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Balancing pump efficiency with NPSH is the key to delivering a cost effective package

Selecting a pump is a balance of many factors, including the volumes and contents to be pumped, the efficiency of the pumps and how frequently the pump will be run. Where space is at a premium or the cost of changing structures or pipework prohibitive, then engineers may also have to deal with an additional factor, a lack of suction static head. Not taking the suction static head into account fully can cause catastrophic cavitation to occur in the pump. Oliver Brigginshaw, Managing Director of Amarinth, a leading company specialising in the design, application and manufacture of pumps and associated equipment, explains NPSH and how pumps can be cost effectively engineered to operate in a low NPSH environment.

Cavitation occurs when the pump cannot get enough liquid and the resulting reduction in pressure causes liquid to vaporise and form bubbles. These bubbles can grow dramatically and choke an inlet, further reducing the flow of liquid and the performance of the pump. In addition, these bubbles can implode with tremendous force, literally tearing away at the metal. The resulting increase in vibration and noise can lead to premature component replacement and in some cases complete failure of impellers.

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To avoid this catastrophic situation, the pump manufacturer should always ask you for the Net Positive Suction Head available at the pump - NPSH(A) - and ensure this exceeds that required by the pump to operate without cavitation occurring – what is known as NPSH(R). See Fig 1.

NPSH (A) is in principle a straight forward calculation, taking into account the suction static head, friction losses, atmospheric pressure and the vapour pressure of the liquid. However, caution must be exercised with the latter parameter, as in an industrial process the liquid may be a cocktail of chemicals and so the vapour pressure may need to be determined experimentally. Also, does the static head change during the process of pumping the liquid, for example during the emptying of a vessel?

For a given NPSH(A), the pump manufacturer will provide a pump with an NPSH(R) less than NPSH(A) by some 0.5M, though if the accuracy of the data is circumspect (such as pumping a cocktail of fluids), then it may be better to increase this difference.

Generally pump manufacturers design their pumps to work at maximum efficiency and hence the lowest running costs. Efficiency is related to pump speed and so the speed is fixed to deliver the maximum efficiency for a given pump. These parameters dictate the NPSH(R) for any given pump.

Important as efficiency is in a pump though, it is not the only criteria when selecting the most cost effective pump for the job. Achieving the necessary static head to run a pump at its optimum efficiency may be either impossible to achieve or could involve costly changes to plant structure, pipe work and associated equipment. If faced with this situation, what are the alternatives?

Computer modelling techniques have better enabled us to understand fluid dynamics and how we can design a pump to run efficiently in a low NPSH environment. However, many of the pumps sold today have designs that date back 50 years and

their manufacturers often have neither the desire, skills, nor wish to make the investment in new patterns to deliver a low NPSH alternative.

This means that if you require a low NPSH pump then you need to turn to one of the specialist pump companies such as Amarinth. Having made significant investments in computer aided engineering tools and engineering staff skilled in fluid dynamics, these companies are the race car equivalents of the road car world.

Using sophisticated tools and techniques they can "tune" existing designs and re-engineer key components to produce pumps capable of delivering the required performance within the NPSH constraints of the plant. They also have comprehensive test facilities, as finding the point of cavitation reliably is a crucial, but largely empirical, process.

The resulting pump will be one that can deliver the specified performance within the suction static head constraints at an efficiency approaching that of a standard pump. The cost of undertaking these modifications is of course not cheap, but it is almost always outweighed by the cost or sheer impracticability of modifying the plant structure.

A good example of a low NPSH application where there was no option to create the necessary static head can be found on a Floating, Production, Storage and Offloading (FPSO) vessel. Wood Group, a global market leader in deepwater engineering, was working with Amerada Hess on a sophisticated filtration system that would enable their Triton FPSO vessel located in the North Sea to meet the pending OSPAR regulations. The project demanded ten high specification pumps to pump the produced water. These had to have a small enough footprint so that they could squeeze within the tight space constraints of the Triton vessel and the restriction of existing headroom so that pumps would have to operate in a very low NPSH (A) environment, leaving them prone to cavitation.

