DESIGN CENTRIFUGAL PUMP ASSISTED BY CF TURBO 10.2 SOFTWARE

Siprianus Ndaha Ate
Department of Mechanical Engineering, Faculty of Engineering, University of Merdeka Malang
Email *corresponding author:* prytosandaate@gmail.com

Abstract

In the industrial world the use of centrifugal pumps is often used to distribute water that is to support the smooth running of industrial processes or to cool a machine. Centrifugal pumps have a very broad scope of use with the head and the resulting capacity is very large and varied. In this final project, a centrifugal pump with a capacity of 30 m3 / hour, a pump head of 10 meters, a shaft rotation of 1500 rpm and a pressure difference of 10 bar in and out is planned. In the planning of centrifugal pumps, CF Turbo 10.2 software is used. Fluid is water ("Water") with a temperature of 200 C. Specific gravity of 1 kg / dm3. The output of the software includes blade diameter, shape, number of blades and geometric representation of blades. In planning this centrifugal pump as a comparison material, the specifications of the centrifugal pump are available. 5-level centrifugal pump is planned, each level has a head of 10 meters, a discharge of 30 m3 / hour.
Keywords *: Centrifugal Pump, Impeller, CF Turbo Software 10.2*

INTRODUCTION

Background

The water pump is a means of transporting liquid fluids, which is a tool commonly used in everyday life. Its benefits in helping to complete the transfer of water/liquid fluid make water pumps commonly used in industry and households. Centrifugal pumps have a simple and versatile structure. With the development of high-speed engine technology, centrifugal pumps are more efficient than the era before the invention of the high-speed motor.

The use of pumps is very broad in supporting production processes ranging from large industries to the home level. The types of pumps on the market have various variants, the use of the pump is tailored to the needs. It can even be said that the presence of a pump cannot be separated in industrial life. With the wide use of pumps, a test is needed to determine the performance of the pump. Centrifugal pumps are one of the most widely used types of pumps in households. The centrifugal pump is a type of fluid transfer pump, with the working principle of converting kinetic energy (speed) into potential energy (dynamic) through an impeller that rotates in the casing. In general, a pump is considered to have good quality if it has a strong thrust and deep suction power. In more general terms the pump thrust is referred to as the pump head. The higher the head indicates the high power generated by the pump.

Judging from the assessment generally understood by the public, engineering is needed to increase the pump lift and suction strength. The reduction in lift at the pump is often called head looss. The physical meaning of the head loss is the loss of mechanical energy in the mass unity of the fluid. The unit head loss is a unit of length which is equivalent to one unit of energy required to move one unit of mass of fluid as high as one unit of length accordingly. The head loss calculation is based on experimental results and dimensional analysis. Head loss occurs with a bend in the pipe. With more turns, the head loss that occurs is getting bigger. (Edi Widodo, ST., MT, 2010).

Research Question

The problems in this final project are: "How to plan a centrifugal pump using software CF Turbo 10.2".

Research Limitation

So that the problem can be fixed on its target, the problem will be focused on:

1. Does not discuss thermodynamic processes in pumps.
2. Does not address pump balancing issues.
3. Does not manufacture pumps.
4. Does not take power measurements, required torque versus rpm.
5. Do not perform finite element method analysis for water flow in the pump (Computational Fluid Dynamics).

Research Objection

The goal to be achieved in this planning is to plan a centrifugal pump with a capacity of Q = 30 m3 / hour, pump head H = 10 meters, and shaft rotation n = 1500 rpm.

