# ABSTRACT

The present research work is focused on computational establishment of material design and product design integrations- the two major domains of product development strategies. Prototype development for complex and multi-dimensional product and then performing property and functionality testing is tedious, time consuming and expensive too. Hence, a novel attempt is made through the current research to overcome these weighty issues of new product development.

In chapter 2, review over literatures for appropriate material selection in high relevance to product specifications to be plugged in at the early stage of product development has been presented. Explanatory details over CFD, FEA and ANN are presented besides highlighting their significant strengths to the current research. A thorough insight over the ways to shorten material oriented design iterations, design methodology for integrative materials and product design are enhanced.

The scope of the present investigation is presented in chapter 3. Chapter 4 discusses in detail the research methodology adopted in the study.

The observed data on results and detailed discussions on the findings of this research work are given in chapter 5.

A low carbon low alloy steel, ASTM A 487 Gr 4 C (equivalent to AISI 8620) material suitable for high pressure applications is widely used as a

material for valve castings and is considered for validation of the current work. The vital mechanical properties like yield strength, tensile strength, hardness, % elongation, % reduction in area and impact toughness are detected in real time through experiments in a foundry for nearly 250 assortments of 11 major alloying elements.

Regression analysis is performed to enhance the dependency facts, as the alloying elements and mechanical property relationships are complex in nature. The results derived through Response Surface Methodology, a module of regression analysis validates and gratifies that the experimental observations are well suited for further proceedings of the research work.

In this context, commercial flow regulators for high pressure systems and the ball and gate valve casted in foundry for specified material composition is selected for research synthesis. Three dimensional modeling of valves in relevance to industrial design metrics is developed using Pro-E software. To have authentication over the research, further experimental and computational analysis are performed for 30 $^{o}$ and 45 $^{o}$ ball openings (in case of ball valve); 10 mm and 70 mm stem openings (in case of gate valve).

In Computational Fluid Dynamics (CFD), the three dimensional valve models are extracted and meshed using the pre-processing software ANSA. Flow investigations for three different fluids viz. water, lubricant oil and diesel at various levels of applicable pressure and temperature is carried over using FLUENT software. The CFD solver after performing the flow calculations produce end results showcasing the critical regions of high pressure concentrations over the valve body created due to fluid flow. Analysis over computed results discloses that among the three different fluids considered, the maximum pressure of 330 bars was exerted when water is considered as flow medium.

The experimental results made over in a valve test rig for the critical evaluation of the product metrics highly correlates with CFD results observed. Also the results are in good correlation for further proceedings of product structural validation through Finite Element Analysis using ANSYS software.

Finite Element Analysis (FEA) is carried over modulated valve body thicknesses in order to have a good acquaintance with the research arena. To specify, 15, 17, 19 and 21 mm thickness variations in case of ball valve; 50, 60, 70, 80 and 90 mm outer diameter in case of gate valve are considered. The analysed results shows that valve body for 17 mm thickness and 75 mm outer diameter in case of ball and gate valves respectively, have the ability to withstand the maximum pressure of 330 bars. FEA study projects that in lieu consideration of casting design optimization, it is sufficient to integrate the values of stress, strain and life.

Artificial Neural Network (ANN) structure for feed forward back propagation type of network is developed with 16 inputs (experimental material attributes), 5 outputs (computational product attributes) and an intermediate hidden layer in close context to the adopted domain integration methodology. The ANN predicted values proves to be precise in comparison with experimental values and shows admissible average error percentage of 5% to 10%.

Integrated Material and Product Development System (IMPDS), a user-friendly graphical user interface has been developed with inborn ability to push out the predicted product variables upon considering all possible material variables. Authorship algorithms are developed for the emergence of IMPDS.

The results of various experimental trials and further validation of results reveals the following facts. The effective implementation of the research work when coupled with various fields, materials and products thereof will emerge as superior supplementation of material tests and design based trail and errors. Successive execution of presented research concept supports in supplying quality product to perform the intended application for the stipulated time span.

In chapter 6, major conclusions for the present study and scope for future work are summarized.