한국기계가공학회지, 제18권, 제9호, pp.17～22(2019.09) ISSN 1598-6721(Print)
Journal of the Korean Society of Manufacturing Process Engineers, Vol. 18, No. 9, pp.17~22(2019.09) ISSN 2288-0771(Online)

https://doi.org/10.14775/ksmpe.2019.18.9.017

A Flow Study by the Number of Wings at Ship Propeller

Moonsik Han*, Jaeung Cho**,#

*Department of Mechanical and Automotive Engineering, Keimyung UNIV.
**Division of Mechanical and Automotive Engineering, Kongju National UNIV.

선박의 프로펠러에서의 날개 수에 의한 유동 연구

한문식*, 조재웅**,#

*계명대학교 기계자동차공학과, **공주대학교 기계자동차공학부

(Received 13 May 2019; received in revised form 29 May 2019; accepted 5 June 2019)

ABSTRACT

A ship's propulsion system is a device to move the ship by means of the power transmitted from the ship's engine to the propeller. In this study, three propeller models, a, b, and c, are designed and their flows are analyzed. Same flows with the same material are applied to all three models. Flow analysis results differ according to the shape of flow model though these models are the same material. In all respects, model C is considered to be more rigid and efficient than models A and B. A propeller model optimized for the driving force and stability can be developed through this study result.

Key Words : Propeller(프로펠러), Wing(날개), Flow Analysis(유동 해석), Equivalent Stress(등가 응력), Total Deformation(전변형량)

1. Introduction

The 21'st century is an era of high oil prices. Companies are trying to maximize efficiency in response to with the ever-increasing price of oil. Development is a key word for survival in this era when the shipbuilding is currently lagging behind as the technology being catched up by China. Currently, shipbuilders are investing heavily in manufacturing and designing parts that are maximized for efficiency. Considering as the efficiency, the company aims to gain an upper hand in competition among countries on the basis of high performance in comparison to price. Therefore, there is the problem which part can be increased on efficiency. Changing the design of the propeller is also one of the ways to increase the efficiency of ship. The propeller has had a great influence on human life, especially on ships and airplanes. As the history of ships has changed with the history of mankind, so has the propulsion method of ship. Representatively, Propeller has become the propulsion system of ship. There are many different types of propellers. In this study, the FPP (fixed pitch propeller) used in the majority of ships is investigated. Each of the fixed-pitch propeller models of A, B and C were analyzed with the

Corresponding Author : jucho@kongju.ac.kr
Tel: +82-41-521-9271, Fax:+82-41-555-9123

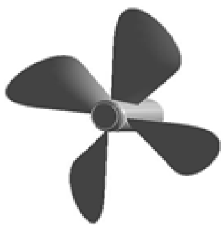
same material, inputting the same value for flow. Flow analyses are also carried out according to the number of these propeller blades. As the flow analysis result, model C is shown to be higher than the models of A and B on strength and efficiency[1~3]. Currently, the number of propeller blades becomes three or four shapes which the shipbuilding company manufactures, while the latest technology involves using a propeller with a total of six wings by overlapping two three-winged propellers. In future, propeller models are expected to be more efficient due to the technological advance[4~12].

2. Analysis Results

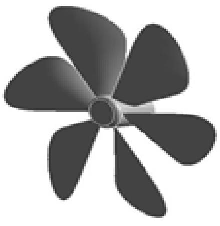
2.1 Analysis models

In this study, ship propellers were modeled similar to actual features, and the number of wings was composed of three types, three, four and eight, respectively, as shown in Fig 1. 3D modeling used CATIA and was then interpreted using ANSYS. Table 1 shows the properties of structural steel, which is propeller material.

