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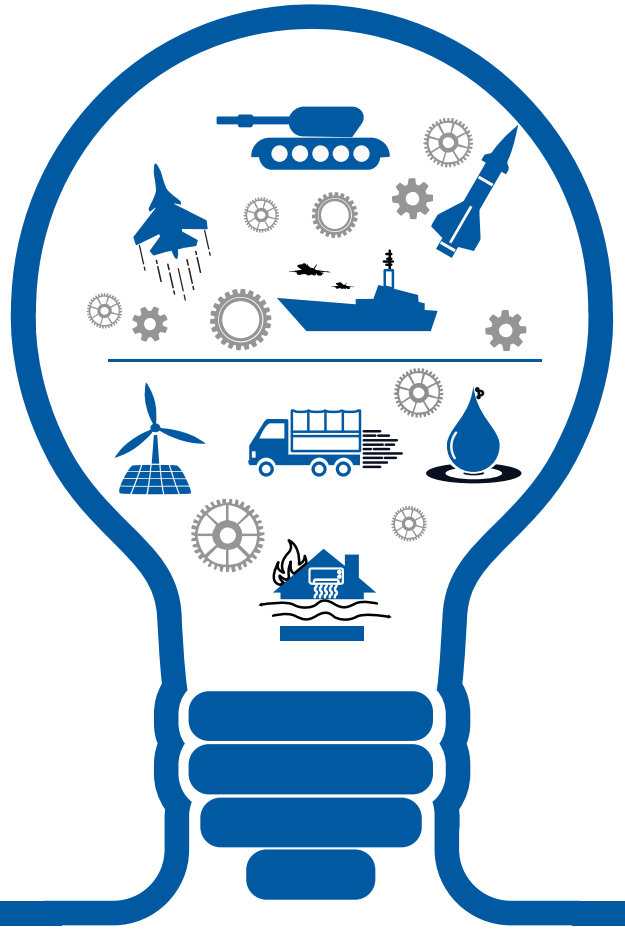
Centrifugal Pump Design

REFERENCE MANUAL



http://labs.zeusnumerix.com/centrifugal-pum-design/

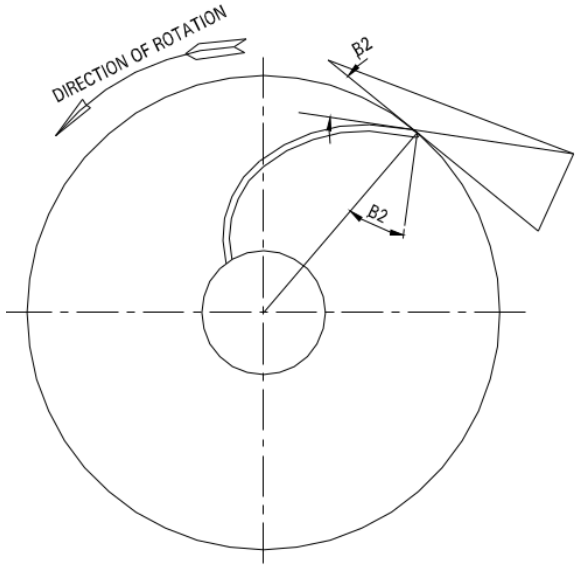
Contents

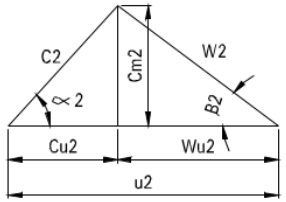
Introduction

- This application is a useful tool in designing a centrifugal pump impeller based on the hydraulic requirements
- The user provides inputs through a JSON format input file. A set of calculations based on empirical formulae, conservation equations and non-linear regression is performed to get a the important design parameters of pump impeller.
- The outputs are stored in a ".csv" file and made available for the user to download and use it for detailed engineering of pump.

Veocity Diagrams and Governing Equations

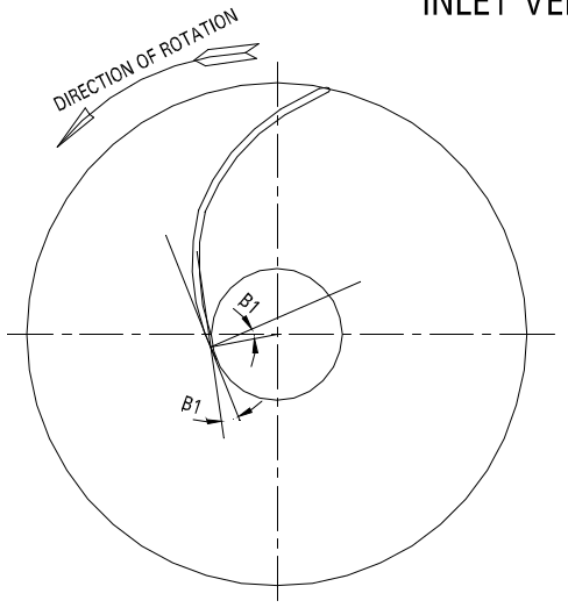
OUTLET VELOCITY TRIANGLE

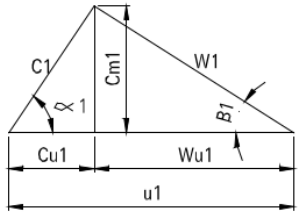




u2 = PERIPHERAL VELOCITY
W2 = RELATIVE VELOCITY
C2 = ABSOLUTE VELOCITY
Cm2 = MERIDIONAL VELOCITY (COMPONENT OF ABSOLUTE VELOCITY NORMAL TO PERIPHERAL)
Cu2 = COMPONENT OF ABSOLUTE VELOCITY TANGENTIAL TO PERIPHERAL)
Wu2 = COMPONENT OF RELATIVE VELOCITY TANGENTIAL TO PERIPHERAL)
β2 = OUTLET ANGLE

