Streamline 설계 방법 및 CFD 분석 기반의 펌프 임펠러 설계

Axial flow pump impeller designed by streamline method and CFD simulation

*#박홍석 [1], Miao Fuqing [1]

*#H. S. Park(phosk@ulsan.ac.kr)[1] , Miao Fuqing[1]

[1] 울산대학교 기계공학부

Key words : Axial flow pump, impeller design, streamline method, CFD simulation

1. Introduction

Axis flow pumps are one type of blade pump with great flux, lower head, high fluids flow. Because of its big useful in agriculture, irrigation and massive water project, so many researchers pay attention to the area of axial flow pump design. Allision think about that with the developing of power computer, 3D simulation will be the main method in hydraulic design of pump [1].

In this paper, streamline method was employed to design axial flow pump in new parameter selection method. The practice in pump hydraulic design showed that: The blade incidence angle increased from hub to tip and the incidence angle near hub can reach 10 ?that increase the blade warping in the pump designed by lifting method; And also, the incidence angle reach 4 ?near the hub of pump designed by circular arc method, but near the tip we usually defined it by 0°. So in this case we can't get a high efficiency pump if it worked in off-design conditions. So streamline method is used in this paper.

2. Linear amendment of exit circular

In streamline method, linear amendment the impeller blade exit circular. Increase the circular of airfoil located in the blade outer side at the same time decrease the circular of airfoil near the hub [2]. The circular correction factor present linear changed between the hub and tip, as shown in Fig. 1: r/R present the position of hub, r/R=1 present the position of tip. Corrected formula:

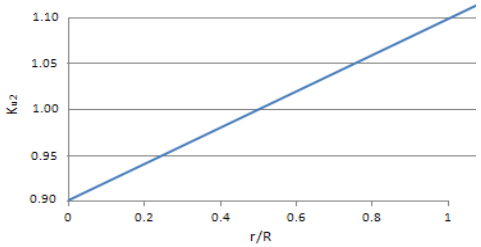
$$Vu2=Ku2\ V'u2$$

Vu2: meridional velocity after correction

V′u2: meridional velocity(assume V′u2 is constant)

Ku2: correction factor of V′u2, Ku2=0.9~1.1

Fig.1 Coefficient of V′u2 from hub to tip



3. Hydraulic model design

Design parameter：Flow Q=1m³/s, Head H=22m, Rotate speed n=2000r/min

Rotator and stator design result

Parameter	Section				
	1	2	3	4	5
Section diameter, d/mm	161	215	268	321	374
Correction factor of V′u2, Ku2	0.90	0.95	1.00	1.05	1.10
Meridional velocity Vu2	20.0	25.5	31.5	37.5	44.6
Incidence angle	3	2.0	0.5	-0.5	1
Blade angle, β	42	35	27	22	18
Max thickness, δmax/mm	16	13	11	9	7
Blade profile radius, R/mm	212	255	300	345	389
NACA	4410	4409	4408	4407	4406

Parameter	Section				
	1	2	3	4	5
Blade profile radium, R/mm	211	256	300	345	387
Chord length l/mm	124	128	130	131	132
Radius of curvature mm	202	218	243	266	295
Blade angle, β	49	54	58	61	63

4. Mesh model

The mesh model as shown below:

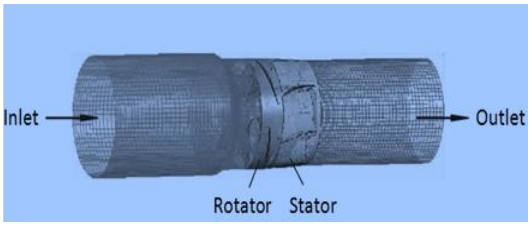


Fig.2 Mesh model

5. Stress filed analysis

Beside to meet the requirement of fluid performance, the impeller has to have high strength. So fluid-structure interaction analysis is necessary. The governing equations contain continuity equation of flow field, momentum equation, k equation and ω equation [3] Hydrodynamic forces combine with gravity and centrifugal load as boundary conditions. After the simulation of fluid-structure interaction, the stress distribution of blade surface as shown below:

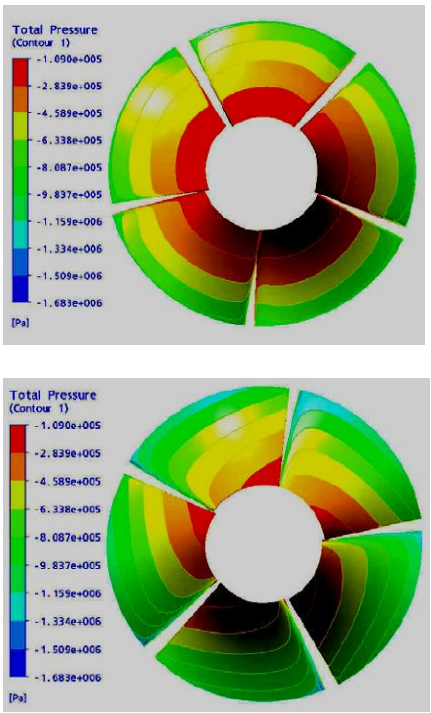


Fig.3 Pressure distribution on the surface of impeller

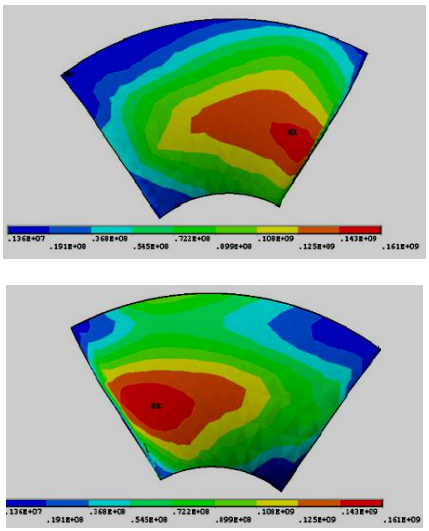


Fig.4 Stress distribution on the surface of impeller

From Fig.4, the blade maximum stress by calculation is 160Mpa. the allowable stress can be calculate is 176Mpa, so the impeller meet the strength requirement.

6. Conclusion

(1) Streamline method was used in this paper and make up the disadvantages of traditional circular arc design method and lifting design method. Under the law of linear amendment of exit circular, high efficiency pump model was obtained.

(2) The flow-structure interaction solution indicated that impeller strength meet the design requirements.

References

[1] ALISION J L, JIANG C, STRICKER J G, et al. Modern tools for water jet pump design and recent advances in the field[C]//International conference on Water jet Propulsion, RINA, Am sterdam.1998.

[2] Guan Xingfan. Research on development of high performance axial flow pump impellers[J]. Pump Technology,1982(1):25~32. (in Chinese)

[3] Huang Minghuan, Gao Hong, Shen Feng, et al. Numerical simulation and experimental validation of the flow in axial flow pump[J]. Transactions of the Chinese society for agricultural machinery,2008,39(8)66-69.