Improved Centrifugal Pump Performance with Counter Helical Inducer Housing Grooves

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Abstract

Net positive suction head required (NPSHR) is closely related to inducer performance and is an important requirement for overall pump performance. The ability of an inducer to propagate fluid towards the impeller inlet is greatly diminished as the fluid begins to rotate with the impeller blades. By machining helical grooves in the inducer housing that are in a counter rotation to the inducer blades, the fluid that has rotational energy is channeled up the grooves and towards the impeller. The helical groove concept was tested on an axial centrifugal pump and yielded positive results. NPSHR level was improved with the modified grooved inducer inlet housing without significant change in the head, power, or efficiency when compared to the same pump without the modification.

Background

As fluid is propagated up inducer blades the fluid begins to take on some rotational energy and therefore begins to rotate with the inducer blade. When this occurs the inducer is no longer able to move the fluid towards the impeller inlet. This is in direct correlation to the point at which the pump reaches the NPSHR limit. It is proposed that if there were grooves machined on the inside of the inducer housing where the grooves were in a counter rotational direction as compared to the inducer blades that these grooves would assist in transmitting the fluid towards the impeller inlet. The grooves would "catch" the rotating fluid which would be pushed up the groove by the rotation of the inducer blade resulting in more fluid translated from the inducer inlet towards the impeller inlet and threfore yielding a lower NPSHR level. An important feature to the counter helical grooved inducer concept is the easy retrofit for pumps already in service.

Design

A model 6-ECC-122 retractable in-tank pump designed and manufactured by Ebara International was used for testing of the grooved inducer housing concept. This particular pump is designed for 330 m^3/hr flow and 266 m of head at 3000 RPM and for service in liquid natural gas (LNG). The pump that was used for testing had two inlet housings, one per standard design and one per standard design that was machined with helical grooves as shown in Fig. 1. The helix of the grooves is in counter rotation to the inducer blades.

