A study on the improvement of high speed blower for fuel cell

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Abstract
Recently, due to the exhaustion of fossil fuel, pollution of air, and demand for capacity increase of power system, new generating technologies using various energy sources, for instance wind, water, geothermal, fuel cell, have been developed. Among them, fuel cell system which generates electric energy from chemical reaction of hydrogen and oxygen is considered one of the promising alternatives due to aspects of environment conservation as well as high efficiency. Fuel cell systems consist of fuel cell stack, air management system, and power conditioning system. Air management systems composed of pump, compressor, and blower determine output performance of overall system on the preferential basis. Besides, the proper matching of a blower high speed/torque to aerodynamic output is especially important in increasing efficiency thereby reducing its demand on a fuel cell system. This study is to develop small size light weight high efficiency and high speed blower for fuel cell module. This paper deals with a design of the air management system, especially brushless DC (BLDC) motor and blade for blower module. We achieved blade flow analysis about high speed blower and presented various design data. We have used the 2D Finite Element Method for calculating the characteristics of brushless DC (BLDC) motor. And we wish to accomplish blower performance elevation and commercialization through this.

1 BRUSHLESS DC (BLDC) MOTOR DEVELOPMENT

In the basic design, the basic shape and the motor specification are decided by magnetic load distribution method and characteristic analysis is performed by finite element method (FEM) and by equivalent magnetic circuit method (EMCM). The simulated results are presented in following Table 1. Among the items, the slotless shape and pole angle of permanent magnet are designed in consideration of analyzed cogging torque. The specifications of the proposed brushless DC (BLDC) motor for cooling fan are shown in table 1.

Table 1. Specification of designed brushless DC (BLDC) motor

Parameter	Value	Unit
Phase/Pole number	3/2	
Input power	25	W
Nominal voltage	12	V
Nominal speed	23,000	rpm
Coil diameter	0.5	mm
Stator core outer diameter	32	mm
Core material	S08(35PN230)	
Nominal torque	8	mNm
Permanent magnet	Nd38(Br 1.25T)	-

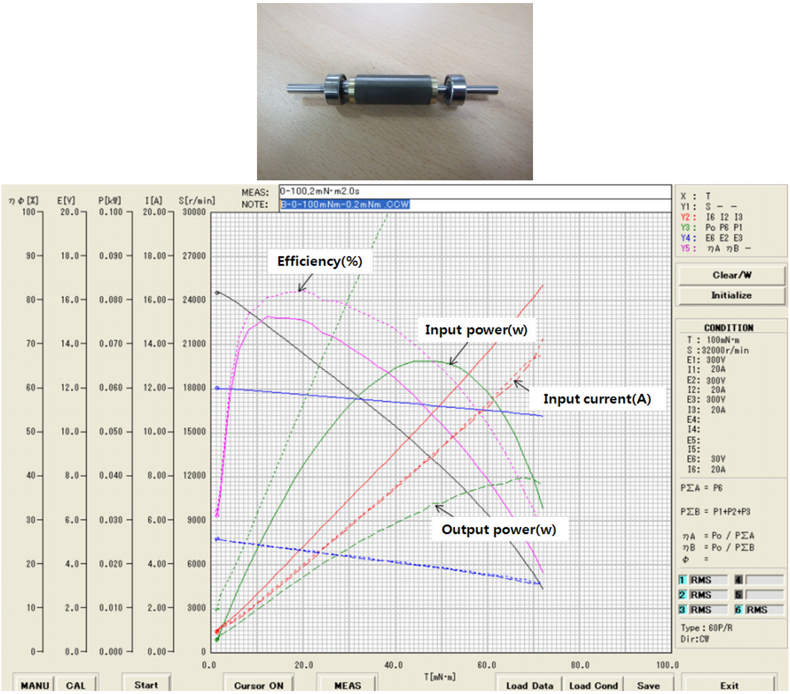

Fig. 1 Rotor shaft of BLDC motor /Measured performance curves of BLDC motor

The features of Speed-Torque-Current (N-T-I) in case of supplying 12V rated voltage are shown in Fig. 1. We confirmed generating power of 25 W that have torque of 8 mNm in speed of 23,000 rpm, in the case of approving voltage of 12 V this experiment. In this load point, input current is about 2 A, efficiency was evaluated about 77 %.

2 BLOWER IMPELLER DEVELOPMENT

We executed numerical analysis to improve blower impeller’s performance that is applied on fuel cell. The impeller's performance in design step can achieve computing fluid mechanics (CFD) as numerical analysis. We modeled imagination wind tunnel for this, achieved numerical analysis locating third dimension data of blower shape in imagination wind tunnel. And, we applied multiple reference frame (MRF) method to consider impeller's turning effect by numerical analysis method. The multiple reference frame (MRF)-model is a steady state approximation where fluid zone in the blower region is modeled in a rotating frame of reference and the surrounding zones are modeled in a stationary frame.

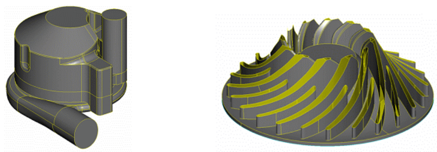

Fig. 2 The blower and impeller geometry

Solver setup and computation

The results are obtained with the solution of the continuity, N-S equations along with the equations for the selected turbulence model. After the boundary conditions are specified and the solution models are selected, the iterations are performed in STAR-CCM (commercial CFD simulation software).

Analysis result

Since the multiple reference frame (MRF) approach is a steady state approximation, using multiple reference frame (MRF) assumes that a steady state solution can be achieved. To monitor total pressure and check the stability does only partly show if a steady state solution has been achieved.

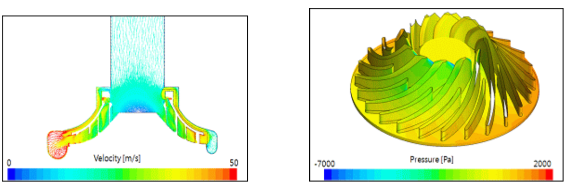

Fig. 3 Velocity of flow distribution / Impeller surface pressure distribution

3 BLOWER TEST

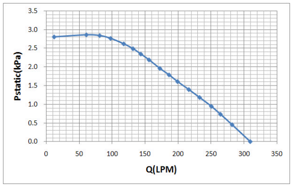

Fig. 4 Measured performance curves of Fan blade

Finally, the designed motor is connected with an impeller, and output characteristics of the overall blower system with respect to pressure and flow condition changes are measured in Fig. 4. As can be seen in Fig. 4, the required output value of system, air pressure of 2.35kPa and air flow of 143LPM, is gained at an input voltage of 12V.

4 CONCLUSION

This study presents a design of high speed blower module for an air management system of a fuel cell. For the designing of high Efficiency and high speed blower Motor, it is proposed optimized design by finite element method. And we executed numerical analysis to improve cooling blower's performance that is applied on fuel cell. The blower impeller's performance in design step could achieve computing fluid mechanics (CFD) as numerical analysis.

Table 2. Final development blower's performance

Major Specifications	Value	Unit
Air flow(Max)	310	LPM
Air static pressure(Max)	2.85	kPa
Speed(Max)	24,000	rpm
Motor efficiency(Max)	77	%
Input voltage	12	V

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