NEW PUMP TYPES FURTHER OPTIMISING A DREDGER'S PROFITABILITY

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ABSTRACT

The cost-effectiveness of dredging today depends to a great extent on the performance of pumps. Targeting the efficient transport of the dredging mixture they are critical components in almost all types of dredging systems. Their capacity has to be adapted to the task in hand and their effective operating life in often difficult operating conditions maximised. Optimal design, reducing the effects of wear, and ensuring easy repair and replacement all play key roles. In other words; upgrading pump quality to the highest level possible and minimizing overall lifetime costs.

When selecting a pump for a given range of duties a balance has to be found considering characteristics like the pump's energy consumption, suction performance, maximum passing particle size, lifetime, size, weight and required investment. To optimise the match between the pump's range of duties and characteristics IHC recently added two new pump types to its pump range. On one side of the size spectrum this concerns the compact *TT-Unit*. This hydraulic, electric or diesel driven *TT-Unit* is envisaged to dredge silt and fine sands from, for instance, the end of an excavator's boom. On the other, large side, of the size spectrum the *high efficiency cutter special (HRCS) type pump* is introduced. The design of the *HRCS type pump* is typified by its large passage and optimized suction performance. These characteristics make the cutter special pump especially favourable when dredging large size materials like rock and gravels containing cobbles and boulders.

Late 2006 the hydraulic design of both the latest additions were put to the test at MTI Holland's pump testing facility, this paper presents results of these tests. Furthermore we will illustrate how the availability of different pump types, as designed for various dredging conditions, help optimise a dredger's profitability.

Keywords: Dredge pump, pump performance, optimum design, pump test results

INTRODUCTION

In general it may be said that to be successful a dredging contractor must adapt its fleet and technology to keep pace with trends in the market, or even to precede them. Given its present fleet and market vision the contractor may hereto define an operational mix for his new equipment, this avoiding the pitfalls of fleet over-capacity, over-specialisation and over-generalisation. Operational mix here refers to the distribution of time spend on the different kind of expected maintenance and/or capital dredging operations. Operations which are further typified by amongst others the volumes and characteristics of the soil to be dredged, the various dredging depths, discharge methods and ranges of sailing and pumping distances.

It is this operational mix that forms the basis for the design. A dredger designed for maintenance work in a specific harbour area will thus differ greatly from a general-purpose dredger resulting from a much wider operational mix. Now the trick of the trade is to compose the most optimal design for a given operational mix, i.e.; to establish the design that offers the highest economic potential. A potential determined by the rate of production in combination with the total cost made to achieve this rate of production.

The cost-effectiveness of dredging today depends to a great extent on the performance of pumps; dredge pumps, submerged pumps and jet pumps, also in high efficiency versions. Targeting the efficient transport of either the dredging mixture or water, they are critical components in almost all types of dredging systems. Their capacity has to be adapted to the task in hand and their effective operating life in often difficult operating conditions maximized.

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Optimal design, reducing the effects of wear, and ensuring easy repair and replacement all play key roles. In other words in upgrading pump quality to the highest level possible and minimizing overall lifetime costs.

When selecting a pump for a given range of duties a balance has to be found considering characteristics like the pump's energy consumption, suction performance, maximum passing particle size, lifetime, size, weight and required investment. To optimise the match between the pump's range of duties and characteristics IHC offers an extensive pump programme consisting amongst others of conventional economy, high efficiency pumps (efficiencies up to 92%), and specifically customised pumps. All are designed and made to respond optimally to the needs of future working conditions. This article will highlight the two latest additions to this programme, namely;

IHC TT-Pump units
IHC High Efficiency Cutter Special pumps

IHC TT-PUMP UNITS

The IHC TT-Unit shown in figure 1 is a multipurpose tool developed for use on a wide range of smaller scale dredging projects. The TT-Unit can be suspended from a crane or A-frame or in combination with a connector the pump unit can easily be fitted to an excavator. If required the pump unit can be mounted on a ladder of a cutter suction dredger or integrated in a suction pipe of a trailing suction hopper dredger.

TT-Units are used for loading and unloading of hopper barges, sand and gravel mining operations and booster station applications. Other applications such as maintenance dredging, trenching operations are amongst others endless possibilities with the TT-units. The TT-Units are available in different sizes; ranging from a suction diameter of 150 mm to 350 mm with a maximum power consumption of 65 to 375 kW respectively. Dredging depth is limited only by practical aspects. When suspended from a craned the dredging depth can be up to hundreds of meters.

The standard configuration is with a highly wear resistant pump casing, 3-bladed impeller and wearing plates. This makes the TT-Units suitable for use in even the most extreme applications. The high wear resistant materials combined with the design for easy maintenance allows for minimum downtime. Together with robustness and ease of maintenance, the initial investment was set high on the design priority list. To meet these priorities the frame was kept simple, the drives are off the shelf units and the bearing assembly has been redesigned from a standard assembly to reduce price.

A subject for special attention during the design phase here was the shaft sealing. The shaft sealing stops the pumped fluid from flowing out of the pump at the point the shaft penetrates the cover of the pump, and contributes to the efficiency of the pump. As in the application of TT-Units the pump is often totally submerged, the decision was made to remove the shaft sealing from the system:

No seal = Price of seal removed + Price of ancillary services for the seal removed + Easy maintenance

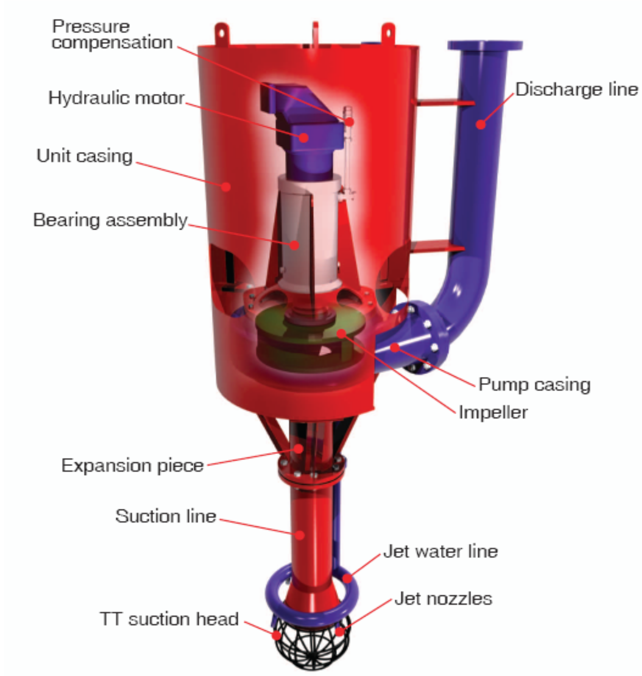


Figure 1. IHC TT-pump unit.

The TT unit shown in Figure 1 is driven by a hydraulic motor directly mounted on the dredge pump shaft. The power supply can be realized by connecting the available hydraulic feed by means of standardized couplings. The TT-unit is also furnished with a jet water system. The jet water is supplied directly to the suction mouth so increasing the output of the TT-Unit. Finally a protective casing shields the unit form damage that could occur when dredging. To further expand flexibility of the TT pump unit alternative drives can be opted and a cutter can be mounted for excavating more compact materials. For illustration see Figure 2, 3 and 4.

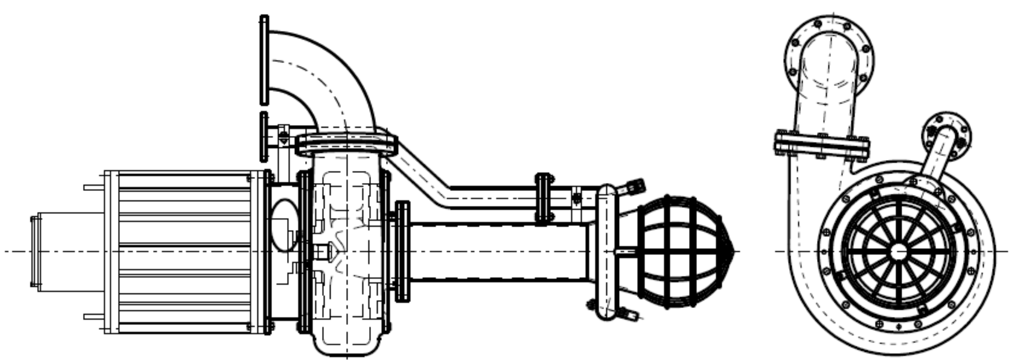


Figure 2. TT pump unit driven by an electric motor.

