CHAPTER 1

INTRODUCTION

At present, world is annually producing hundreds of thousands of centrifugal pumps which consume more than 200 billion kWh of electric energy per year. A further improvement of centrifugal pumps in the direction of increasing the efficiency and head coefficient of the impeller is an important problem whose solution will make it possible to reduce the consumption of electric energy and metal. For example, a 1.5% increase of efficiency just for feed and condensate pumps of a thermal electric power station during the year can save 1 billion kWh, and for each 15% increase of the head coefficient of the impeller the consumption of metal will decrease 10%.

Pump characteristics obtained from test can be modified by a variety of relatively simple and inexpensive modifications of the impeller or volute geometry. Accurate dimensional checking of finished pump components may reveal areas where manufacturing errors have been made and frequently the task of the designer consists of restoring the agreement of the dimensions with the drawing. In some cases when total agreement with the drawing cannot be reached the designer can still 'save' the unit by correcting its performance with the appropriate modifications. In addition to corrective steps, which the designer can take to remove the influence of errors or imperfections, there are frequent requirements to modify performance of an otherwise satisfactory pump to suit a specific order requirement. The description of the type of modifications to an existing pump and the changes in pump performance expected as a result, should assist the designer in selecting the steps best suited to his particular problem.

In other cases when a relatively small change of pump characteristics of any existing unit is needed, the designer should also be in the position to tell whether and how such a change can be accomplished

The total head developed by a centrifugal pump is the resultant of the theoretical head developed by Euler's equation minus hydraulic losses. The value of this theoretical head is affected by the velocity distribution of fluid flow at impeller exit. Within the diffusion passage of centrifugal impeller under the effect of reversed pressure gradient, the side wall boundary layers increased gradually from inlet to outlet, causing the secondary flow under the combined effect of centrifugal and Coriolis forces. This result in gathering of lower energy fluid from pressure side boundary layers and finally causing a distortion of exit velocity profile and consequently reduce theoretical head and pump efficiency performed by El-Ghany.

In centrifugal pumps, high or low blade numbers will cause untidy flows in the impellers. An increase in the pressure coefficient and the efficiency is expected with increasing blade number. However, because of the increases in blockage and surface friction in the impeller passage, a loss of efficiency also occurs. The decrease in efficiency occurs especially with the increasing congestion in the impeller inlet area. Therefore, high blade numbers will cause a decrease in efficiency. On the other hand, when the blade number is decreased, the liquid flow in the impeller will not obey the one dimensional flow laws, resulting in an increase in the local losses. Here, apart from frictional losses, there will also be loss arising from flow separation. In the separation, the fluid deviates from the blades as the frictional losses increase. Because of these reasons, the effect of blade number on the stable/unstable nature of head-flow curves is high. It was observed that low or high blade number increased the instability risk of head-flow curves, and the optimum efficiency was obtained when the blade number was between 5 and 8.

The secondary flow affects the slip factor that is a function of number of blades (as per Stodola formula). In order to reduce the effect of the secondary flow on pump theoretical head, it is recommended to enhance this factor by increasing of number of blades in expenses of impeller friction losses. The optimization for number of blades to reduce total pump hydraulic losses has been investigated by Neumann.

One of the methods of modifications to increase the theoretical head developed by the impeller is to break down the circulation near the impeller exit. This can be achieved by using shorted blades. The shorted blades are partial blades with a shorter meridional length than the main full blades and are located between two full blades.

Experiment results of M. F. Abd Rabo shows that using shorted blade of length 24% of the full blade length (with inlet diameter of $0.8D_2$) improve efficiency and head of the pump by 8% and 9% respectively.

In the present work, a mathematical model using CFD will be illustrated to predicate the performance of a centrifugal pump using standard impeller and other impeller configurations with optimum shorted blades length at different positions. Also a test rig is established to test the centrifugal pump characteristics with different impeller configurations and study experimentally the effect of these shorted blades on pump performance.

A summary for the contents of the present thesis is as follow:

Chapter (1) Introduction: An introduction for the importance of centrifugal pumps in deferent industrial application and how the improvement in pump efficiency is is highly affecting the running cost for a plant.

Chapter (2) Literature review: In this chapter, a revision for pervious researches on field of improvement of centrifugal pumps efficiency is explained.

Chapter (3) Numerical Modelling for Centrifugal Pump: In this chapter A detailed explanation for using Fluent as a CFD tools to analyse the flow field in Turbo machines and perdition of performance parameters.

Chapter (4) Experimental Work: Description for the test bed components which used in testing of the centrifugal pumps with different impeller configurations and steps of test has been explained.

Chapter (5) Results and Discussion: Presentation for Numerical & experimental and discussion for these results has been explained.

Chapter (6) Conclusion and Suggestion for Future Works: