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C.F.D. Analysis of Industrial Pump: A Case Study

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ABSTRACT

There is an ever-increasing use of centrifugal pumps in industrial applications. The application in industry nowadays such as oil and gas with the increasing use of centrifugal pumps for applications of this type, it becomes important to be able to predict pump characteristics and create efficient design. Design changes will be suggested in an attempt to improve the performance of the impeller used in the pump. This study consists of the detailed study of a model of the centrifugal pump and also consists of the detailed to identify, observe and determine the pattern of velocity profile and pressure distribution by using commercial CFD tool (FloEFD). This project will definitely provide much helpful information while contributing to the knowledge about the design and characteristics of centrifugal pumps.

Keywords – CFD, Turbomachines, HVAC, Hydraulic Machines, Pump

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I. INTRODUCTION

Industrial pumps play a particularly important role because of their capacity to handle high flows. In fact, industrial pumps constitute more than 75% to 85% of the world's production of pumps, as they are frequently used in sewage, food processing, water treatment and manufacturing plants, as well as the chemical and petroleum industries, where they are used for the pumping of all types of low-viscosity fluids. They can also easily handle liquids with high proportions of suspended solids present in them [1-20].

With the many varieties of available pump configurations, a proper design is the most important requirement for any facility. 20% of the total energy consumed globally is used to run a pump of one sort or another—yet, two-thirds of these pumps use 60% more energy than is required. To ensure energy efficiency and prevent equipment failure, it is important to be able to predict and evaluate the improved design with CFD Simulation under different operating conditions [21-40].

II. METHODOLOGY ADOPTED

The governing equations of viscous flow are based on conservation of mass, momentum and energy which are Langrangian in nature. There are many commercial general-purpose CFD programs (Interdisciplinary field of study based on Physics, Engineering, Mechanics, Biology, Material Science supported by both Mathematics and Computer Science) available, e.g. Ansys-Fluent, Ansys-CFX, Star-CD, FLOW 3D, SoldWorks Flow Simulation (FloEFD) and Phoenics. A very useful open-source program that can handle CFD problems is OpenFoam. However, the documentation and the user interface are not well developed as those for the commercial codes. Commercial CFD packages contain modules for CAD drawing, meshing, flow simulations, solver and post-processing [41-60].

The CFD analysis for the same was carried out using the FloEFD, for analyzing the performance. For very complex systems the results are not very accurate, but CFD can still be very useful saving design engineer's time-cost-effort. Experimental validation verifies the codes to make sure that the numerical solutions are correct and compare the results [61-75].

III. THEORY AND CALCULATION

The FloEFD commercial CFD tool solves the Navier Stokes and conservation equations. The equations that we used are not closed, so we need to use Turbulence Modelling to close the equation set and then iterate towards a solution. We used what is called a Reynolds Averaged Navier Stokes (RANS) approach, (or we can use an Eddy Simulation technique which resolves the larger eddies in the flow and is only really required when you have separation or large re-circulating regions). The most commonly used models are the RANS models due to their low cost in terms of compute power and run times. The Eddy Simulation methods can be quite mesh sensitive but will yield much better results for separated and recirculating flow, but takes much longer run times. There are different turbulence models available in FLOEFD as mentioned below: Spalart-Allmaras Model; k- \mathcal{E} (k-Epsilon) Modelwidely used; k- ω (k-Omega) Model; v2-f Model; Reynold's Stress Model (RSM); Detached Eddy Simulation Model (DES); Large Eddy Simulation Model (LES) etc conclusion [50-25].

IV. RESULT AND DISCUSION

The advanced CFD model used in this research solves the Navier-Stokes equations, which are formulations of mass, momentum and energy conservation laws for fluid flows. This CFD model is able of predicting both laminar and turbulent flows.

Most of the fluid flows in engineering practice are turbulent, so this model uses the RANS equations, where time-averaged effects of the flow turbulence on the flow parameters are considered. Through this procedure, extra terms known as the Reynolds stresses appear in the equations for which additional information must be provided.

To close this system of equations, it employs transport equations for the turbulent kinetic energy and its dissipation rate (k- ϵ model).



Fig.-1 Pump CFD Analysis (Pressure)



Fig.-2 Pump CFD Analysis (Velocity)



Fig.-3 Pump CFD Analysis (Turbulent Viscosity)



Fig.-4 Pump CFD Analysis (Turbulent Energy)

This research shows the utility of the CFD numerical simulations (FloEFD) as a tool for design and optimization of Industrial Energy Efficient Pump performance and flow behavior through hydro mechanical devices or hydraulic structures at minimum time-cost-effort.

Comparison between above numerical results and manufacturer's data (not shown here for company privacy policy) reveals a good agreement.

V. CONCLUSION

The advanced CFD model used in this research solves the Navier-Stokes equations, which are formulations of mass, momentum and energy conservation laws for fluid flows. This CFD model is able of predicting both laminar and turbulent flows. Most of the fluid flows in engineering practice are turbulent, so this model uses the Revnold-Averaged-Navier-Stokes (RANS) equations, where time-averaged effects of the flow turbulence on the flow parameters are considered. Through this procedure, extra terms known as the Reynolds stresses appear in the equations for which additional information must be provided. To close this system of equations, it employs transport equations for the turbulent kinetic energy and its dissipation rate (k- ε model). This research shows the utility of the CFD numerical simulations as a tool for design and optimization of Industrial Energy Efficient Pump performance and flow behavior through hydro mechanical devices or hydraulic structures at minimum time-cost-effort.

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Authors declare, there is no conflict of interest.

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