Technology Improving Fan Reliability

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1. Introduction

Sanyo Denki developed and produced long-life fan, L type (hereinafter "conventional model") as high reliable fan in 1991 being pioneered in the market. Ever since, we have built a strong track record for two decades or move. The first developed product was 120 mm sq., 38 mm thick fan size and we have enriched lineup to 8 sizes from 40 mm sq., 28 mm thick to ϕ172 mm, 51 mm thick at present. 2.5 to 5 times longer life than general fans particularly satisfies needs of customers who require their equipment to be long-life and high reliability and those customers use the long-life fans in a variety of applications. [1) 2) 3) 4)]

The trend in recent years for information and communications devices to have high performance and down - sizing has resulted in higher - density devices. This has created a demand for cooling fans to achieve higher cooling performance (air flow - static pressure characteristics) without changing in size.

Here we introduce technologies to improve fan reliability and ones mainly adopted for high air flow and long-life "San Ace 60L, 80L, 92L" 9LG type (hereinafter "new model") that newly developed as cooling fan that increases cooling performance and has high reliability and long-life comparing to conventional model.

As for details on the new model, please refer to new product introduction.

Fig.1: New model (San Ace 80L 9LG type)

2. Key Thing for Long Life

One of the key things of fan reliability is life (expected life). Fan life is mainly determined by bearing life. Ball bearing for our fan seals in lubrication grease. There are "rated fatigue life" and "grease life" regarding fan life and what determines fan life is grease life.

The main factors to improve grease life are as follows;

(1) Reduction of bearing temperature
(2) Reduction of bearing load
(3) Grease improvement
(4) Bearing improvement

(1) Reduction of bearing temperature

We have conducted accelerated life test at high temperature and confirmed that life can be extended by reducing ambient temperature of fan. Moreover, through estimated equation of grease life, we have ascertained that temperature reduction of bearing also leads to longer life. The reduction of bearing temperature is essential in achieving longer life.

(2) Reduction of bearing load

Unlike industrial motors, basically any load isn't applied to the motor except its blade and rotor, therefore bearing load is also relatively low in most cases. However, with shift towards high speed, there is a tendency for load on bearing to increase.

By reducing bearing load, the load applied to grease is reduced thereby alleviating grease degradation, which can be anticipated to lead to longer life. Moreover, through estimated equation of grease life, we have ascertained that reducing bearing load results in longer life.

(3) Grease improvement

The improvement of grease itself is effective in improving grease life. The factors of grease degradation should be chemical degradation caused by temperature, etc., and physical degradation due to grease being mechanically damaged reduces as a result of bearing rotation. Grease that these degradation factor has to be selected in consideration of fan's usage environment and conditions.

(4) Bearing improvement

Improving ability of bearings to withstand loads has the same benefit as reducing bearing load. Generally-speaking, bigger bearings are capable of withstanding bigger loads however this has the disadvantage of bigger motor size and higher load torque of bearing itself. So bearing is selected considering fan size and performance requirements.

We developed long-life fan considering above (1) and (2) especially. In regards to (3) and (4), after considering performance requirements and motor size, we adopted grease type and bearing with proven performance on our fans.

Moreover, in order to achieve both longer life and a higher air flow on new model compared with conventional model, we selected suitable material for not only bearings, but also some other components in consideration of ability to be used for a long time at high temperature. Also, we conducted development so as to achieve appropriate derating of various components in motor drive circuit.

3. Implementation for Long Life of New Model

We achieved both higher air flow and longer life of new model through below technical implementations in correspondence to each fan sizes.

3.1 Bearing temperature reduction

The following two measures were taken to reduce the bearing temperature of new model:

(1) Reduction of heat generation of motor

(2) Promotion of heat dissipation through self-cooling of fan

(1) Reduction of heat generation of motor

Compared to conventional model, new model achieved significantly higher - static pressure characteristics, i.e. maximum air flow of 1.3 to 1.8 times higher, maximum static pressure of 1.5 to 3.5 times higher. Fig. 2 shows one example of static pressure characteristics of conventional and developed 80 mm square fan. Table 1 is comparison of each specifications.

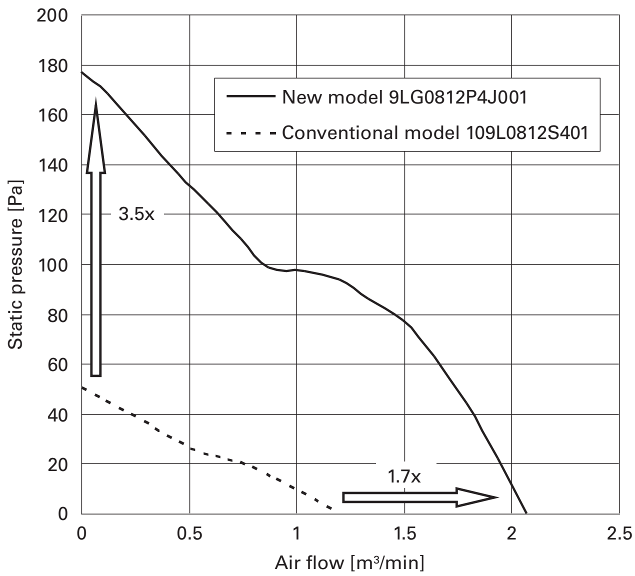


Fig. 2: Comparison of air flow - static pressure characteristics between our conventional model and new model

Table 1: Comparison of specifications between conventional model and new model (at 12 V DC)

	Model No.	Speed [min^{-1}]	Max. air flow [m^3/min]	Max. static pressure [Pa]	Power consumption [W]	Expected life [h]
New model	**9LG0812P4J001**	7,400	2.07	177	7.2	180,000
Conventional model	**109L0812S401**	3,400	1.2	50	3.12	100,000

If speed of conventional model was simply increased in order to achieve equivalent air flow - static pressure characteristics to new model, theoretically, power consumption of fan drive motor would increase by approximately 2.2 to 5.8 times that of current model, increasing degree to which motor heats up, therefore making it impossible to achieve equivalent life to that of conventional model. In order to achieve “high air flow and long-life” concept of new model, it was essential to increase efficiency of fan drive motor and fan air flow and by doing so, reduce heat generation of motor.