Initially a "vertical in-line pump" was considered but this was quickly ruled out as it required significant headroom to remove the motors during maintenance, which was not available. Additional pipework before and after the pump would also have been required, expanding the footprint beyond the space available.

To achieve the dimensional space constraints within the tight contract deadline, a completely new pump design was not feasible and so Amarinth proposed a hybrid design. This was based on its proven 'C' series heavy duty ISO 5199 chemical pump. This "horizontal" pump would fit the space constraints and was already suited to operating in low NPSH environments.

Up-rated API 610 bearing brackets were designed and incorporated which would allow the pump to meet the demands of the application, both in terms of the space available and the NPSH constraints of the vessel, thus achieving Wood Group's requirements of low maintenance, high reliability pumps that required low NPSH(R). The alternative would have been to redesign the system and pipework or at worst build new decks to deliver the NPSH (A) that a standard high efficiency pump would require for normal operation.

This project showed that by choosing the correct pump for the application and focusing on low NPSH rather than high efficiency, Wood Group was able to make significant cost savings on the overall project as the major system and vessel changes that would have been required to accommodate other pumps were avoided.

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OPTIONAL PANEL or BOX ITEMS

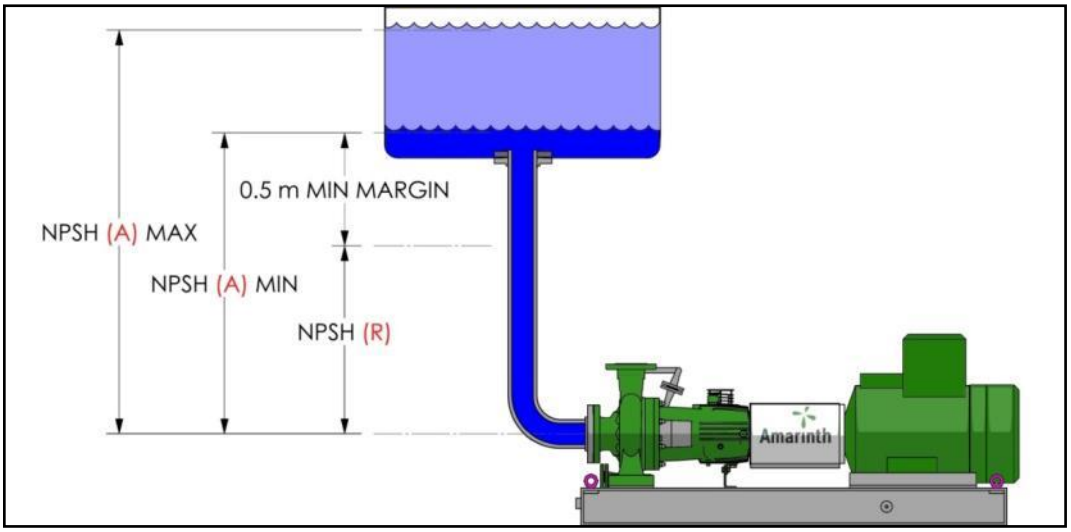

Fig 1 – The correlation between NPSH (R) and NPSH (A)

