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Computational Fluid Dynamics Based Investigation on Volute Geometry of Centrifugal Pump

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Abstract-Volute is an important hydraulic part of centrifugal pump, hydraulic loss within pump volute takes up a large part of total hydraulic loss within pump, and thus appropriate design of pump volute has significant meaning to centrifugal pump performance. In this project work, CFD method was adopted to investigate volute main geometric parameter in relation to pump performance. A design method of high-efficiency pump volute is developed through the influence of volute main geometric parameters to pump performance. The part drawings of various parts that are used for manufacturing the centrifugal pump are designed and drawn with the help of solid works (2012). While design a pump, it is required to optimize radial gap to better efficiency and less vibration. Here in this project work, CFD based investigation is performed on different range of radial gaps of volute and impeller are evaluated to verify the performance impact. In CFD analysis the radial gap to pump performance, the highest efficiency is reached when the radial gap is 9 mm and Optimum radial gap pump is fabricated and tested. The cost estimated for the production of the prototype is obtained as Rs.15,345 which include all kind of expenses such as miscellaneous expenses, material purchase and labour cost etc. The bill of material is sorted on the Table 4.1 from the table the components used in this project and its materials and its quantity are mentioned.

Keywords- *Centrifugal Pump, Centrifugal Impeller, CFD*

I. INTRODUCTION

A centrifugal pump is a rotating machine in which flow and pressure are generated dynamically.The problem description they are many types of pumps, but to improve efficiency, particularly in water pump. From studies of parameters influencing performance are throat area, impeller vane angles, design rule of spiral development areas, and radial gap between impeller and volute tongue. Therefore, radial gap between impeller and volute tongue is a parameter which needs to be considered in performance of centrifugal pump. Here in this project work, CFD based investigation is performed on different range of radial gaps of volute and impeller are evaluated to verify the performance impact. Optimum radial gap pump is fabricated and tested. The objectives of the project are

a. To design a centrifugal pump impeller and expands towards volute design.

b. To analyse the performance of pump at different range of radial gaps of volute and impeller using CFD.

Due to dynamic pressure loss in the case of generating internal flow, decreased pump performance can occur. Proper design of impeller will improve the performance of a centrifugal pump. After analysis, high-efficiency impeller design are implemented.

II MATERIALS AND METHODS

This chapter explains the various materials used and methodologies followed in designing the ‘volute geometry of radial flow centrifugal pump’. The various part drawings that are used to manufacture the “volute geometry of radial flow centrifugal pump” by using the solid works (2012) and designing of that parts are discussed in this chapter.
The components used in centrifugal pump are
Manufacturing Components

i.	Centrifugal pump casing	-	Aluminium
ii.	Impeller	-	Aluminium

Purchased Components

i.	Bolts, nuts & washer	-	Mild steel
ii.	Motor	-	0.5hp

Input Parameter

H	=	18 m
Q	=	126 lpm
N	=	2990 rpm
Impeller used	=	Semi open
Type of flow	=	Radial flow

Calculated data:

Mass flow rate	m	=	2.1 kg/ s
Vane inlet angle	β_1	=	48.21°
Inlet vane height	b_1	=	5.85 mm
Inlet diameter	D_1	=	26 mm
Outlet diameter	D_2	=	126 mm
Outlet vane angle	β_2	=	60°
Outlet vane height	b_2	=	3 mm
Number of vanes	Z	=	8 mm

III MANUFACTURING DRAWINGS

The manufacturing drawings which are used to manufacture the centrifugal pump using the solid works (2012) and designing parts are shown in following figures