METHODOLOGY OF RESEARCH

Research Flowchart

The several stages of the process that will be carried out in this centrifugal pump planning are shown in the following planning flow diagram:

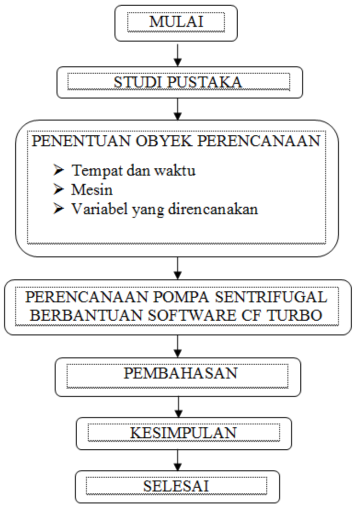


Figure 1. **Research Flowchart**

DISCUSSION

Start and Planning

In this plan, primary data is used, namely by measuring the centrifugal pump with the following specifications:

Table 1. Centrifugal Pump Specifications

Parameter terukur	Dimensi
Hub diameter (dH)	25 mm
Suction diameter (dS)	88 mm
Impeller diameter (d2)	178 mm
Outlet width (b2)	14 mm
Pump capacity (*Q*)	30 m^3 / hour
Head Pompa (*H*)	10 meter
Rotation (n)	1500 rpm

In the design process of the centrifugal pump impeller section based on CF Turbo software, there are several steps that must be carried out sequentially. The process steps are as follows:

a. *Project*

This process is a process of entering the dimensions of the centrifugal pump and determining the impeller model according to the type of pump being analyzed. Another parameter is a design variable that can be modified to improve the performance and efficiency of the impeller while operating.

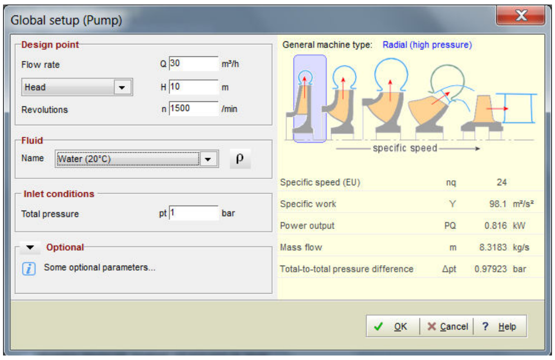


Figure 2. **Global Setup**

b. ***Impeller***

This menu is used to carry out the calculation process to obtain three display variables, namely:

➢ ***Value***

This menu is a menu that displays the calculation results based on the centrifugal pump parameters that have been entered.

Characteristics			
Meridional flow coefficient	φm	0.083	
Flow coefficient	φt	0.024	
Work coefficient	ψ	1.003	
Diameter coefficient	δ	6.472	
Inlet			
Average inlet velocity	cmS	1.6	m/s
Average inlet velocity (net)	cmS*	1.5	m/s
Inlet circ. velocity	cuS	0	m/s
Inlet rel. velocity	wS	4.2	m/s
Inlet pressure	pS	49.99	bar
Inlet total pressure	ptS	50	bar
Outlet			
Outlet mer. velocity	cm2	1.2	m/s
Outlet mer. velocity (net)	cm2*	1.1	m/s
Outlet circ. velocity	cu2	8.2	m/s
Outlet rel. velocity	w2	5.9	m/s
Outlet peripheral speed	u2	14	m/s
Outlet pressure	p2	50.6	bar
Outlet total pressure	pt2	51	bar
Global values			
Meridional deceleration	cm2/cmS	0.73	
Relative velocity ratio S->2	w2/wS	1.40	
Outlet width ratio	b2/d2	0.08	
Axial force	Fax	489	N

Figure 3. **Impeller Calculation Results**

➢ ***Meridian***

This menu describes a sketch of the impeller section of the centrifugal pump resulting from the input dimension parameters.