INLET VELOCITY TRIANGLE





u1 = PERIPHERAL VELOCITY AT IMPELLER EYE
W1 = RELATIVE VELOCITY OF FLOW
C1 = ABSOLUTE VELOCITY OF FLOW
Cm1 = MERIDIONAL VELOCITY (COMPONENT OF ABSOLUTE VELOCITY NORMAL TO PERIPHERAL)
Cu1 = COMPONENT OF ABSOLUTE VELOCITY TANGENTIAL TO PERIPHERAL)
Wu1 = COMPONENT OF RELATIVE VELOCITY TANGENTIAL TO PERIPHERAL)
β1 = INLET ANGLE

Veocity Diagrams and Governing Equations

- Values of speed constants (Ku, Km1, Km2, K3) have been calculated through graphs of specific speed vs head coefficient (psi) and capacity coefficient (phi). In order to get the values of psi and phi for any specific speed and impeller outlet angle, nonlinear regression is used.

$$\Psi = (0.3322) * (specificSpeed)^{(-0.0936)} * (\beta 2)^{(0.3078)}$$

$$\phi = (3.309e-04) * (specificSpeed)^{(0.5448)} * (\beta 2)^{(0.6410)}$$

$$Ku = \frac{1}{\sqrt{(2*\Psi)}}$$

$$u2 = Ku * \sqrt{(2gH)}$$

$$\phi = \frac{cm2}{u2}$$

$$Km2 = \frac{cm2}{\sqrt{(2gH)}}$$

using the value of km1 using graph:

$$cm1 = km1 * \sqrt{(2gH)}$$

Web App - Usage

- User needs to upload input / control file having desired performance data (head, flow rate & RPM) of pump. Number & angles of the vanes are other inputs.
- The uploaded input file must me in .JSON format.
- Upon execution, a summary file is generated that contains following information:
  1. Design and geometric parameters for the impeller.
  2. Shaft diameter and specific speed for the pump.
  3. Thrust acting on the impeller.

Input File Description - Default

Parameter	Default Value	Unit	Description
RPM	3000	RPM	Shaft rotational frequency
flow_rate_m3/hr	40	m^3/hr	Total discharge or flow rate
head	10	m	Total head in m
number_of_vanes	6	-	No. of vanes on the impeller
vane_thickness	0.006	m	Thickness of each vane in m
vane_outlet_angle	24	Degrees	Vane outlet angle (must lie between 24 to 40 degrees).
vane_inlet_angle	15	Degrees	Vane inlet angle (must lie between 15 degrees to 70% of vane_outlet_angle).

Input File Description

- Default input file name: control_file.JSON
- The format of the input file is as shown below:

```
{
"INPUTS" : {

        "RPM"                : 3000,
        "flow_rate_m3/hr"    : 40,
            "head"           : 10,
            "number_of_vanes"  : 6,
        "vane_thickness" : 0.006,
        "vane_outlet_angle" : 24,
        "vane_inlet_angle" : 15
    }
}
```

Summary File Description - Default (Summary.csv)

Parameter	Default Output	Unit	Description
Specific Speed:	2904.2	US Specific Speed	Specific speed for the pump.
Shaft Diameter in mm:	15	mm	Diameter of the pump shaft in mm.
Impeller Diameter (D2) in mm:	97.4	mm	Diameter of the impeller in m.
Impeller Width at Outlet (b2) in mm:	13.7	mm	Width of impeller at the outlet section in m.
Impeller Eye diameter (D1) in mm:	80	mm	Eye diameter of the impeller in m.
Impeller width at inlet (b1) in mm:	20.4	mm	Width of impeller at the inlet section in m.
Base Circle Diameter in mm:	103.2	mm	Base circle diameter of the casing.
Casing Throat Area in mm^2:	2266.4	mm^2	Throat area of the casing in m^2.
Axial thrust in N:	268.1	N	Axial thrust on the impeller in N.
Radial thrust in N:	47.2	N	Radial thrust on the impeller in N.

References

- “Centrifugal and Axial flow Pumps”, A.J. Stepanoff
- Thin, K.C., Khaing, M.M. and Aye, K.M., 2008. Design and performance analysis of centrifugal pump. World Academy of Science, Engineering and Technology, 46, pp.422-429.
- Lei, T. and Shuliang, C., 2010. Optimal design and numerical simulation for impeller of centrifugal pump with medium-high specific speed. Journal of Drainage and Irrigation Machinery Engineering, 28(4), pp.282-285.
- “ Centrifugal and Rotary Pumps”, Lev Nelik., CRC Press LLC.

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Thank You !

Durganshu Mishra

+91 72760 31511

durganshu.mishra@zeusnumerix.com

www.zeusnumerix.com