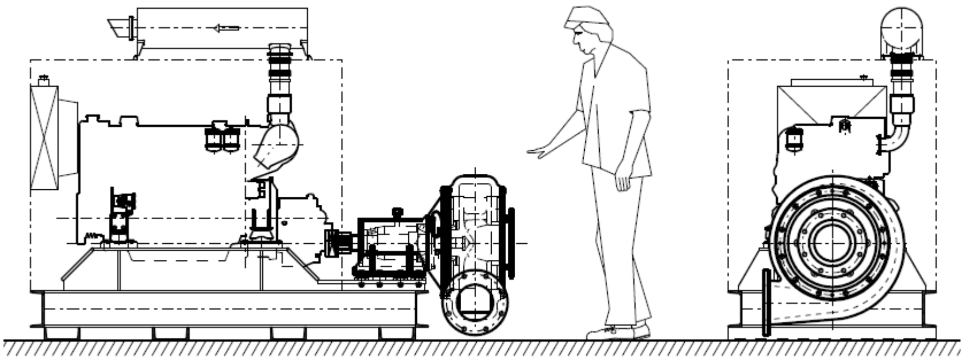


Figure 3. TT pump unit driven by a diesel engine.

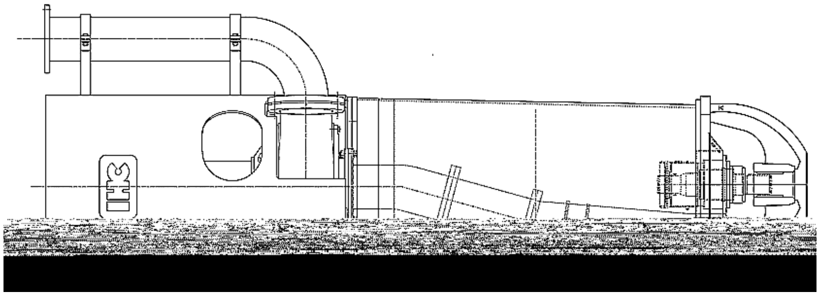


Figure 4. TT pump unit equipped with a cutter to dredge more compact materials.

For transport of the slurry the TT-pump unit is furnished with a robust pump with a wide working range, a large sphere passage and good suction properties. This allows the unit to operate over a broad range of dredging projects. Some main characteristics of the TT-unit range are printed in Table 1, Figure 5 illustrates the performance of these units. In Figure 5 the output of m^3 situ material per hour is shown against the discharge length. Depending on the required output this figure can help choosing the right TT-unit for the job on hand.

Table 1. Main characteristics of the IHC TT-unit range.

	TT 15-65	TT 20-95	TT 24-150	TT 30-250	TT-35-375
Suction diameter	150 mm	200 mm	240 mm	300 mm	350 mm
Number of blades	3	3	3	3	3
Speed	1370 rpm	990 rpm	845 rpm	705 rpm	625 rpm
Power	65 kW	95 kW	145 kW	210 kW	375 kW
Hydraulic drive:					
Flow	225 l/min	255 l/min	445 l/min	745 l/min	1155 l/min
Pressure	205 bar	280 bar	240 bar	225 bar	220 bar