(a) Model A



(b) Model B

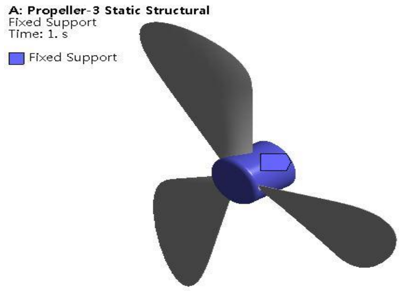


(c) Model C

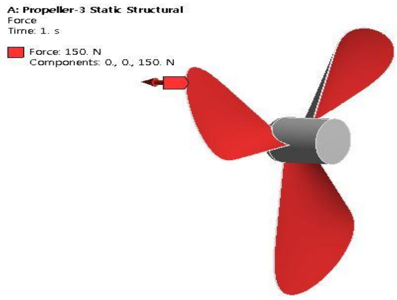
Fig. 1 analytical model

Table 1 Material property

Young's modulus	2×10^5MPa
Poisson's ratio	0.3
Density	7850kg/m³
Tensile yield strength	250MPa
Compressive yield strength	250MPa
Tensile ultimate strength	460MPa



(a) Fixed support at models



(b) Forced condition at models

Fig. 2 Analysis condition

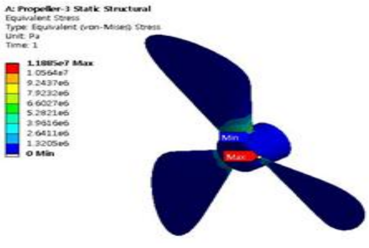
2.2 Structural analysis

2.2.1 Structural analysis conditions

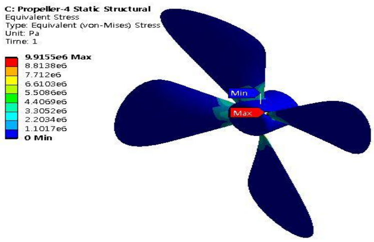
Fig. 2 shows the analysis conditions at each model representatively. When the propeller is driven, the force of water is applied to the surface of the propeller. Therefore, the propeller centre was fixed as the supported face and a force of 10 N was applied in Z direction.

2.2.2 Structural analysis results

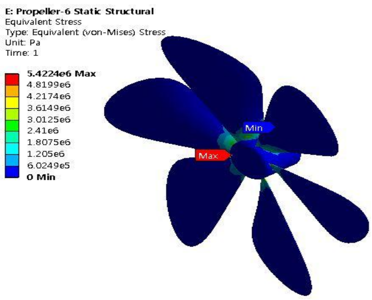
Fig. 3 shows the contours of equivalent stresses at models A, B and C.



(a) Model A



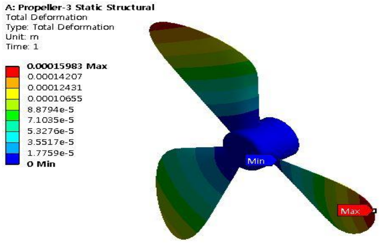
(b) Model B



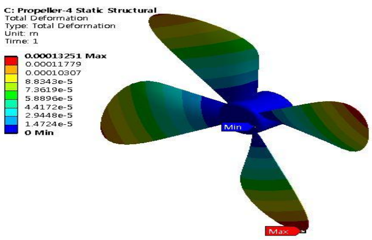
(c) Model C

Fig. 3 Equivalent stresses of models

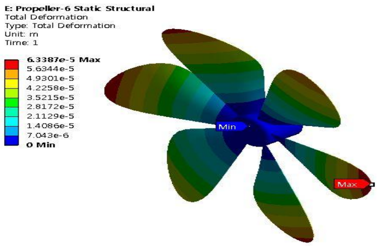
At Fig. 3, the maximum equivalent stress values become 11.885 MPa, 9.9155MPa and 5.4244MPa at models A, B and C respectively. The maximum equivalent stress values of three models are made of the same material, but the equivalent stress values vary by depending on the geometry. The maximum equivalent stress of model A becomes more than two times by comparing with that of model C[13]. Fig. 4 shows the contours of total deformations at models A, B and C. As shown by Fig. 4, three models appeared to have the largest deformation at the tip of the propeller's wing.