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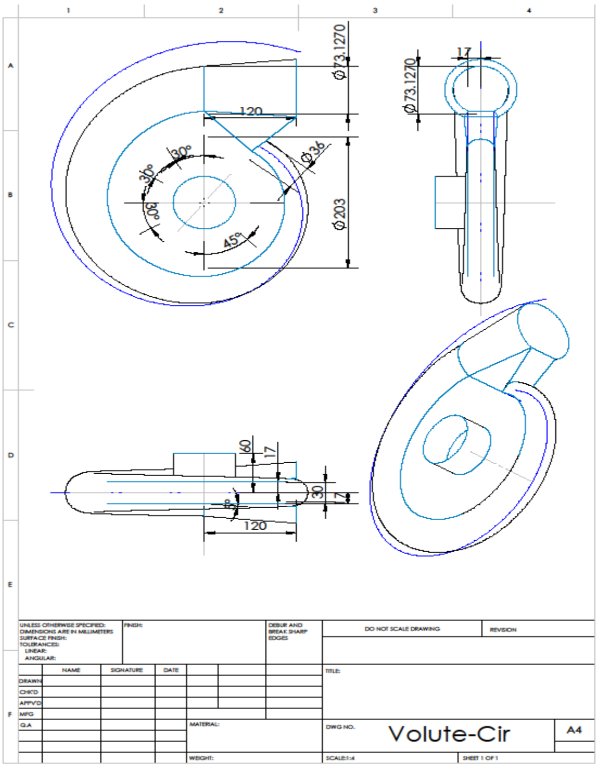

Fig.3.1 Circular cross-section

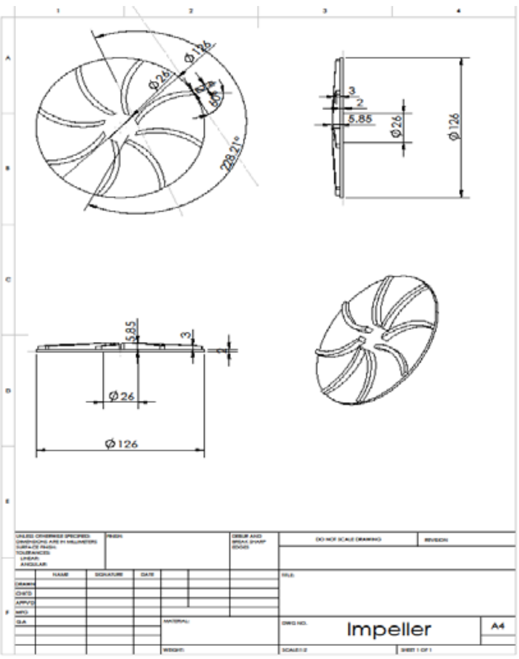

Fig.3.2 Impeller

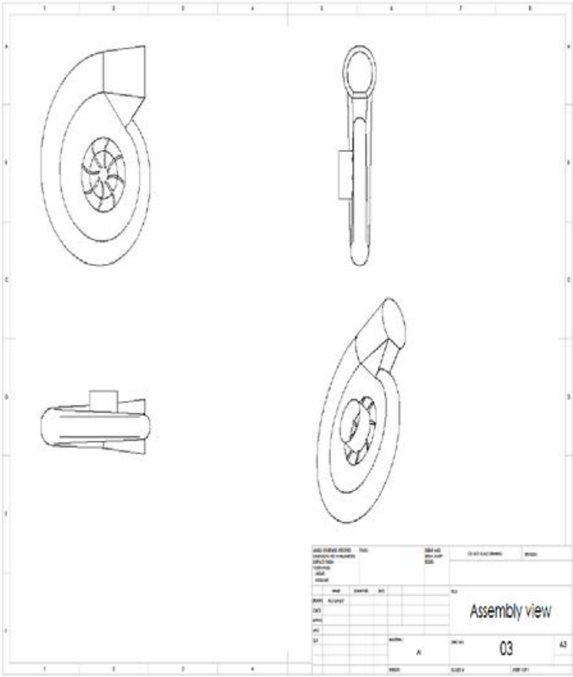

Fig.3.3 Assembly view of centrifugal pump

IV SIMULATION

Simulation Details

Analysis Type – Internal Flow
Solver – COSMOS FLOW WORKS

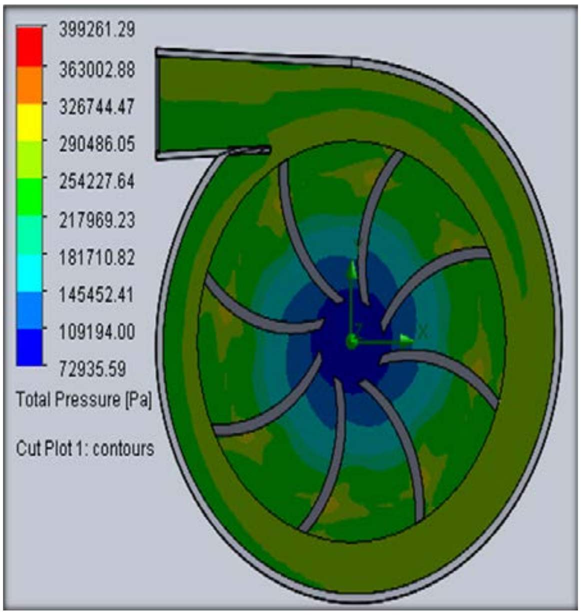

Fig.3.4 Total Pressure at 126 LPM

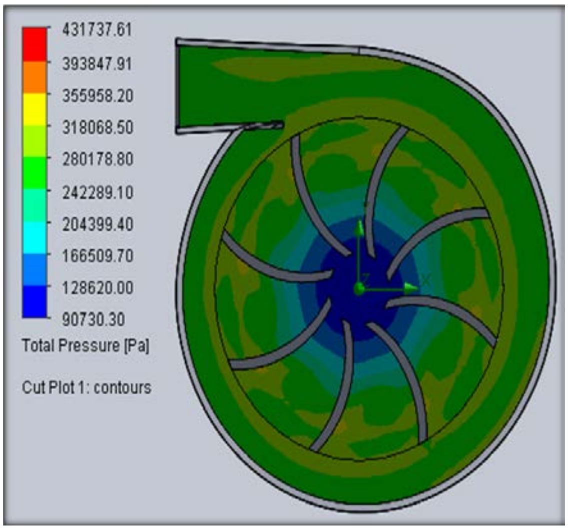

Fig.3.5 Total Pressure at 66 LPM

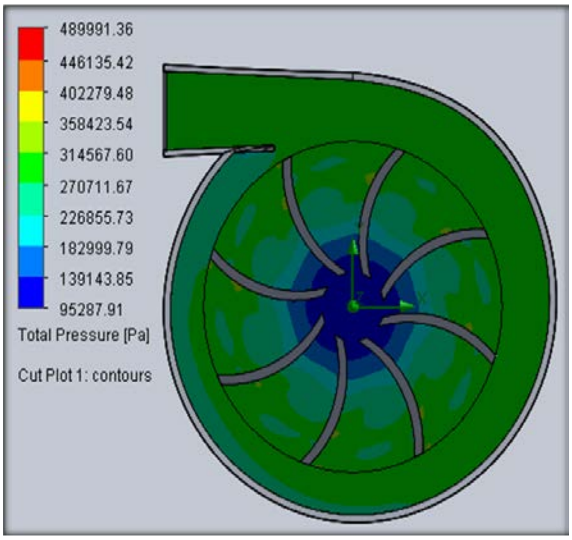

Fig.3.6 Total Pressure at 30 LPM

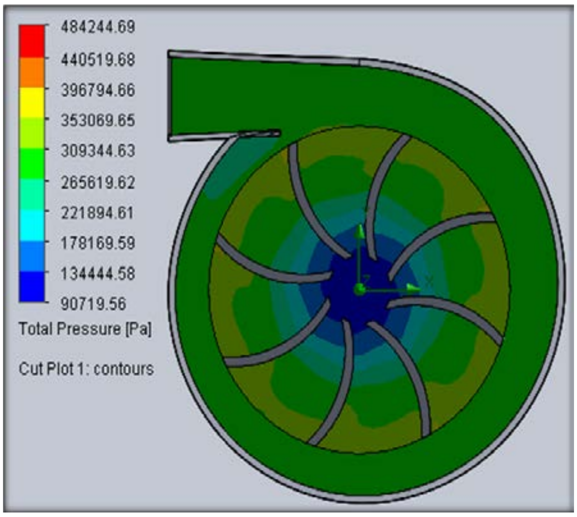

Fig.3.7 Total Pressure at 0 LPM

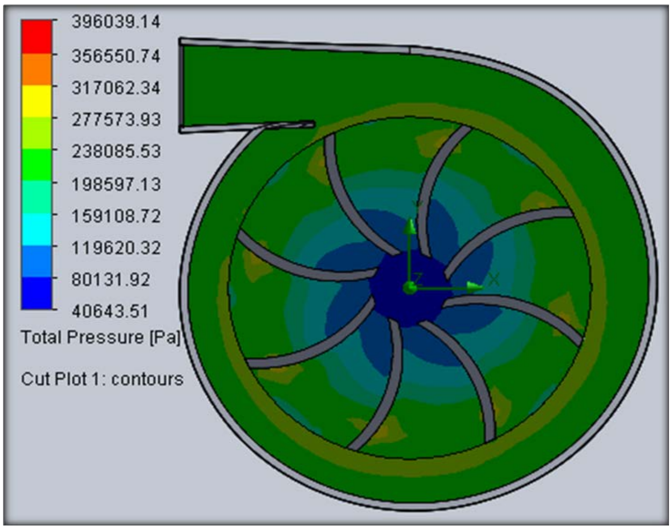

Fig.3.8 Total Pressure at 186 LPM

