Chapter 18
Optimization of the Impeller and Diffuser of Hydraulic Submersible Pump using Computational Fluid Dynamics and Artificial Neural Networks

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ABSTRACT

Overall performance of hydraulic submersible pump is strongly linked to its geometry, impeller speed and physical properties of the fluid to be pumped. During the design stage, given a fluid and an impeller speed, the pump blades profiles and the diffuser shape has to be determined in order to achieve maximum power and efficiency. Using Computational Fluid Dynamics (CFD) to calculate pressure and velocity fields, inside the diffuser and impeller of pump, represents a great advantage to find regions where the behavior of fluid dynamics could be adverse to the pump performance. Several trials can be run using CFD with different blade profiles and different shapes and dimensions of diffuser to calculate the effect of them over the pump performance, trying to find an optimum value. However the optimum impeller and diffuser would never be obtained using lonely CFD computations, by this means are necessary the

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application of Artificial Neural Networks, which was used to find a mathematical relation between these components (diffusers and blades) and the hydraulic head obtained by CFD calculations. In the present chapter artificial neural network algorithms are used in combinations with CFD computations to reach an optimum in the pumps performance.

INTRODUCTION

Several processes on industry are linked directly with liquids’ transport, for this reason, the pumping devices are one important part of them. One of the most used devices in the industrial process are hydraulic pumps. For the correct design and operation of a pump is relevant to consider factors such as the working liquid, hydraulic head, vibration, cavitation and efficiency especially. In general, a hydraulic pump is a machine used to move liquids through a piping system and to increase the fluid pressure; this uses the mechanical energy of a impeller to increase the pressure in a liquid. Hydraulic pumps are among the group of machines called turbomachines, all these share similar characteristics between them.

A turbomachine is a rotating engine in which a fluid passes continuously and there are a energy transfer process, the energy exchange process could occur from fluid to rotating engine or vice versa. Turbomachinery differs from other devices because the energy transfer process in continuous, not cyclical or alternating as an internal combustion engine or piston pump, besides they can add or remove power to the working fluid, making pressure, thermal or kinetic energy.

Turbomachinery consists of several parts depending on the type, size, design and application. However, the majority of consists of static and rotating parts, within these two sets may have elements in common, for example all turbomachinery has a rotor and a stator.

The rotor is the central part of the whole turbomachine and is where the exchange of energy occurs. Consists of one or more disks which support the blades, vanes or spoons depending on the type of the turbomachine. The geometry of the blades is essential for this exchange of energy with the fluid, and directly impacts on the performance of the turbomachine and the rate of energy generated (if the energy is transmitted by exchange pressure or velocity). In the particular case of pumps, the set of blades and support is called impeller.

Stator is the set of all static parts of the turbomachine like housing (volute casing, scroll), stay vanes, bearings, seals, etc. However taking a design lead approach to interaction fluid-machine is considered, the main component of the stator is the diffuser (Lobanoff, 1992).

The pump under study is a submersible hydraulic pump with a power of 1/2 HP, with an impeller diameter of 5.2”, closed type and 2 blades, with a discharge diameter of 2”, and a hydraulic head of 7.53298 meters to a volumetric flow of 3 Liter/second. The pump is optimized by changing the shape of the blades and the diffusor, the artificial neural network algorithms are used to find the mathematical relation between changes in the shape of the blades and the diffusor, and the hydraulic head pump. This mathematical relation is given by a function of two variables, with this mathematical function, local maximum related to the geometrical parameters are found, optimizing this way the hydraulic submersible pump.

As mentioned previously, the shape of the blades and the diffusor affects directly the pump efficiency, equations 1, 2 and 3 shows the variables which are related to efficiency.

\[ P = \rho g H \]  

(1)
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