(a) Model A



(b) Model B



(c) Model C

Fig. 4 Total deformations of models

The values of the maximum total deformations become 0.15983 mm, 0.13251 mm and 0.063387 mm at models A, B and C, respectively. As the maximum equivalent stress value becomes, The maximum total deformation of model A becomes more than two times by comparing with that of model C. So, model C showed less overall maximum equivalent stress and less structural deformation than models A and B.

2.3 Flow analysis

2.3.1 Flow analysis conditions

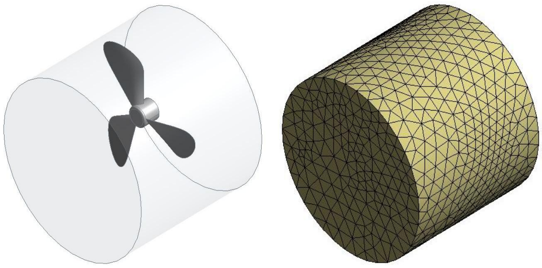
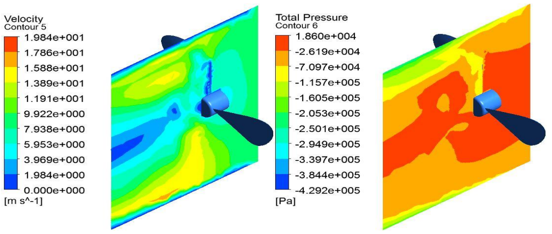
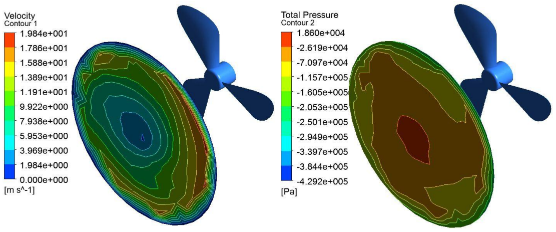


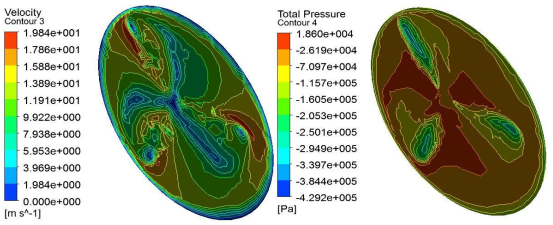
Fig. 5 flow zone the fluid zone without propeller



(a) Velocity and pressure at the middle plane of flow at model A



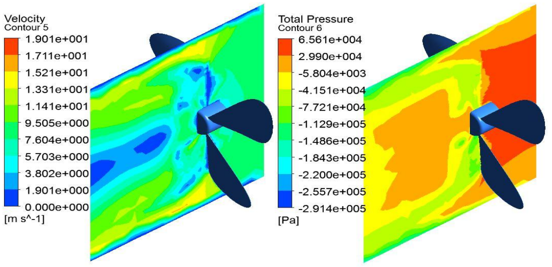
(b) Velocity and pressure of output at model A



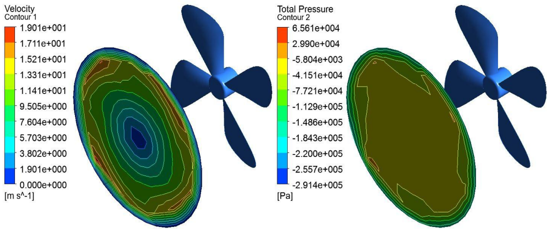
(c) Velocity and pressure of the plane section of wing at model A

Fig. 6 Contours of velocity and pressure at model A

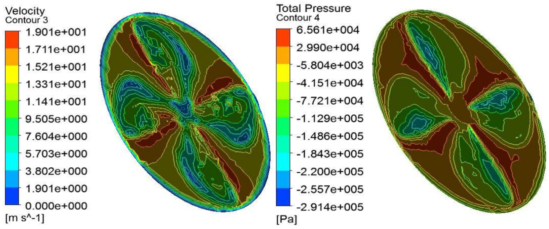
Fig. 5 shows the flow zone of model 1representatively. In order to proceed with flow Analysis, the total length and diameter at each flow zone becomes 100 cm and 5 cm, respectively.



