

ARE THE DAYS OF THE
DOUBLE-WALLED
PUMP HOUSING

NUMBERED?

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For several decades, the preferred solution for isolating dredging pumps within a vessel has been the double-walled pump housing. While an improvement in both safety and reliability compared to the previous use of single-walled pumps, it still has two significant problems: it requires the pump to be raised to accommodate the casing, which has a negative impact on pump efficiency, and it adds considerably more weight to the pump assembly.

This extra weight reduces the additional payload that the dredger can take and over the years can represent a significant loss of capacity. To address this Damen has been conducting an extensive research project in partnership with its customers and materials specialists to develop a solution that can overcome these issues. The result is now available commercially and will no doubt surprise many as it is radically different to what has gone before.

A demand for greater efficiency

The double-walled pump housing was introduced in the early 1970s by De Groot Nijkerk (see Figure 1). The design is made up of an outer housing in fabricated structural steel fitted around the cast inner pump housing. The steel outer casing protects the external environment in the event that the cast inner housing, which ensures that the pump has sufficient wear resistance, fails. The double-walled pump housing was a great improvement, significantly increasing both the safety and durability of the dredge pump. With the double-walled

pump housing in place the cast pump could safely be operated until it reached the end of its life and disintegrated.

However, the conventional double-walled pump house did come with a number of disadvantages. Firstly, all that steel is heavy,



FIGURE 1

In the early 1970s, De Groot Nijkerk introduced double-walled pump housing.

and the extra weight comes with the cost of reducing the final payload that the trailing suction hopper dredger can carry before having to cease operations and move away to offload. A few tonnes less payload may sound insignificant, but over the course of year this adds up to a substantial loss of capacity. Also, with its double-wall housing, the pump requires more space, which is a particular issue with Cutter Suction Dredgers (CSDs), and results in the pump being raised to a greater height than would otherwise be the case. With the core of the pump now closer to the surface of the water the suction efficiency of the pump is reduced, negatively affecting the production rate of the dredger.

A new approach

As the Damen team reviewed the issues arising from the standard steel double-walled pump housing, it was quickly realised that an effective solution would need a number of key attributes. It would need to be:

- Lightweight
- Easily accessible to allow the replacement of parts subject to wear

- Water tight up to 20 atmospheres
- Safe and reliable
- Hard wearing
- Easy to retrofit

To meet these requirements, the team launched an extensive research project in association with a number of industry and research partners.

The first stage was to determine the material to be used for the new casing. In particular, it had to be strong and durable, yet also lightweight. It also had to be resistant against seawater, sunlight (UV), chemicals and micro-organisms. Initial candidates were the textiles Twaron/Kevlar and Dyneema, both of which offered the necessary high-tensile strength. However Dyneema emerged the winner due

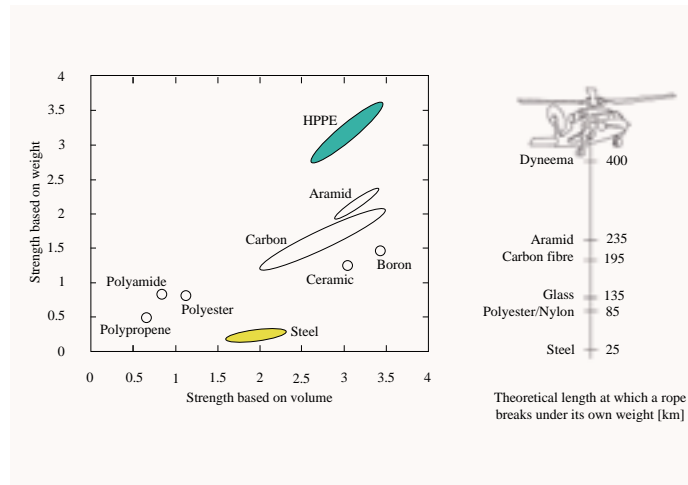


FIGURE 2

In the early 1970s, De Groot Nijkerk introduced double-walled pump housing.

Why is the height difference between the waterline and the pump significant?



A pump doesn't really suck in the sense that it creates a partial vacuum into which water flows. It actually just moves water using an impeller. As the water moves, the pressure in the inlet pipe drops due to the resistance of the suction pipe. The pump itself also needs some pressure, plus a margin. The outside pressure (atmosphere and water above the pump) pushes on the water inside the suction pipe (which has a lower pressure). The maximum suction pressure is therefore limited. When a pump is positioned at the waterline, the maximum pressure available is only 1 bar (atmospheric pressure). For the pressure drop of the suction pipe in general only 0.6 bar is available. An additional metre of water increases this by 0.1 bar (17%), so even raising the pump by only 0.5m results in a loss of suction capability of almost 10%.

to its ability to meet all the other criteria (see Figure 2).

Dyneema is a UHMWPE (Ultra High Molecular weight Polyethylene) fibre that has a yield strength as high as 2.4 GPa (240 kg/mm² or 350,000 psi), making it comparable to high-strength steel. However it has a strength-to-weight ratio eight times that of high-strength steels. It was invented by Albert Pennings in 1963 but became commercially available in 1990.

Dyneema fibres also have a very high molecular weight which makes them lightweight, strong and durable, as well as resistant to ultraviolet light, oil and seawater. As a textile, Dyneema is also proven when it comes to high stress environments. Current uses include body armour, cut-resistant gloves and various aerospace applications. Calculations were performed to determine the number of layers that would be required to meet the pressure goal of 20 atmospheres.

With that decision made, the next step for the team was to create a textile casing with an opening through which technicians could gain access to the pump within for maintenance and the replacement of worn-out parts. The challenge here lay in the fact that the entire textile 'shell' had to be fabricated as a single piece to guarantee its strength. Zips and other fasteners would compromise the shell's integrity.

With the case clamped to the inner pump housing, folds in the shell of textile were introduced so that the opening could be enlarged. This in turn launched a search for a solution that would ensure that the line of connection to the pump would be watertight.

Making it 100% watertight

Ensuring that the entire housing was watertight was a consistent theme throughout the project. Dyneema itself is not completely waterproof. Over time water will make its way through the weaving, however this was easily solved by incorporating a layer of plastic film between the layers of Dyneema that make up the overall fabric. The plastic film selected is very elastic and does not fail under high pressure. The fabric is produced to very tight tolerances, using a special drum developed for this process plus a special, heated press for gluing the layers together.

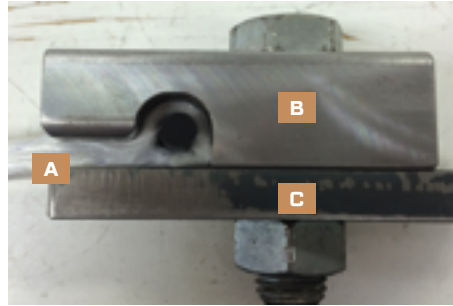


FIGURE 3

The connection to the pump is comprised of textile with a rim [A], the clamp [B] and the base plate inner pump casting [C].

The second challenge was to connect the textile to the steel of the pump in such a way that it is completely watertight and yet still easy to handle. The solution involved attaching a rim around the edge of the textile that could then be clamped to the pump's steelwork (see Figure 3). The design of the clamps was vital to the success to the Dynacover product and much effort went into their design and testing.

The key challenge was to reconcile the need for complete water resistance with that of the need for folds in the fabric that allow the opening to be enlarged for easy access to the wear parts. Fortunately a useful property of Dyneema is that, by simply pressing the folds down using a wedge, they become completely watertight. Subsequent testing demonstrated that this can be done hundreds of times without damaging the textile. A range of weavings and clamps were tested, starting with a simple clamp and then moving through different formats until a clamp which met the specified requirement of being watertight to 25 atmospheres was found.

The newly-developed clamps are fabricated using the lost-wax casting process (see Figure 4A). They were engineered using finite element calculations and are optimised for weight at just three kilos a piece, making handling easy (see Figure 4B). The result is a pleasingly organic-looking design and they can be fitted on any pump type and size. The Dyneema shell is also lightweight and easily carried by one

As a textile, Dyneema is also proven when it comes to high stress environments.



FIGURE 4

The Dynacover's clamps are fabricated with a lost-wax casting process [A] and weigh only three kilos each which enables easy handling [B].