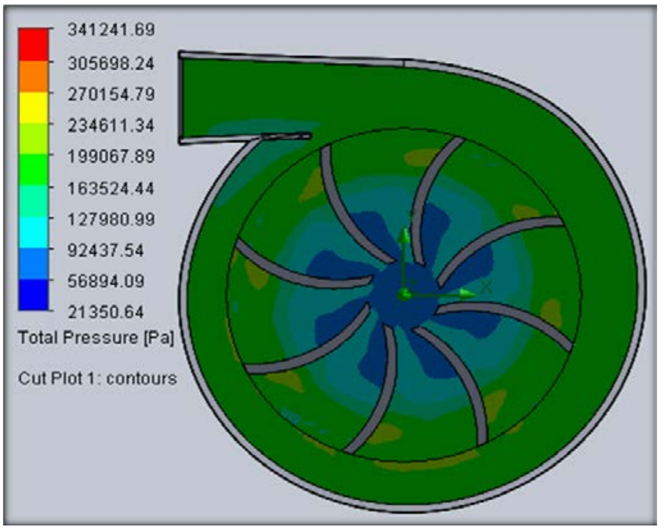

Fig.3.9 Total Pressure at 246 LPM

The table 3.1 shows the changing of head at different discharge levels in 9 mm radial gap between impeller and volute.

S.No	Discharge (LPM)	Radial Gap 3 mm Head (m)	Radial Gap 6 mm Head (m)	Radial Gap 9 mm Head (m)	Radial Gap 12 mm Head (m)
1	0	27.159548	28.888858	29.2656	28.935592
2	30	28.138703	28.81284	28.2034	26.736927
3	66	26.842514	27.615767	27.9397	25.093231
4	126	24.620395	24.484	25.4806	22.820778
5	186	18.492461	18.240687	22.8951	16.713083

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6	246	13.315637	14.87064	17.8972	7.571908

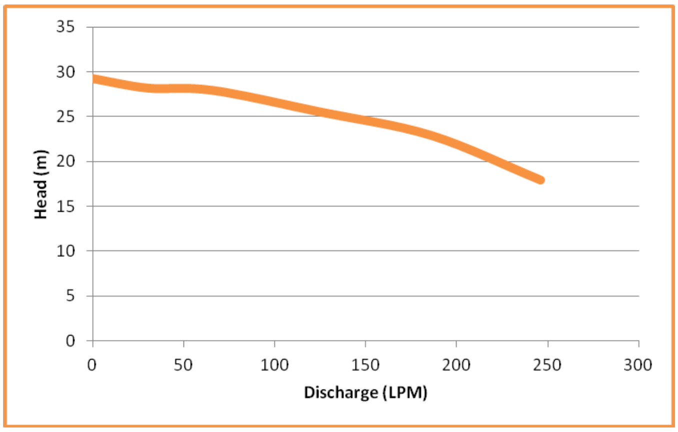

Fig.3.10 9 mm Discharge Vs Head

IV RESULTS AND DISCUSSION

The design and CFD anlaysis is done.The bill of materials are listed in the table 4.1. From the bill of materials number of items its quantity and the material used to manufacture can easily identified. The cost estimation and cost statment are discussed in this chapter.

Item	Description	Quantity	Material
1	Motor(0.5 hp)	1	-
2	Impeller	1	Aluminium
3	Casing	1	Aluminum
4	Stuffing box	1	Cast Iron
5	Shaft	1	Mild Steel
6	Nut & Bolts	12	Mild steel

The cost of manufacturing the prototype of centrifugal pump given in the tables 4.2 from the table the cost for the material purchase can founded as Rs.12,425 and the labour cost as Rs 1,120

Items	Unit	Qty.	Rate per unit (Rs.)	Amount
Motor	0.5hp	1	-	3500
Impeller	kg	7	350	2450
Casing	kg	8.5	350	2975
Stuffing box	kg	3	800	2400
Shaft	Nos	1	1000	1000
Bolt,Nuts &Washer	kg	1	100	100
			Total	12,425
Labour cost				
Manufacturing cost	Per hour	80	15	1,120

The cost estimation for the manufacturing of the centrifugal pump is obtained from the Table 4.3 from the table the cost for the production of the prototype can estimated as Rs.15,345 which includes all kind of expenses and the material cost.

Particulars	**Amount (Rs.)**	**Amount (Rs.)**
Manufacturing cost		
Materials	12,425	
Labour cost	1,120	
Consumables stores & spares	500	
Power & fuels	300	
Miscellaneous expenses	1000	15,345

V SUMMARY AND CONCLUSION

SUMMARY

CFD method was adopted to investigate volute main geometric parameter in relation to pump performance. A design method of high-efficiency pump volute is developed through the influence of volute main geometric parameters to pump performance. The radial gap between impeller and volute tongue is a parameter which needs to be considered in performance of centrifugal pump. Small gap leads to more efficiency more noise and vibration. Large gap leads to less efficiency and less noise and vibration. While design a pump, it is required to optimize radial gap to better efficiency and less vibration. Here in this project work, CFD based investigation is performed on different range of radial gaps of volute and impeller are evaluated to verify the performance impact.

From the results of CFD analysis, the velocity and pressure in the outlet of the impeller is predicted. CFD analysis are done using ANSYS software. These outlet flow conditions are used to calculate the efficiency of the impeller and Optimum radial gap pump is fabricated and tested. The

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detailed drafting of the centrifugal pump are done according to the industrial standards with the help of solid works 2012 version. The cost estimated for the production of the prototype is obtained as Rs.15,345 which include all kind of expenses such as miscellaneous expenses, material purchase and labour cost etc. The bill of material is sorted on the Table 4.1 from the table the components used in this project and its materials and its quantity are mentioned.

CONCLUSION

In CFD analysis the radial gap to pump performance, the highest efficiency is reached when the radial gap is 9 mm. As the radial gap continues to increase, its head begins to drop. when the radial gap increases from 3 mm to 9 mm, the variation of pump pressure head is small. As the radial gap increases to 12 mm, pump pressure head begins to drop. Investigation into the radial gap between impeller and volute tongue illustrates that there is an optimal radial gap for a high-efficiency pump design. The detailed drafting of the centrifugal pump are done according to the industrial standards with the help of solid works 2012 version and CFD analysis are done using ANSYS software. The cost estimated for the production of the prototype is obtained as Rs.15,345.

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