(a) Velocity and pressure at the middle plane of flow at model B



(b) Velocity and pressure of output at model B



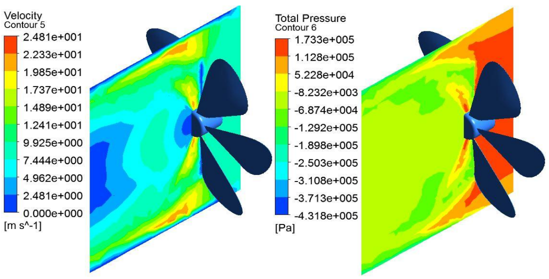
(c) Velocity and pressure of the plane section of wing at model B

Fig. 7 Contours of velocity and pressure at model

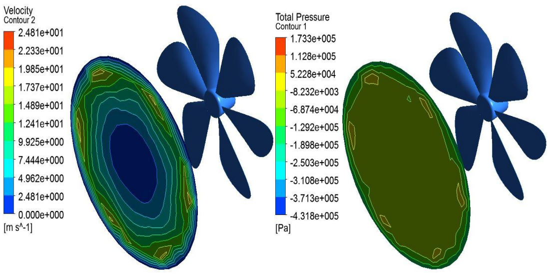
The flow velocity at inlet and the pressures at Boutlet are set as 8.5 m/s and 1 pa, respectively.

2.3.2 Flow analysis results

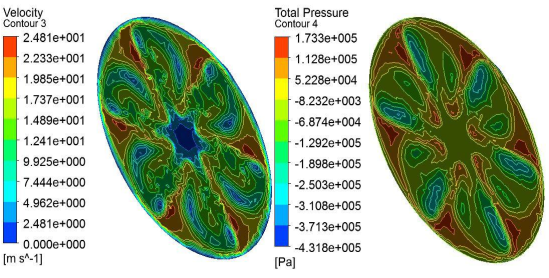
As flow analysis results, Figs. 6, 7 and 8 show velocity and pressure at the middle plane of flow at models 1, 2 and 3. Also, Figs. 6, 7 and 8 show the velocity and pressure of output and the plane section of wing at models 1, 2 and 3. As shown by Figs. 6, 7 and 8, the velocity at the inlet was same at models 1, 2 and 3. The flow velocities at the exit at models 1, 2 and 3 were 19.8449 m/s, 19.0107 m/s, and 24.812 m/s, respectively. It is shown that the speed of the exit increases with the increase in the number of blades. The flow velocity at inlet and the pressures at outlet are same at models A, B and C. The pressures at the exit at models 1, 2 and 3 were 18,595.9Pa, 65,606.1Pa and 173,294Pa, respectively, respectively. The results show that the pressure at the exit increases with the number of blades. So, the velocity and pressure of flow at the exit at model C become greater than models A and B [14~15].



(a) Velocity and pressure at the middle plane of flow at model C



(b) Velocity and pressure of output at model C



(c) Velocity and pressure of the plane section of wing at model C

Fig. 8 Contours of velocity and pressure at model C

3. Conclusion

In this study, the propeller of any vessel was modelled by using CATIA like the actual shape. And the structural analysis and flow analysis were carried out with models 1, 2 and 3. So, the following results of this study were obtained:

1. In common, models A, B, and C all showed the most deformation at the tip of the propeller's wing. Model C showed less overall maximum equivalent stress and less structural deformation than models A and B.
2. the velocity and pressure of flow at the exit at model C become greater than models A and B.
3. Summarizing the results of this study, the arbitrary models are set as the same input pressure and velocity values as the number of wings increases. The number of wings is shown to be optimized as six.