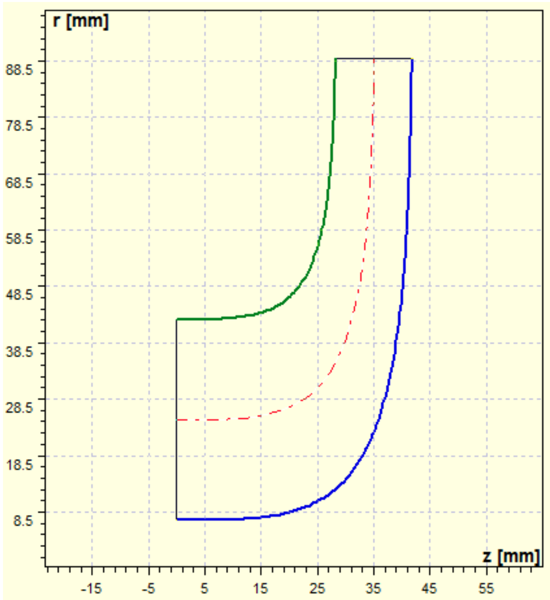


Figure 4. **Impeller Cross-sectional Sketch**

➢ ***Diagram Cordier***

The dimension parameters of the centrifugal pump entered will be able to display the appropriate impeller type. In this case the pump dimension parameters entered to produce the appropriate impeller type are radial based on specific diameter, specific speed and work coefficient.

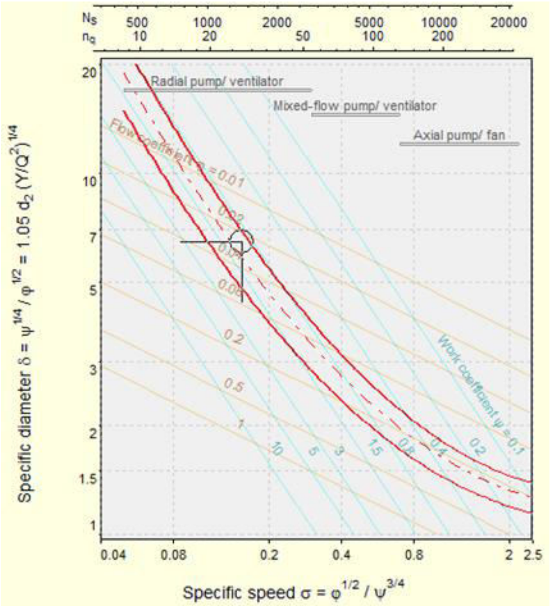


Figure 5. **Impeller Cross-sectional Sketch**

c. *Meridional Contour*

Meridional contours are second most important after impeller planning. In this menu we can change the line position according to the need to get the most pump performance. Through this menu we can see the meridional contours in 2 and 3 dimensions as well as the detailed dimensions of the impeller geometry.

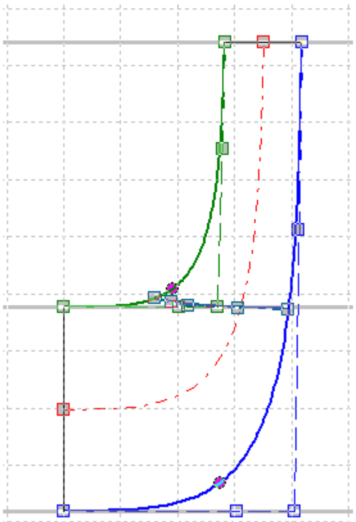


Figure 6. **Meredional *Contour* 2D**

d. *Blade Properties*

In the blade design process, there are two steps, namely: Blade Setup The blade setup is used to determine the number, thickness and shape of the blades in the pump.

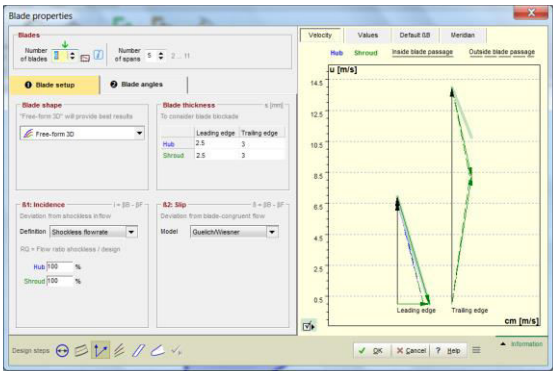


Figure 7. **Blade Setup**

e. *Blade Angles*

Average line planning depends on the number and position of meridional blade profiles called blade angles. Blade angles β B1 and β B2 are calculated based on the velocity triangle.

