtained taking an average shrinkage of approximately 1,7% into account.

Talc reinforced PP was also chosen due to its relatively low cost compared with other reinforced materials and because it is produced locally and need not be imported.

To produce this product a new split mould concept was developed. The concept has since been patented. The mould was manufactured by the Instrument Making Department at the University. The production of prototypes and later the mass production was performed by PLASTIKON, a private injection moulding company which belongs to the INGTEK 2000 group of companies.

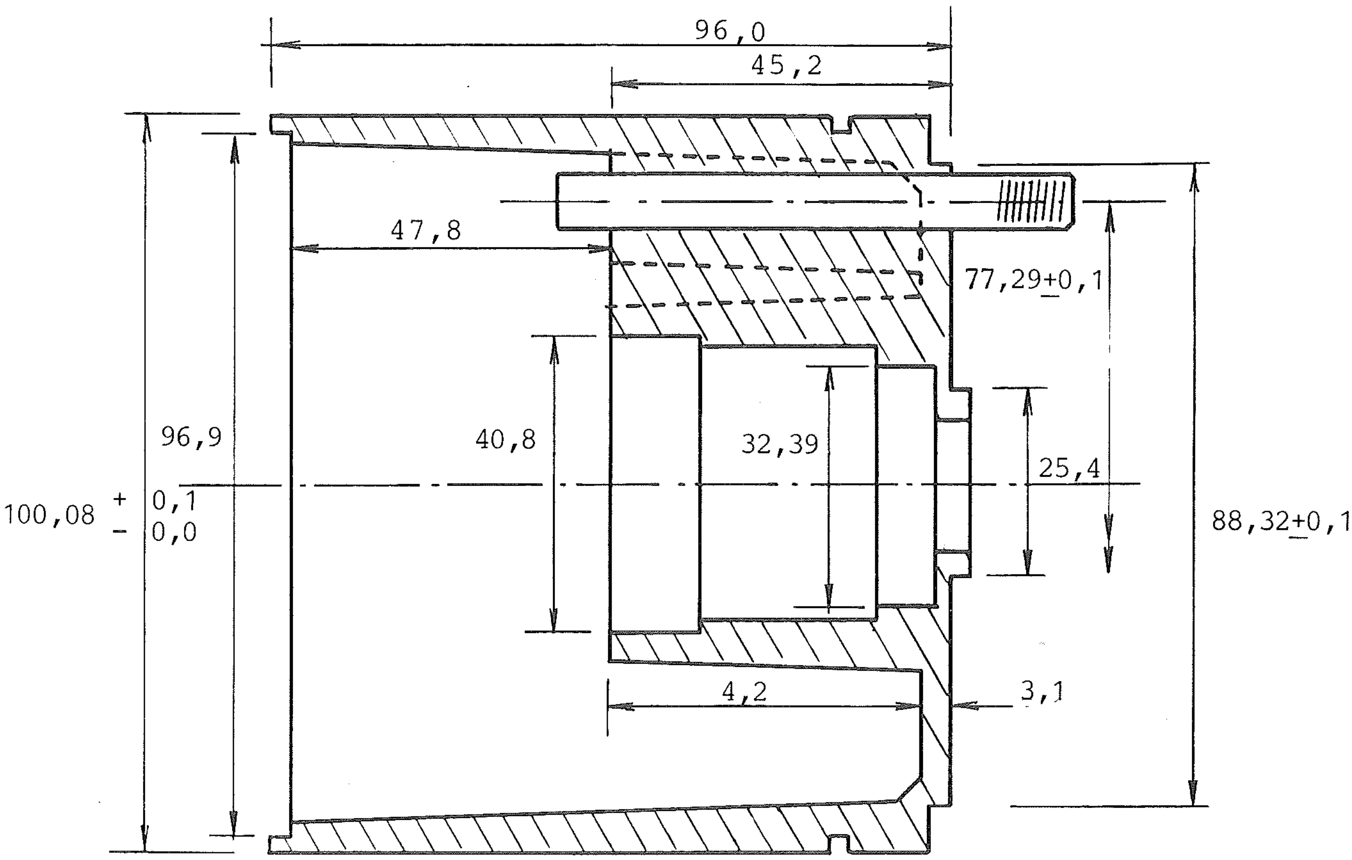
The production cost of the talc reinforced polypropylene end pieces is less than R10,00 and the cycle time 95 sec. This compares very favourably with the cost of R60,00 and the time consuming production of the steel end pieces.

The bottom endpiece which serves as the lower bearing housing was also produced with talc reinforced polypropolene. The amount of steel wasted in producing this end piece and the time required to remove this material resulted in an expensive product. By replacing the steel with talc reinforced PP the production time was cut to only 60 seconds and a considerable amount was saved on material. When steel is replaced with plastic or a composite material the properties of the material used need to be considered carefully. The design has to take these properties into account. Stiffness was for example obtained by using ribs inside the bottom end piece rather than a thick section as in the case of its steel counterpart.

The electrical motor was produced successful using the polypropylene end pieces. The company producing the motors then decided to provide the motors with replaceable electrical cables. To incorporate this modification the top end piece had to be changed. The mould was accordingly modified to accomodate copper inserts for electrical connections on the end piece. The electrical plug on the cable was also injection moulded using a composite material. In this case glass reinforced PP was used providing this small component with the necessary strength.

CONCLUSION

There is a continually increasing choice of engineering plastics and composite materials. Steel replacement will become increasingly important in the production of cost effective products. The replacement of steel with talc reinforced PP in a submersible motor is but one of many cases where steel replacement provided a technically successful and an economically viable final product.



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