Pumps in situ between decks

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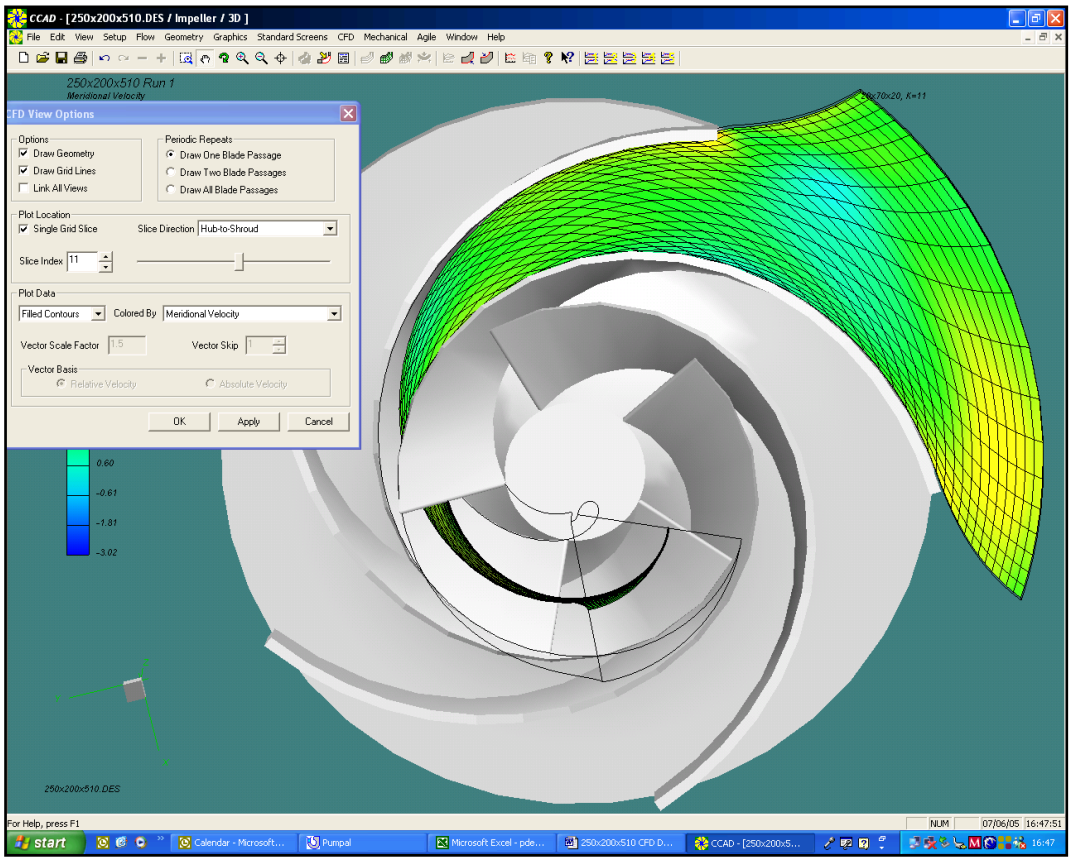
Cavitation damage in an impeller



Computer Fluid Dyamics modelling

NOTES TO EDITORS:

Founded in 2002, Amarinth has harnessed the skills, creativity and passion of people who have worked in the pump industry for many years. Amarinth delivers world-leading expertise in the design, application and manufacture of centrifugal pumps and associated equipment to ISO, ANSI & API standards, primarily for the industrial, chemical & petrochemical markets. Their portfolio includes:

- **Pumps**: Horizontal and vertical API 610 pumps, chemical and industrial pumps, many of which are interchangeable with the Girdlestone pump ranges, eliminating the need for expensive modifications when replacements are required.
- **Pressure Vessels**: Protect System Plan 52 and 53A and 53B sealant systems with inbuilt condition monitoring for pumps and mixers that are suitable for Safe area up to Zone 1.
- **Spares & Service**: High quality, fast lead-time re-engineered spare parts to improve performance and extend pump life, including many which are directly interchangeable with the Girdlestone pump ranges.
- **Packages & Modules**: Condensate Recovery Units manufactured for Spirax Sarco incorporating the innovative Ci-Nergy intelligent variable speed control system, plus bespoke packages & skids built to order.
- **Business Systems**: state-of-the-art e-commerce technologies that deliver 24/7 support enabling customers to select pumps and place orders on-line and then track every stage of manufacture through to delivery, any time, anywhere in the world.

The company operates globally from its base in Rendlesham Suffolk, United Kingdom and has a customer base of world-leading companies, including BP, Shell, ExxonMobil, GlaxoSmithKline, Pfizer, Spirax Sarco, Diageo, AMEC, Fluor and Halliburton.

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