The degrees of freedom of blade planning depend on the blade shape. It should refer to the blade angles that are the result of the average line calculation.

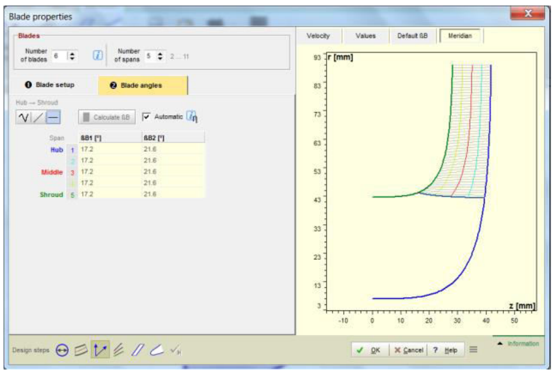


Figure 8. **Blade Angels**

f. *Blade mean line*

It is a depiction that combines blade angle, blade passage area and lean angle. Based on the combination of the three, it can be seen that not all blade profile lines have the same length. That is because the blade profile lines have a different maximum m-value.

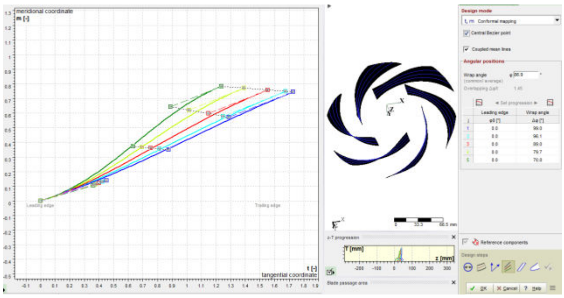


Figure 9. **Blade Mean Line**

g. Blade profile

To make blade profiles orthogonal blade thickness distribution for hubs and shroud profiles are used. Orthogonal blade thickness values are added to both sides of the blade to create side pressure and suction.

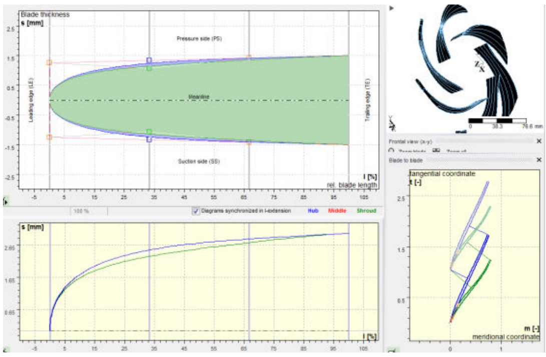


Figure 10. **Blade Profile**

h. Blade Edges (Leading Edge)

The blade is designed to have a blunt end and a trailing edge (the line between the endpoint of the suction and the pressure side). The blade edge is designed by determining the thickness distribution.

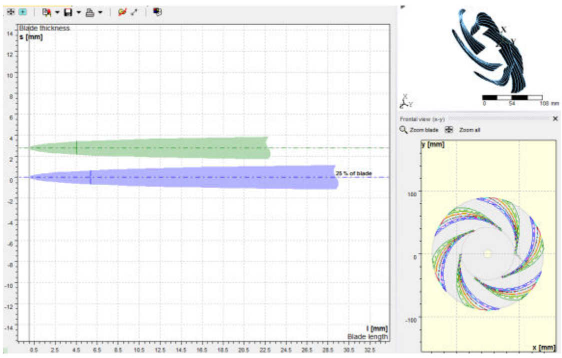


Figure 11. **Blade Edge-Leading Edge**

i. Blade Edge (Trailing Edge)

The trailing edge is the planned portion of the back edge of the impeller.

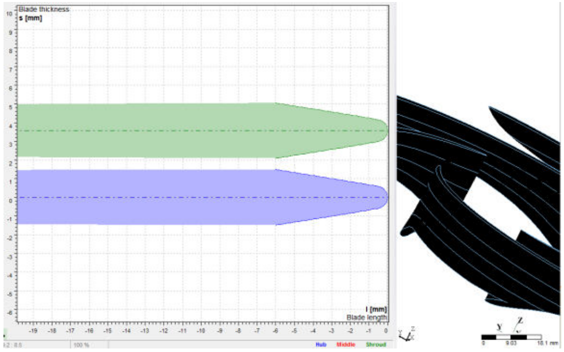


Figure 12. ***Blade Edge–Trailing Edge***

j. Volute

The spiral area development can be calculated manually or automatically. The results of these calculations can be displayed in the form of cross-sectional images, spiral areas, diffusers and cut-water.

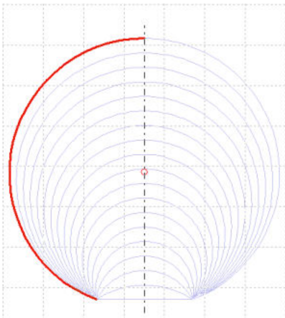


Figure 13. **Volute Profile**

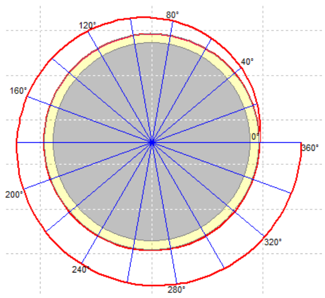


Figure 14. **Spiral Area**

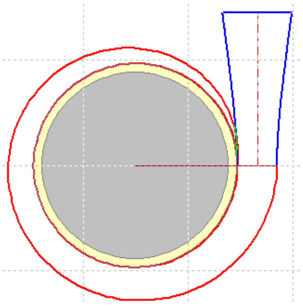


Figure 15. **Diffuser**

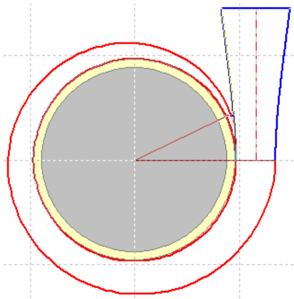


Figure 16. **Cut Wear**

Based on the simulation that has been carried out like the steps above, the final results of the impeller design are as follows:

