

Chapter 25

Strategic Designing and Optimization of Mixed Flow Impeller Blades for Maritime Applications

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ABSTRACT

Mixed flow impellers are extensively used in turbomachines either to convert mechanical energy to fluid energy or to convert fluid energy to mechanical energy. According to the geometry of flow passage, turbo machines can be classified as radial, axial and mixed flow. Mixed flow turbomachines are widely used for engineering applications like cooling water duties, water intake impellers for maritime applications, flood water draining, irrigation and other application fields. The design of mixed flow impellers of high specific speed is a direct extension of the well-established methods of the designing of radial flow impellers but the introduction of near diagonal flow layout at a still larger specific speed stimulated the incorporation of axial impeller design techniques in mixed flow impeller technology. Here, an attempt has been made to design a mixed flow turbo machine blade from the basic principle of turbomachinery and fluid mechanics. On the basis of stress analysis, the blade positioning in the meridional annulus was selected and validated using artificial neural network.

1. INTRODUCTION

Over the past decades, the mean line analysis method based on the conventional empirical loss correlations (assuming that the flow characteristics averaged over the cross-section of flow passage could represent the three-dimensional flow phenomena through the passage of turbomachinery) has been widely employed

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to determine the overall geometric design variables for each component of turbomachinery and to predict the on and off-design performance characteristics. In recent past, mixed flow impellers are extensively used in turbomachines either to convert mechanical energy to fluid energy or to convert fluid energy to mechanical energy as torque. Mixed flow impellers are unification of axial and radial characteristics. As per geometrical shape analysis, turbo machines can be classified as radial, axial and mixed flow. In axial flow machines, flow is mainly parallel to the axis of rotation and is used where low pressure head and high volumetric discharge are primary requirements. On the contrary, centrifugal turbomachines, comprise a very wide range for generation of pressure head and the flow through the impeller is largely normal to the axis of rotation. Mixed flow turbo machine are the intermediate types which are in between the axial and centrifugal. Since the flow through impeller has both radial and axial components; the mixed flow impeller blades have very complex in its geometry. But owing to its geometrical complexities, mixed flow turbomachines are extensively used for cooling water duties and specifically in water intake impellers for maritime applications. Apart from these, mixed flow turbomachines are also widely used in flood water draining, irrigation, urban water supply, cooling water system for various power plants, fire fighting systems and many other engineering and management fields.

Design of mixed flow impeller blades are quite complex as a large number of variables play a significant role on the overall performance of blades. The design of mixed flow impellers of high specific speed is a direct extension of the well-established empirical methods of the designing of radial flow impellers. Extension of similar methods serves for the design of mixed flow impellers, but introduction of near diagonal flow layout at a still larger specific speed stimulated the incorporation of axial impeller design techniques in mixed flow impeller technology.

Usual industrial design methods for mixed flow impellers are basically based on the use of empirical correlations and design constants. Industrial design method often obscures or ignores the actual happening within the mixed flow turbo machine flow passage and consequently a poor guide when the question of new design and development of such turbo machine comes into the picture. In this present work, an attempt has been made to design a mixed flow turbo machine blade from the basic principle of turbomachinery and fluid mechanics. As compared to radial flow and axial flow turbomachines, mixed flow type turbomachines got less importance due to its complexity. The flow through the mixed flow type turbomachines is very complex due to its highly complicated blade and fluid flow passage geometry. A schematic of a mixed flow turbomachine impeller is shown in Figure 32 in Appendix 1. The present work relates to designing of impeller blade primarily. Entire research can be divided into four basic sections: namely Design, Model Development, FEM Analysis and validation / optimization of proposed design via Artificial Neural Network in ANSYS.

2. NOTATIONS AND ASSUMPTIONS

To design a mixed flow turbo machine blade from the basic principle of turbomachinery and fluid mechanics, the following notations are used (Srivastava et al. 2014):

Ω = specific speed, rad. / sec., Q = discharge of the fluid, m^3/sec .

g = acceleration due to gravity, m/s^2 ; H = Pressure head developed, m ; N_s = specific speed, rpm.

γ = specific weight of the fluid, kg/m^3 ; D_{m2} = mean blade diameter at the outlet.

u_2 = circumferential velocity at the impeller exit; D_{2o} = outlet blade diameter at tip.

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