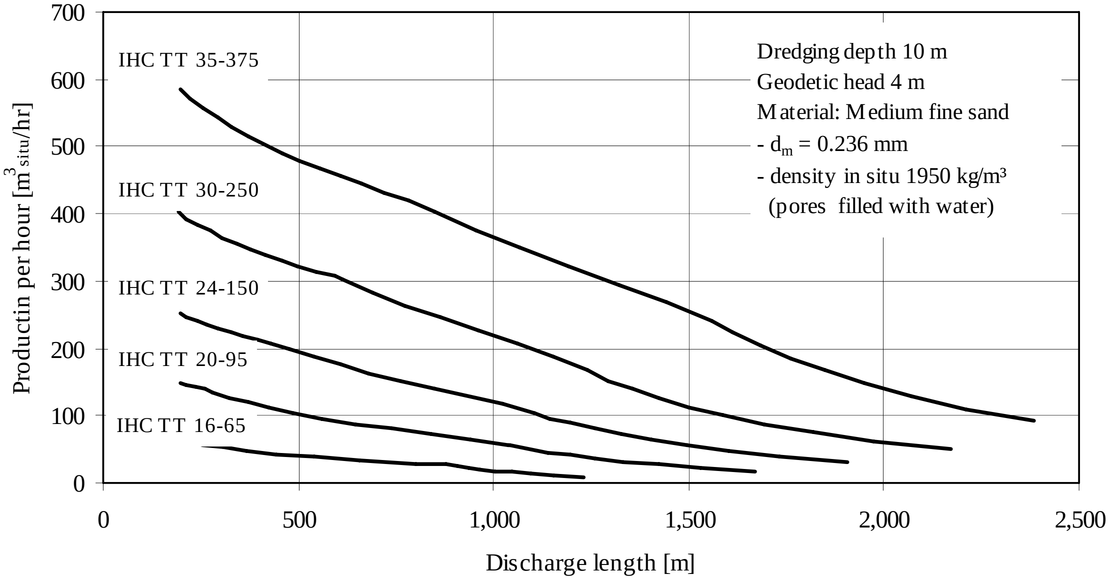


Figure 5. Production per hour set against the discharge length.

IHC HIGH EFFICIENCY CUTTER SPECIAL PUMPS

Whenever oversized material is present the project's success might be negatively affected by a lot of downtime. This obviously when heavy duty cutter dredgers like the JFJ de Nul or d'Artagnan work in rock, but also when smaller size cutter suction dredgers or hopper dredger work in areas where a lot of oversized materials like cobbles and boulders or debris is present.

When working in this type of material, see Figure 6, one generally tends to limit the passage of the excavation tools like cutter or draghead down to the passage of the pump. In this way one strives to prevent oversized material entering the pump and therewith avoid downtime due to blockage of the pump. However, this limitation of the excavation tool's passage evidently implies sub optimal production rates. It is apparent that whenever working in oversized material the application of a pump with a large passage is favourable to minimise the amount of downtime.

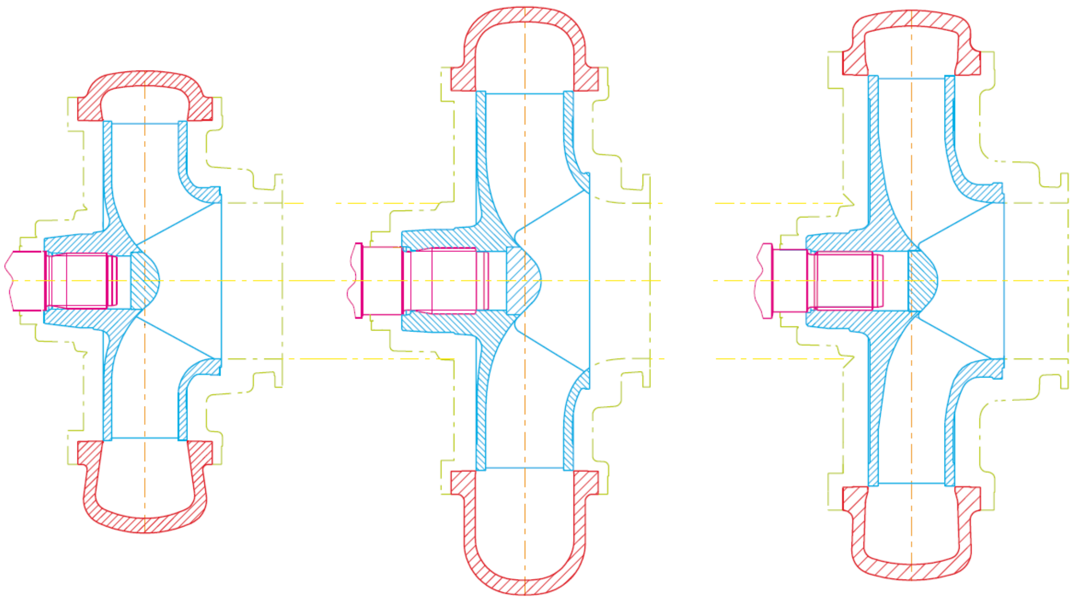
Figure 6. Shore deposit filled with large sized material by a heavy duty cutter suction dredger.