To increase motor efficiency, we (a) optimized stator shape, and (b) changed motor drive system. (See Fig. 3).

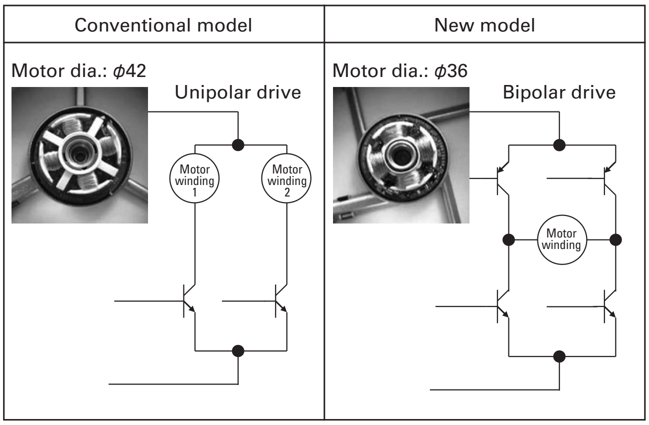


Fig.3: Comparison of size and drive system for conventional model and new model

(a) Optimization of stator shape:

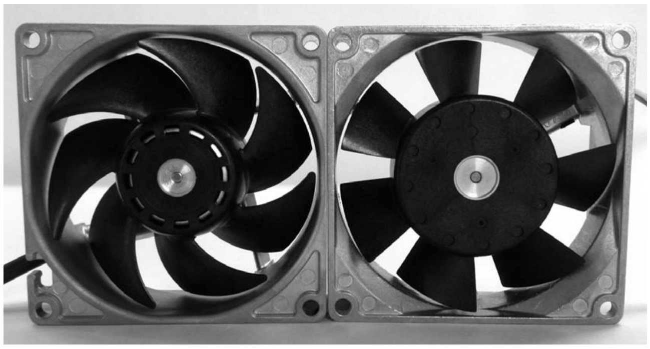
We modified shape of conventional model’s stator to be more suitable for achieving high torque and enhance winding space factor.

(b) Motor drive system change:

Regarding motor drive system, we went from unipolar drive system on conventional model to bipolar drive on new model. Unipolar drive was adopted on conventional model due to its simplicity with small number of components, however bipolar drive is used on new model for purpose of achieving motor efficiency. (See Fig. 3)

By making these changes, motor efficiency was increased, and it was possible to drive 80 mm and 92 mm square fans with smaller motors than the drive motors of conventional fans.

Being able to adopt small size motor provides secondary benefit like increasing room for blade of the fan because freedom degree of blade design can be enhanced. Leveraging the freedom degree of blade design, we optimized blade/frame shape (see Fig. 4) and improved air flow efficiency.



New model Conventional model

Fig.4: Comparison of blade/frame shapes for new model and conventional model

(2) Promotion of heat dissipation through self-cooling of fan

In the same way as conventional model, aluminum die cast was also used for frame material on new model, therefore bearing temperature is reduced due to heat dissipation effect of self-cooling. Moreover, aluminum die cast frame has been adopted for long-life fans for some time now, and is effective in securing long-term reliability on new high speed model as well.

Due to the above, in spite that new model accomplished higher air flow and higher speed than conventional model, it was possible to reduce bearing temperature rise by down to half.

3.2 Reduction of bearing load

As for new model, as previously explained, blade and frame designs were optimized at the same time as achieving higher speed compared with conventional model in order to achieve higher air flow. To accompany higher speed, load on bearing tends to increase, therefore below actions were taken to reduce bearing load.

(1) Reduction of rotor unbalance

Rotor unbalance directly effects to increase of bearing load upon higher speed. Rotor unbalance may also occur defects of noise and operational as a result of vibration caused by fan, and it is important to minimize as much as possible.

In order to achieve dynamic balance of rotating parts (impellor and rotor), it is ideal to adopt dual plane balancing, therefore this was implemented for new model.

(2) Reduction of impeller and rotor mass

Reducing mass of rotor will result in reduction of bearing load, regardless of speed.

Being able to use smaller motor on new model compared with conventional model thanks to increased motor efficiency, as mentioned above, has significantly contributed to reducing rotor mass. The rotor was lightened further by making a hole at the part without functional impact. Furthermore, sintered ferrite was used for magnet of conventional model, lighter material is adopted for new model.

(3) Improvement of load balance

The fan has two bearings, however load tends to be higher on one bearing because of fan’s structure. On new model, distribution of load across two bearings was improved and structure was reviewed so that one of bearing doesn’t have excessive load.

As a result of taking the above action, bearing load of new model with higher air flow was reduced by approximately 5% of conventional model.

This enable bearing load of new model to reduce with bearing temperature reduction at 3.1 and we achieved 180,000 hours expected life (survival rate 90%, rated voltage continuous operation, free air state, normal humidity) that was 1.8 times compared to conventional model.

4. Conclusion

We introduced technologies which increase reliability using high air flow/long-life “San Ace 60L, 80L, 92L” 9LG type are developed and produced by Sanyo Denki as an example. We will continue to explore technologies which lead to high reliability in order to develop products which can be used by many customers with peace-of-mind and trust.

Documentation

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