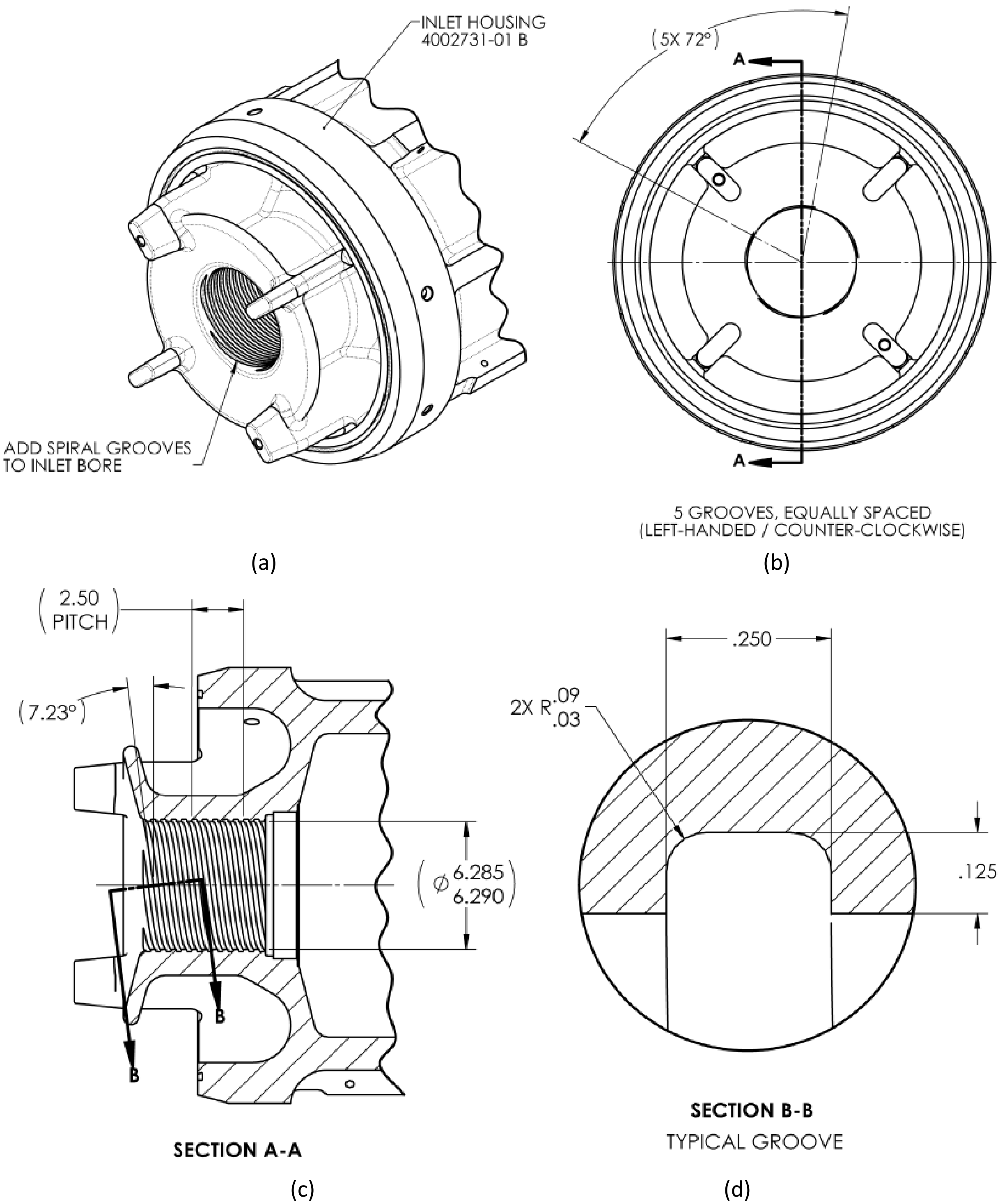


Fig. 1 (a)-(d): Machine Drawing of the Modified Inducer Housing with Counter Helical Grooves

The counter helical grooves were machined to be equally spaced with a 2.5 inch pitch as shown in Fig. 1 (c). The grooves had a depth of 0.125 in, a width of 0.250 in and the corners of the grooves were rounded as shown in Fig. 1 (d). The pump was configured and tested using the unmodified and the modified inlet housing.

Testing and Results

As discussed in the previous section one pump was tested with two different inlet housings, one per standard design (unmodified) to provide a baseline and one with the counter helical grooves (modified). Tests were performed at Ebara International's Test Stand located in Sparks, NV. Each configuration was subjected to an NPSHR test to identify the impact of the grooves on NPSHR levels and each configuration was also tested per standard testing procedures to investigate how the grooves affected overall performance including head, power and efficiency.

Figure 2 is a comparison graph showing the NPSHR curves for both the modified and the unmodified inducer housing. The pump with the unmodified inducer housing is denoted by the blue data points and curve and the pump with the modified grooved inducer housing is denoted by the green data points and curve. This graph shows that the modified inducer housing had a significant positive impact on the NPSHR performance of the pump. At flow rates close to the rated 330 m^3/hr the modified inducer housing improved the NPSHR by 1 m of head which corresponds to an 11% improvement. This is a considerable increase when related to how much more fluid may be pumped out of a tank which will increase profits.