One way of increasing the pump's passage is by simply choosing a larger size pump, the larger geometry simply implies a larger passage. For illustration: A 3-bladed IHC High Efficiency Medium Pressure pump with a suction diameter of 900 mm has a passage of 380 mm, the same type pump with a suction diameter of 1,000 mm has a passage of 420 mm. Downside of this method is that one moves away from the best efficiency point of the pump, i.e.: the (hydraulic) efficiency at the actual operating point will be below the efficiency of the pump's best efficiency point. With the optimisation of the operational efficiency one thus compromises the hydraulic efficiency. Furthermore; when working off the best efficiency point one will introduce unwanted side effects as higher radial loads on the pump shaft (shortening the lifetime of the pump shaft and its bearings) and an increase of the pump's (local) wearing rate (shortening the lifetime of the pump casing and impeller). Improvements in one area (in this case passage) thus tend to result in negative impacts in other areas.

Whenever requirements tend to conflict priorities have to be set. Bearing this in mind, the priorities for the new design of the cutter special pump were set to include a very large passage, and a low Net Positive Suction Head required (NPSHr). The hydraulic design was subsequently optimised for the maximum achievable efficiency within the limitations of the required passage and suction performance [van den Berg et al., 2005]:

- Passage of 50% of the suction diameter
- NPSHr below 30-35 kPa at maximum flow
- Efficiency above 85% around the operating point
- Differential head above 550 kPa

The resulting design is shown in Figure 7. Please note that in comparison with IHC's High Efficiency Medium Pressure (left hand side) and High Efficiency High Pressure pump (right hand side), the High Efficiency Cutter Special is quite wide; both the width and the passage are approximately 50% of the suction opening. The inlet edge is cut back, resulting in a short built-in length. The relatively large diameter of the impeller results in a good suction performance.



IHC High Efficiency Medium Pressure | IHC High Efficiency Cutter Special | IHC High Efficiency High Pressure

Figure 7. Comparing cross sections.

Figure 8 shows the manometric head and the efficiency for the 3-bladed Cutter Special pump with a suction diameter of 900 mm. The Best Efficiency Point of the newly designed pump is close to the critical velocity of material coarser than 10 mm in a 900 mm pipe; the maximum efficiency is above 85%. This characteristic is favourable for a pump for very course material, which of course was the starting point of the design process. Finally: the NPSHr is calculated to be about 36 kPa around the design point.