FIGURE 5

The outer cover is partly removed to show the clamps.

man. Its initial installation and all subsequent openings for inspections can therefore be done without hoisting tools. Indeed, the only tool needed is a wrench.

The final test

For the full-size water test, the inner pump housing was sealed off using flanges, but a connection was made between the inner space of the inner pump housing and the outer Dynacover pump (see Figure 5) housing to allow the pressure to equalise between the two. This was done to prevent the inner pump casing from collapsing under the high external pressure. The casing was then filled with tap water and then, once all the air was removed and replaced by water, the high-pressure pump was connected and activated. The Dynacover was pressurised up to 20 atmospheres, at which point some minor leakage occurred.

This test resulted in the design of the flexible housing undergoing an improvement in which the biggest fold was reduced in size by cutting the textile and gluing the fabric together again. A final, full-size water test proved the effectiveness of the modification

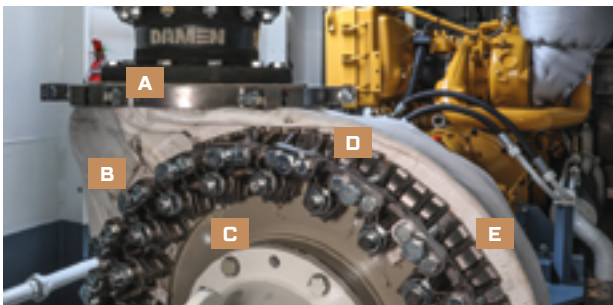


FIGURE 6

The complete Dynacover includes a 6-part clamp [A], Dyneema [B], pump cover [C], clamps at the pump cover [D] and a wedge for folds [E].

Benefits for both CSDs and TSHDs

With CSDs generally compact vessels of limited space and shallow draft, making it not possible to position the dredge pump much below the waterline. Raising it so as to fit a double-walled pump housing only reduces the pump efficiency even further. With the pump often mounted inside the engine room, if it does suffer a major leakage then the risk is that the entire engine room is flooded, causing significant damage to the engines and electronics. The Dynacover is therefore ideal for use in these circumstances.

Trailing Suction Hopper Dredgers are generally much larger, with the dredge pump mounted well below the waterline in a dedicated pump room. Damage from flooding is therefore not an issue, however the weight of the double-walled housing is, and its replacement with a Dynacover makes the vessel more efficient through the ability to carry additional payload.



at eliminating the leakage. It also ultimately resulted in the reduction of the height of the clamps (see Figure 6).

A new era for pump housing

The introduction of the Dynacover opens a new chapter in the story of the double-walled dredge pump. It delivers substantial advantages over the traditional double-

walled pump, its dramatically reduced weight and smaller dimensions eliminate the main disadvantages of the existing concept. Any CSD – new or old – can be fitted out with the system, while replacing the traditional steel double-walled pump housings in trailing suction hopper dredgers will also allow them to accommodate greater payloads, thereby delivering greater fuel economy. All users will appreciate the safety and environmental gains. Additional benefits include ease of handling, fitting and servicing, and cost efficiencies. Installation on an existing mounting takes less than four hours. Once again, a Damen R&D initiative has delivered efficiencies and performance gains by applying new materials technologies to old issues.



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Summary

For many years the steel double-walled pump housing has been the preferred solution for isolating dredging pumps within dredgers so as to minimise damage from sudden failure and any subsequent leakage. However, it has significant disadvantages in the form of weight, space required and loss of pump efficiency. To address this, Damen initiated a research programme to find an alternative form of housing that would retain the same levels of protection but without the negatives. The solution is the Dynacover, a lightweight, flexible casing made from Dyneema, a proven ultra-high molecular weight polyethylene fibre, which is fastened to the pump casing using special clamps. As well as performing to the required specification in terms of pressure and durability, it also allows easy access to the pump for maintenance, is easy to handle and simple to retrofit.



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Ewout studied mechanical Engineering at the University of Applied Sciences before starting work at Voith Paper Fabrics Haaksbergen. In 1998 he joined Damen Dredging Equipment as a sales engineer. Currently he is working in the Research, Development and Innovation department. He is responsible for the general engineering of the standard range of Cutter Suction Dredgers build by Damen Shipyards. He introduced the application of CFD of dredge pumps and is involved with several innovative solutions for Damen Shipyards.