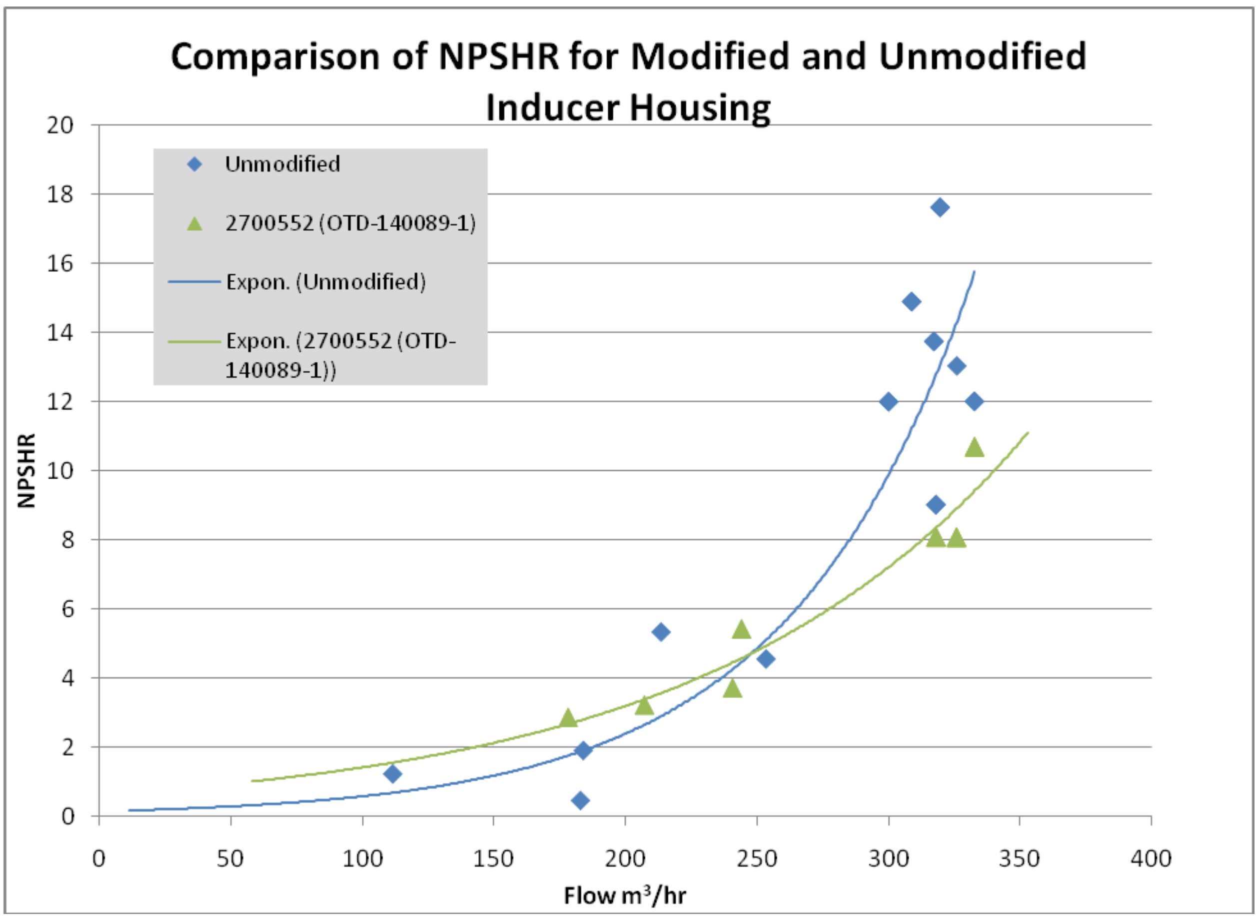
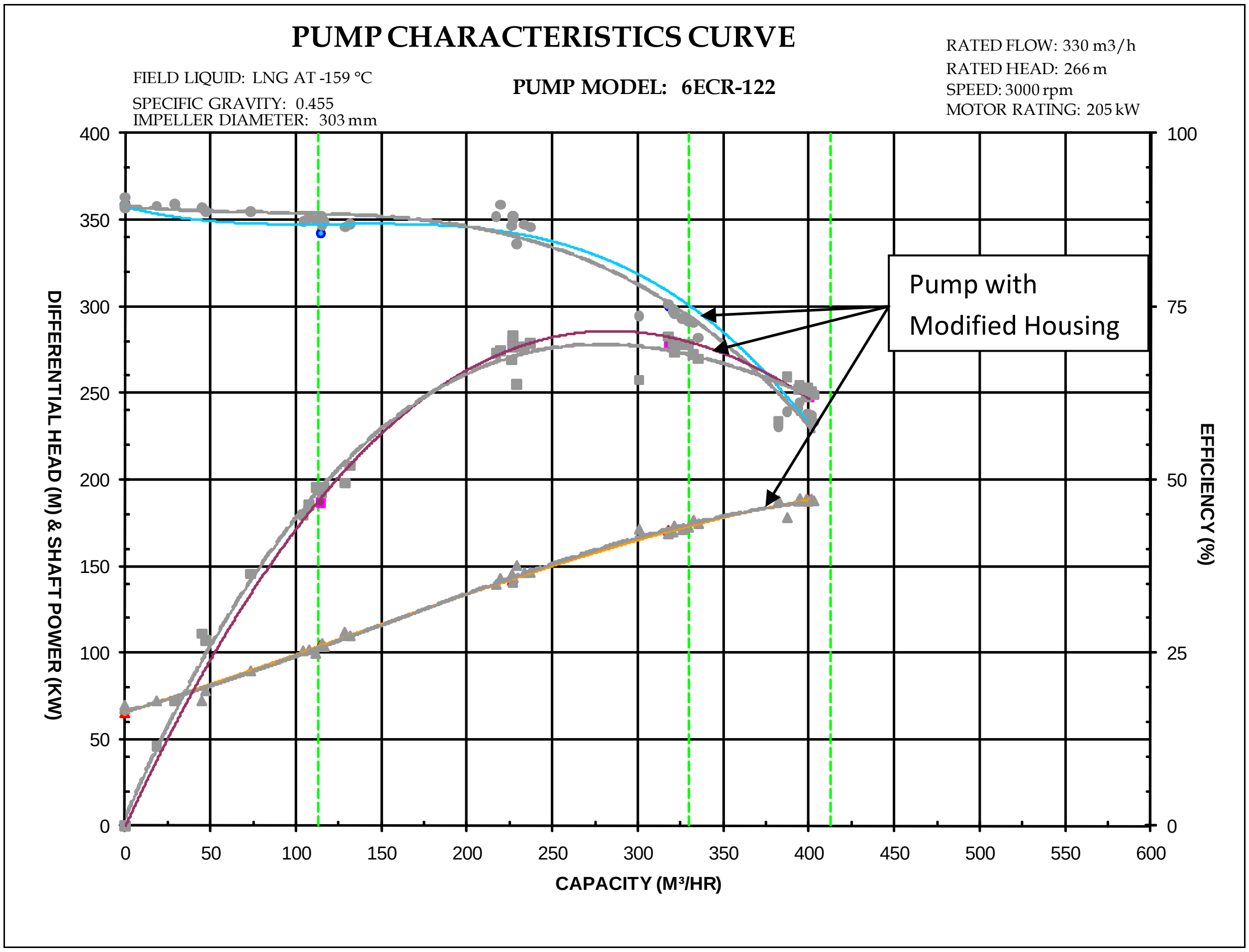


Figure 3 shows the pump characteristics curves for both the modified configuration denoted by smooth curves and the unmodified configuration denoted by the dashed lines and data points. As shown in the curves the pump power is the same between both designs. From approximately 250 m^3/hr to 375 m^3/hr the efficiency of the modified grooved inducer housing is increased. This includes the BEP and rated flow. The head curve doesn't see a significant shift in performance; however, at relatively low flow the modified inducer housing exhibited a reduced head curve that is reversed at relatively higher flows when compared to the unmodified baseline. There is an interesting "flat" portion of the modified head curve between approximately 75 m^3/hr and 225 m^3/hr. This is an interesting restult and is currently under further investigation.



Future Work

The results of this initial test are inciting and deserving of further investigation. Future tests and computational fluid dynamics (CFD) of variations of the groove concept are under investigation. The concept is also patent pending.