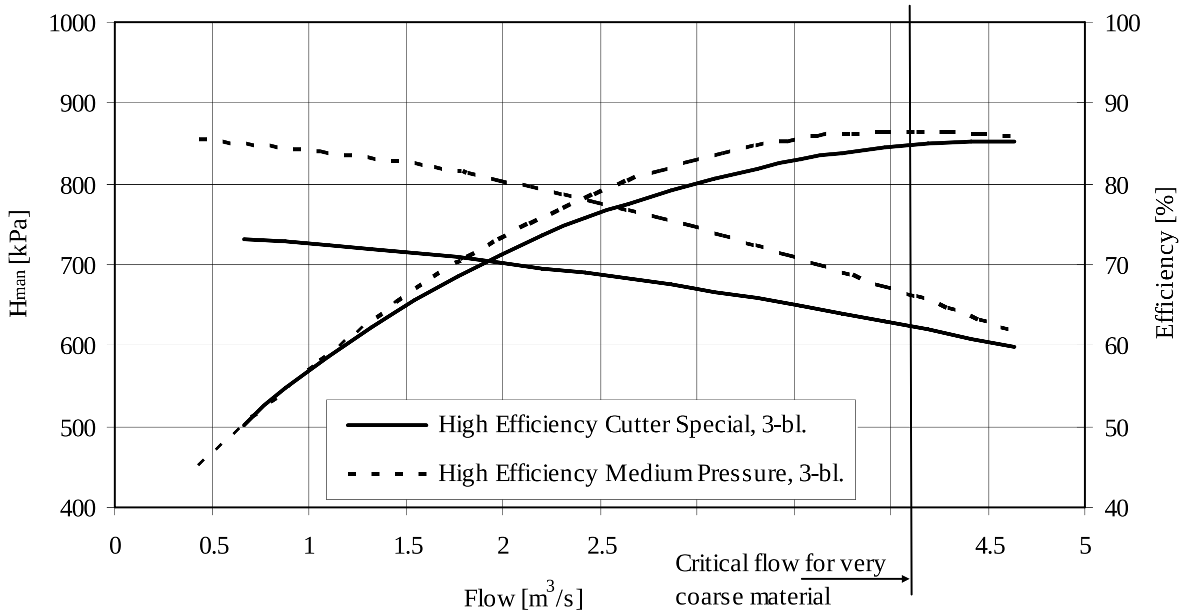


Figure 8. H_{man} and efficiency of the newly designed Cutter Special pump (900 mm suction diameter).

The application of the cutter special pump was evaluated by determining the overall performance of a heavy duty cutter suction dredger equipped with three pumps. The first dredge pump is placed (submerged) on the ladder, the other two dredge pumps are placed inboard. The pumps were designed for a maximum power of 2,000 kW, 3,330 kW and 3,330 kW respectively.

The overall performance of this imaginary dredger was first calculated for the situation when equipped with three high efficiency medium pressure pumps and subsequently with three cutter special pumps. Dredging conditions for both situations were assumed as being dredging coarse material and rock (larger than 10 mm).

The dimensions printed in Table 2 demonstrate that the cutter special pump is slightly larger than the medium pressure pump. The larger dimensions are basically required to increase the ball passage which, thanks to the new design, has been increased from 380 mm to 450 mm. Furthermore, the speed of the cutter special pump is significantly lower, resulting in less wear of the impeller, around the suction opening.

Table 2. Main dimensions of the high efficiency medium pressure pump (IHC HRMD) and the cutter special pump (IHC HRCS) chosen for the imaginary heavy-duty cutter dredger.

Pump type	IHC HRMD 182-38-90	IHC HRCS 216-45-90
Number of blades	3	3
Suction diameter	900 mm	900 mm
Impeller diameter	1,816 mm	2,160 mm
Impeller width	380 mm	450 mm
Ball passage	380 mm	450 mm
Speed	392 rpm	302 rpm

Figure 9 compares the performance per productive hour. Please note that up to a discharge length of approximately 1,700 m the production is similar. Beyond this length, the High Efficiency Medium Pressure pump provides greater production, but such lengths are not common practice when pumping large size particles. In stead, as the pumping of large size particles over a long distance requires a lot of pumping power, it is often more economical to load barges.