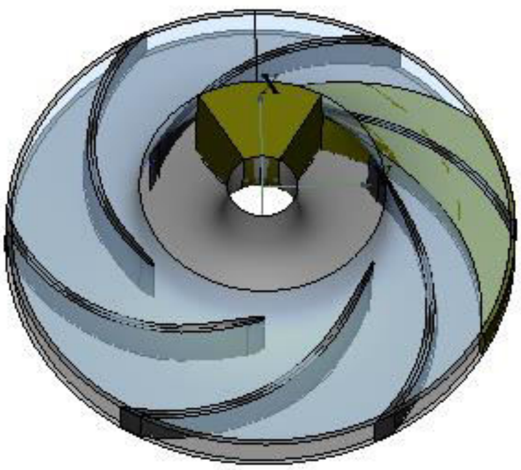


Figure 17. **3D Design of Impeller**

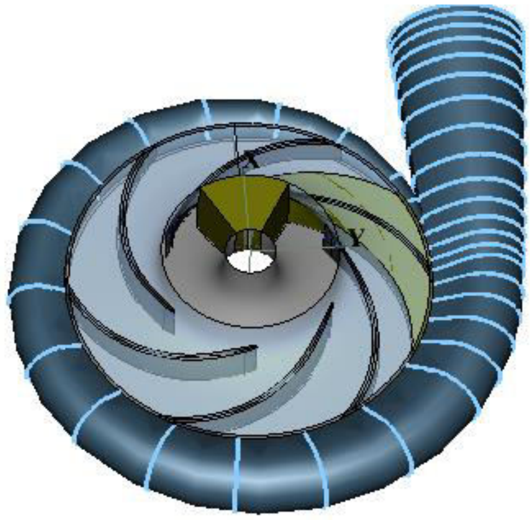


Figure 18. **Impeller & Casing**

Based on the simulation that has been carried out like the steps mentioned above, the optimal parameter results are as follows:

Table 2. **Software Input and Output Parameters**

Design Point			
Massa flow	M	[kg/s]	8.3183
Revolutions	N	[/min]	1500
Additional hydroulic	ɳh+	[%]	100
Specific work	Y	[m^2/s^2]	98,1
Specific speed (EU)	nq		24
Power output	PQ	[W]	816,0
Rotation direction			Right
Swisrl number	A	^{0}	90
Flow rate	Q	[m^3/h]	30
Total pressure difference	Δpt	[bar]	0,97923
Head	H	[m]	10
Fluid Properties			
Fluid name			*Water 20^{0}C*
Density	P	[kg/m^3]	998,2
Parameters			
Hydroulic eficiency	ɳh		85,2
Volumetric eficiency	ɳv	[%]	94,8
Internal eficiency	ɳl	[%]	77,1
Mechanical Eficiency	ɳm	[%]	96,9
Motor eficiency	ɳmot	[%]	80
Stage eficiency	ɳst	[%]	74,7
Stage eficiency incl	ɳst*	[%]	59,8
Empirical funtion for dS parameter			Cf Turbo default
Empirical funtion for dl parameter			Cf Turbo default

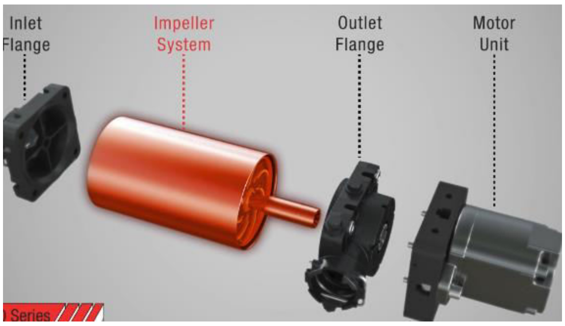
Empirical funtion for bl parameter			Cf Turbo default
Work coeffisient	ψ	[-]	1,003
Outled width ratio	b2/d2	[-]	0,076
Required driving power	PD	*[kW]*	1.1
Required power inch	PR	*[kW]*	1,4
Intake coofisient	τ	*[-]*	0,113
Side friction eficiency	ƞs	*[%]*	95,5
Main dimension			
Automatic calculator			*Yes*
Hub diameter	dH	[mm]	25
Suction diameter	dS	[mm]	87,7
Work coefficient	ψ	[-]	1,00
Average inlet velocity	cmS	[m/s]	1,58
Average inlet velocity	cmS*	[m/s]	1,50
Average outlet velocity	Cm2	[m/s]	1,16
Average outlet velocity inch	Cm2*	[m/s]	1,10
Impeller diameter	d2	[mm]	178,1
Outlet width	b2	[m/s]	13,54
Meridional contour			
Desai mode			*Hub shroud*
Axial extension max.	ΔzMax	[mm]	41,821
Radial extension	ΔrMax	[mm]	76,55
Axial extension	Δz	[mm]	35,051
Setup			
Type			*Single*
Volumetric eficiency	ƞv	[-]	1
Flow faktor	FQ	[-]	1
Spiral Inlet			
Diameter	d	[mm]	181.7
width	b	[mm]	13,54
Inlet			
Hub point		[mm]	[41.853;90.784]
Shroud point		[mm]	[28.328;90.784]
Center point		[mm]	[35.091;90.784]
Offset hub		[mm]	[0.0071089;0]
Offset Shroud		[mm]	[-0.0071089;0]
Offset center		[mm]	[0;0]
Width	b	[mm]	13;54
Angel mode			*Axial*
Cross section			
Cross section			*RadiusBased*
Angel	φ	[^{0}]	360
Main radius	R	[mm]	0
Cone angle	σ	[^{0}]	30
Base height	h	[mm]	0
Base radius	BR	[mm]	0
Corner radius	RC	[mm]	0