REFERENCES

1. Cho, J. U. and Han, M. S., “Analysis of the Sir Flow due to the Number of Electric Fan Blades,” Journal of the Korean Society of Manufacturing Process Engineers, Vol. 11, No. 1, pp. 107-112, 2012.
2. Cho, J. U. and Han, M. S., “Air Flow Analysis due to the Configuration of Car Body Radiator Grill,” Journal of the Korean Society of Manufacturing Process Engineers, Vol. 12, No. 3, pp. 21-27, 2013.
3. Cho, J. U. and Han, M. S., “Study on Flow and Stress Analysis of Gas Turbine Blade,” Journal of the Korean Society of Manufacturing Process Engineers, Vol. 10, No. 3, pp. 67-72, 2011.
4. Kim, H. J. and Kim, S. H., “A Study on Air Flow Characteristics of Mid-mower for Tractor (Ⅰ),” Journal of the Korean Society of

Manufacturing Process Engineers, Vol. 14, No. 3, pp. 27-35, 2015.
5. Park, S. B., Kang, J. H., Kim, J. M. and Kim, H. N., "Analysis of Flow Through High Pressure 3/2-Way Valve by using a Ship Engine," Proceedings of KSMPE Conference, pp. 57~58, 2011.
6. Kim, J. H., Kim, J. B. and Oh, Y. L., "Performance Prediction of Wind Power Turbine by CFD Analysis," Transactions of the Korean Society of Mechanical Engineers - B, Vol. 37, No. 4, pp. 423-429, 2013.
7. Kim, B. H. and Jung, D. S., "Flow Analysis for the Sludge Pneumatic Dehydrator with Cyclone Type," Journal of the Korean Society of Manufacturing Process Engineers, Vol. 8, No. 4, pp. 1-6, 2009.
8. Wang, Z. H., Chun, C. K. and Kwon, Y. C., "Study on Exhaust Air Heat Transfer Characteristics of Heat Exchange System for White Smoke Reduction," Journal of the Korean Society of Mechanical Technology, Vol. 20, No. 6, pp. 739-744, 2018.
9. Choi, Y. S. and Kwon, Y. C., "An Experimental Study of Air-side Heat Transfer and Pressure Drop of Evaporator for Refrigerator Unit," Journal of the Korean Society of Mechanical Technology, Vol. 21, No. 1, pp. 42-47, 2019.
10. Hwang, S. W., "A Comparison Study of Performance due to the Oil-cooler Fin Shape for Diesel Engine using Numerical Analysis," Journal of the Korean Society of Mechanical Technology, Vol. 21, No. 1, pp. 1-7, 2019.
11. Jang, B. M. and Cho, D. H., "A Study on the Flow Characteristics around Vertical Wall with Flap," Journal of the Korean Society of Mechanical Technology, Vol. 21, No. 2, pp. 248-253, 2019.
12. Kang, H. J. and Lee, H. S., "A Study on Heating and Cooling Performance Characteristics of Heat Meter for Water Source Heat Pump System," Journal of the Korean Society of Mechanical Technology, Vol. 21, No. 2, pp. 321-326, 2019.
13. Ku, H. K., Kim, J. W., Won, C. and Song, J. I., "Optimization and Structure Analysis of Brake Disc for Free-fall Winch," Journal of the Korean Society of Manufacturing Process Engineers, Vol. 11, No. 3, pp. 55-61, 2012.
14. Kwag, S. H., "Flow Analysis over Moving Circular Cylinder Near the Wall at Moderate Reynolds Number," Journal of the Korean Society of Marine Engineering, Vol. 36, No. 8, pp. 1091-1096, 2012.
15. Lee, S. Y. and Kim, S. C., "Flow Analysis for Optimal Design of Small Gear Pump," Journal of Energy Engineering, Vol. 24, No. 1, pp. 88-96, 2015.