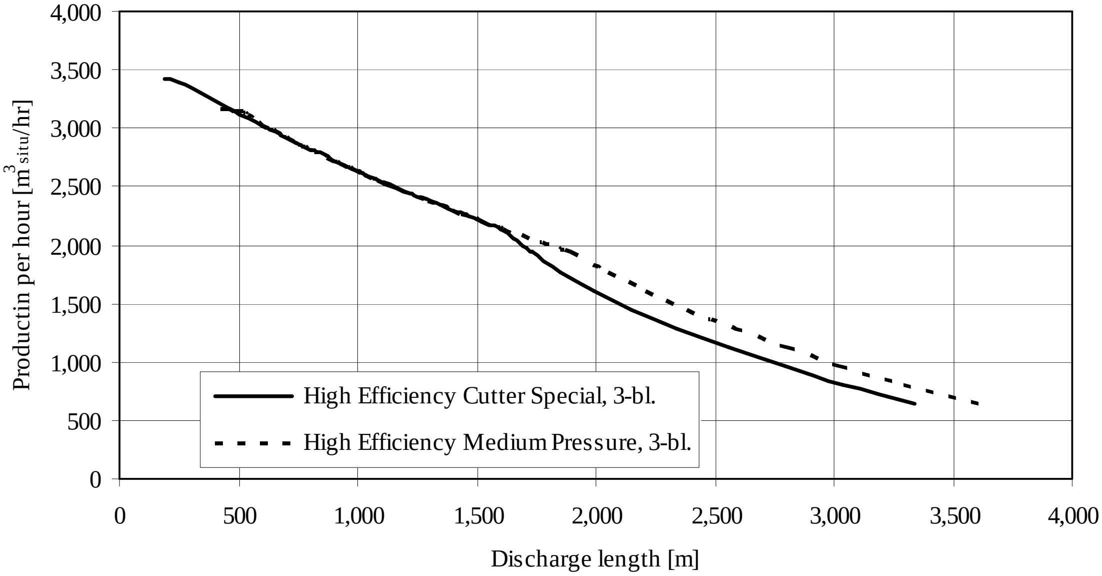


Figure 9. Production per hour of a heavy duty cutter dredger, set against the discharge length.

In Figure 10 the advantage of the larger ball passage is taken into account. The newly-designed high efficiency cutter special pump provides much better operational efficiency, as the larger ball passage reduces downtime due to blockages. Naturally in daily practice the actual reduction in downtime will be determined mainly by the percentage of oversized material present at the dredging location. The results of figure 10 followed from the assumption that the reduction in downtime is about 20%. This 20% roughly matches the relative difference in passage (+18% for the cutter special pump).

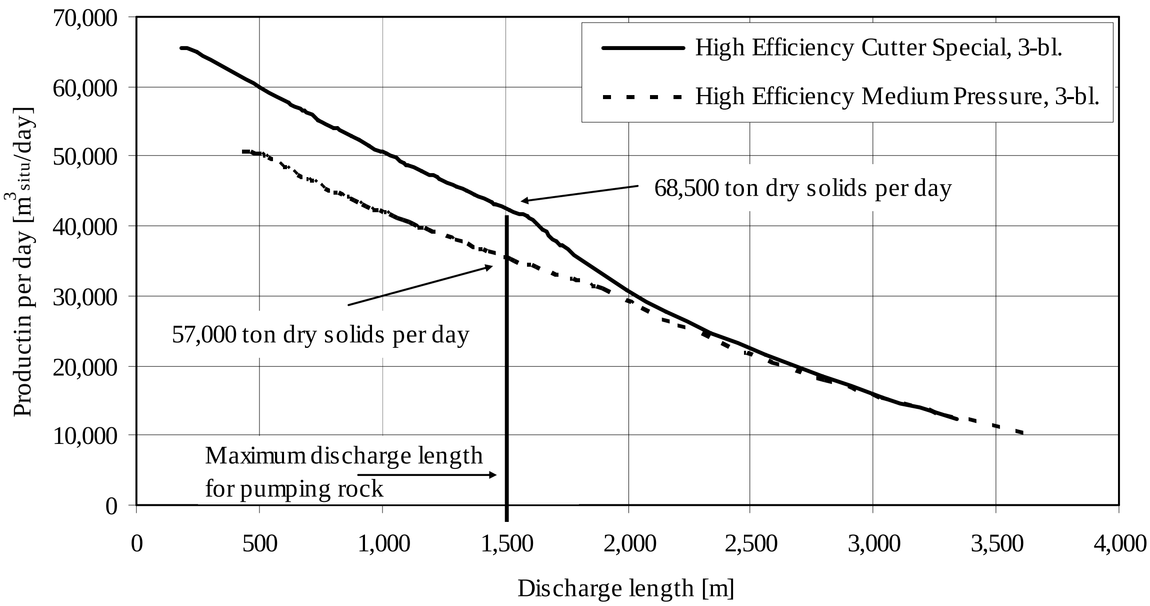


Figure 10. Production per day of a heavy duty cutter dredger, set against the discharge length.

CONCLUSIONS

The cost-effectiveness of dredging today depends to a great extent on the performance of pumps. Targeting the efficient transport of the dredging mixture they are critical components in almost all types of dredging systems. Their capacity has to be adapted to the task in hand and their effective operating life in often difficult operating conditions maximised. Optimal design, reducing the effects of wear, and ensuring easy repair and replacement all play key roles. In other words; upgrading pump quality to the highest level possible and minimizing overall lifetime costs.

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