CFRP-Containment Shells made by Filament Winding

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***Abstract*— This paper covers the manufacturing of carbon containment shells using filament winding technology. Containment shells are installed in magnetic coupled pumps and separate the motor from the pumped medium. The torque of the motor is transmitted to the pump wheel via magnets which rotate around the containment shell. Containment shells manufactured using filament winding technology offer high mechanical load-bearing capacity with a low wall thickness, so that the distance between the magnetic rotors can be minimized. At the same time, in contrast to metallic designs, the fibre composite remains almost completely free off eddy currents and thus enables a significant increase in the pump efficiency.**

***Keywords*— Pump, eddy current, electromagnetic clutch, composite, containment shell, separating can**

I. Introduction

Increased awareness of environmental protection and occupational safety over the years has led to increasingly stringent health and safety regulations in all sectors of industry. Especially in the operation of chemical and petrochemical plants it is important to minimize the leakage of aggressive and toxic substances. The shaft seals are a shortcoming of conventional centrifugal pumps. They can wear out and become leaky, causing the medium to escape. Regular maintenance due to wear and tear is cost-intensive and reduces the availability of the system [1].

This can be remedied by the use of magnetic coupled pumps. In these, the motor is separated from the medium by a containment shell. The torque is transferred from the outside to the inside of the containment shell by two magnetic rotors. Since the containment shell is only statically sealed, this design is completely free of leakage and maintenance.

Usually, containment shells are made of Hastelloy® C, an electrically conductive material. Due to the magnets rotating around the containment shell, eddy currents are generated in its wall, which reduce the efficiency of the pump and heat the containment shell. The heat has to be extracted at great effort and a dry run of the pump can overheat it to a total loss [2] [3]. For this reason, more and more containment shells made of fibre-reinforced composites, especially carbon fibre-reinforced plastics (CFRP), are being installed. By using such CFRP-containment shells, eddy currents can be avoided almost completely and thus a heating-up of the containment shell is prevented.

In this project, a CFRP-containment shell was manufactured using the FilaWin® filament winding technology. The filament winding technology provides high strength and good automation of the manufacturing process.

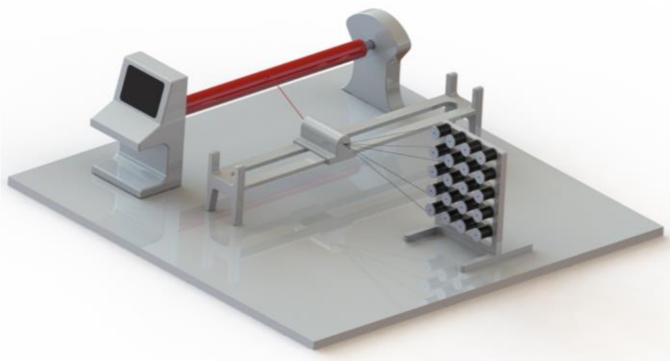

Fig. 1: Filament winding technology.

II. FilaWin®-Containment Shell

In magnetic coupled pumps with metallic containment shells, eddy currents cause a power loss of up to 10 % of the transmitted power [2]. To avoid these losses, containment shells made of materials such as plastics or ceramics are used. These offer very high electrical resistances, so that the induction of eddy currents is practically eliminated [2]. Due to their specific material properties, however, the field of application for these solutions is limited to low working pressures [4].

In order to avoid eddy currents also under higher operating pressures, containment shells are increasingly made of fibre-reinforced plastics, usually CFRP. The carbon fibres increase the strength and stiffness of the containment shells, so that the wall thickness in the gap between the two magnetic rotors and also the radial elongation under increased pressure can be significantly reduced. CFRP- containment shells are manufactured, for example, from fibre preforms which are impregnated with resin by resin transfer moulding (RTM) [5]. Another production method is the forming of containment shells from carbon fibre-reinforced thermoplastic such as PPS (polyphenylene sulfide) or PEEK (polyether ether ketone) [6] [7].

The aim of this project was to produce a CFRP containment shell using FilaWin® filament winding technology. In the filament winding technology, filaments impregnated with resin are laid on a rotating winding mandrel by means of a CNC (Computerized Numerical Control) controlled automatic unit (see Figure 1). In this way, the preforming work step is saved and a high reproducibility of the product is achieved. In addition, the orientation of the fibres in the winding process can be ideally adjusted to the loads in operation, thus improving the fibre efficiency in comparison to preforming. As a result, the laminate build-up and consequently also the air gap between the magnet rotors can be made thinner. This improves the transfer of torque.

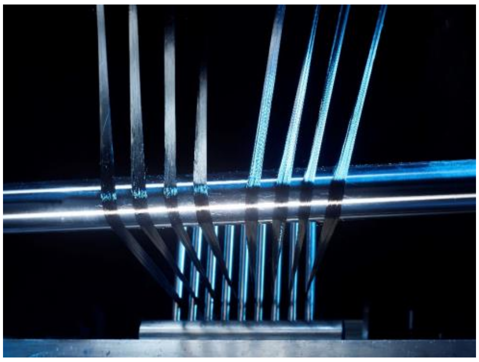

Fig. 2: FilaWin®-roving feed.

The bottom of the containment shell is designed as a flat steel plate. In this way, the thickening of the laminate in the centre of a winded bottom is avoided and the installation space required for the containment shell is kept to a minimum. Since there are no magnet rotors in this area, this does not cause any eddy current problems. In order to protect the mechanically load-bearing shell from aggressive fluids, the inside of the containment shell is covered with a PTFE-liner. In addition, the liner, better than the load-bearing laminate, guarantees the tightness of the containment shell [8].

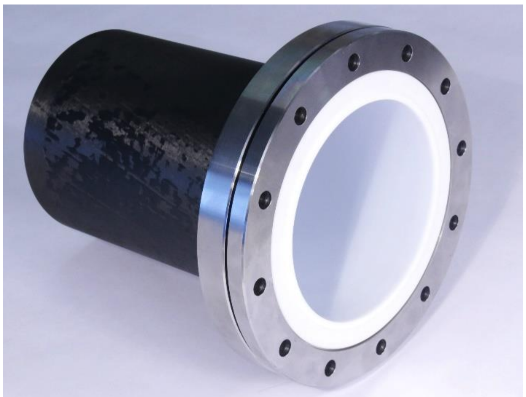

Fig. 3: FilaWin®-containment shell made of CFRP.

The FilaWin® containment shell can withstand an internal pressure of 60 bar for more than 30 seconds without pressure loss. In a burst pressure test, a maximum pressure of 100 bar is achieved in the version shown.

TABLE I: PROPERTIES OF THE FILAWIN®-PROTOTYPE CONTAINMENT SHELL

Properties		
Burst pressure	bar	100
Inner diameter	mm	144
Wall thickness CFRP	mm	1.0

III. CONCLUSION

The burst pressure of 100 bar of this prototype with an inner diameter of 144 mm and a CFRP wall thickness of 1 mm demonstrates the great potential of containment shells manufactured using FilaWin® filament winding technology. Depending on application and customer-specific requirements, even far higher pressures can be achieved by further optimization and adjustment. The filament winding technology enables an ideal fibre efficiency and thus guarantees highest strength at low wall thicknesses. CNC-controlled winding machines ensure a high degree of reproducibility of the product and reduce its production time. Since the composite remains practically free of eddy currents during operation, the FilaWin® containment shell made by CirComp GmbH offers a good alternative to increase the efficiency of powerful magnetic coupled pumps.

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