Spiral areas geometry			
Design rule			*fleiderer*
Swirl exponent		[-]	1
Automatic flow properties			*No*
Ref. velocity		[m/s]	8.0742
Volume flow		[m^3/h]	0.0083333
Wrap angel	Φ	[^{0}]	360
Dicharge area	A	[mm^2]	1284.5
Diffuser			
Direction			*Tangensial*
Eccentricty	Δx	[mm]	0
Eccentricty mode			*Centric*
Heigt	H	[mm]	136.18
Center distance	C	[mm]	113.25
Start angel	$Φ^0$	[^{0}]	0
Endcross section			
Type			*Circle*
Exit diameter	D	[mm]	66.2
End cross section position		[%]	100
Lenght	L	[mm]	136.18
Cone angel	Θ	[^{0}]	5.4
Cut water			
Mode			*Simple*
Position	Φc,0	[^{0}]	37.3
Equiv. Diff. diam.	D	[mm]	53.768
Cross section area	A	[mm^2]	2270.6
Radial offset	e	[mm]	0
Side position left			0.288
Side posetion right			0.288
Rounded edges			No
Cut water angel			
Inner	αlnn	[^{0}]	5.4708
Outer	αOut	[^{0}]	32.328
Average	αAvg	[^{0}]	16.622
Cut water diameter			
Inner	dlnn	[mm]	200.31
Outer	dOut	[mm]	210.9
Average	dAvg	[mm]	202.42
Minimal	dMin	[mm]	200.02

CONCLUSION

In planning a centrifugal pump with the aid of CF Turbo 10.2 software, a five-stage water pump can be planned.

The pump that is planned is as shown in the image below with the following specifications:



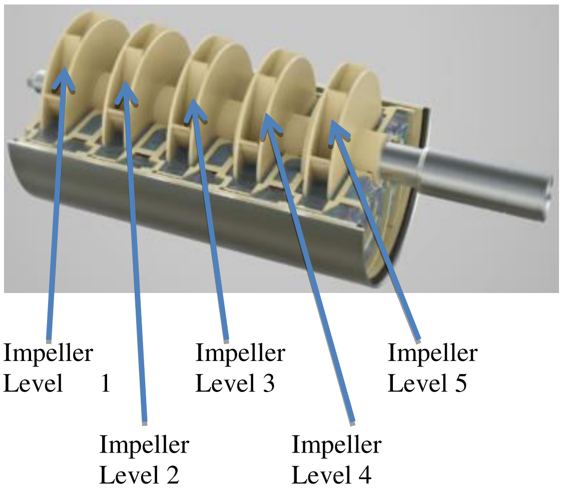


Table 3. **Pump Specification**

	Level 1	Level 2	Level 3	Level 4	Level 5
Debit (m^3/jam)	30	30	30	30	30
Input pressure (bar)	1	10	20	30	40
Output pressure (bar)	10	20	30	40	50
Spindle rotation (rpm)	1500	1500	1500	1500	1500
Motor power (kW)	1,4	1,4	1,4	1,4	1,4

Based on the simulations that have been carried out based on the dimensional parameters of the centrifugal pump with the technical specifications mentioned above, it can be concluded that:

1. This type of centrifugal pump impeller is a radial impeller.
2. Simulations that have been carried out on a centrifugal pump impeller have produced the most optimal parameters.

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