



Implementing the manufacture plan and use of high-efficiency permanent magnet electric motors in evaporative coolers

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Abstract

Nowadays, increasing energy efficiency is the economical and fastest way to generate electricity in the world. Therefore, the importance of energy saving has been considered for many years in Iran, but the allocation of subsidies to energy production sector has led to the lack of a logical and specific solution to reduce energy consumption and is still one of the main challenges in Iran's economy since paying insufficient attention to energy saving in all applications. Due to the climate of Iran, the use of evaporative coolers for cooling and air conditioning is very common in summer, but installed electromotors in these coolers are one of the high-consumption equipment in peak hours which the upgrade of them can have a significant impact on reducing the peak of energy consumption in the country. From this point of view, Brushless DC (BLDC) motors, as high-efficiency electromotor type, have been investigated for evaporative cooler application.

In this paper, the technology development procedure of these BLDC motors for evaporative coolers in the country is presented and at the end, the results of production of this type of electromotors by seven domestic companies and their operation these coolers are presented.

Keywords: energy consumption, high-efficiency electromotor, BLDC, evaporative cooler

1. Introduction

According to the World Energy Council in 2016, improving energy efficiency is the fastest, cheapest and cleanest way to generate electricity in the world [1]. Electromotors applications are ranged from computer hard drives and small motors in home appliances to medium and large motors in commercial buildings and factories. In accordance with the International Energy Agency report in 2018, more than half of the world's electricity is consumed by a single product called the electromotor system [2, 3]. According to studies conducted in international references [4, 5], the use of optimal systems of electromotors can reduce global electricity demand by 20 to 30%.

In 1388, in Iran, the Energy Efficiency Organization (SABA) defined a plan to upgrade the energy grade of evaporative coolers, refrigerators, freezers and refrigerator-freezers. In a part of this plan, which also included evaporative coolers, with the help of government facilities, about 200,000 coolers were upgraded in quality and energy grade over the course of three years. Then, since Esfand 1394, when the first symposium on the use of permanent magnet motors in evaporative coolers was held, Niroo Research Institute (NRI) has implemented projects such as "Codification of an operational plan to complete the production technology cycle and use of permanent magnet electromotors" and "Review of Energy consumption of Induction

motors standard codification of energy consumption of permanent magnet motors standard "and" Implementation of pilot project for production and use of permanent magnet electromotors in evaporative coolers "in order to codify a standard in this field as first step [6] and evaluate the technical knowledge of these motors in the second step.

During the above-mentioned projects, in cooperation with the Energy Efficiency Organization (SABA), three management meetings and 6 meetings of the specialized working group were held in this regard. Finally, it was decided to extract and implement a suitable operational plan to improve the condition of evaporative cooler electromotors in production, by using the previous experiences done in SABA. To evaluate the technical capability in the country, first during the meetings of the specialized working group from August to October 2016, the approved technical specifications of electromotors in three power ranges of 1.3, 1.2 and 3.4 hp, which are abundant in installed evaporative coolers, are extracted. Then, during a public-call in late November 2016, companies were invited to build these electromotors. Seven domestic companies of submitted their documents to manufacture products.

In this article a summary of the project "Implementation of a pilot project to produce and use permanent magnet motors in evaporative coolers" results in which the electromotor design, how to build them in each company and also the results of performance tests by seven participating companies have been presented.

2. The Effect of Upgrading Cooler Electromotors on the Electricity Industry

According to the statistics of the number of households and also the number of coolers based on census reports in 1375, 1385 and 1390 and calculating the household growth rate and also the growth rate of using coolers, the number of coolers is estimated about 18 million in 1397 and 30 million in 1410 (just in residential sector). Also, about 1 million coolers are produced annually, of which about 200,000 units replace used coolers. On the other hand, by considering the average 400 watts consumption of coolers and

their power distribution coefficient as well as power plant efficiency coefficients and distribution and transmission network losses, a demand of 10,000 MW is imposed on the grid during peak hours, which by using new technologies and reducing the average power consumption to 247 watts, the demand will be reduced by 3,850 MW and the electricity consumption demand will be reduced to at least 6,150 MW. In contrast, if the technology in this sector is not improved and upgraded, the demand will be equal to 16,770 MW in this sector in 1410, which requires a very significant investment. Accordingly, following up and taking the necessary actions to upgrade the technology of coolers with the aim of managing consumption, especially during peak times, is mandatory and inevitable.

2.1 Technology development procedure

Based on the documents submitted by the companies and visiting of the companies in person and the results of the tests performed there, the technical ability of the companies in designing and manufacturing the brushless motor and its drive according to the extracted technical specifications are summarized in TABLE. 1. Some companies were looking to set up a production line within the company and some of them were considering outsourcing to domestic companies [7].

TABLE. 1. Technical ability of domestic companies in designing and manufacturing brushless motors and drives

Companies activities	1	2	3	4	5	6	7
Motor design and construction	x	x	x	x	x	x	Transferring technology
Drive design and construction	x	x	x	x	x	x	x

3. Tests Results

During this project, the electromotors were tested in three ways. First, these motors were tested according to the requirements of the employer within the company and with their available facilities. Then, in the laboratory of Lorch Company in Isfahan, BLDC motors were tested by installing on the relevant coolers. Finally, to test all BLDC motors under the same conditions and with the same equipment, were also tested in the laboratory of Iran National Standard Organization (INSO).

The process of product manufacturing as well as factory tests in companies are shown in Fig.1. in addition, Fig.2 shows the test process performed in the electromotor laboratory of INSO and also the water cooler laboratory of Lorch company.



Fig. 1. Manufacturing process



Fig.2. Laboratory tests in a) INSO laboratory and b) the water cooler laboratory of Lorch company

Since 7000 cfm cooler with 3/4 hp motor are abundant in residential sector, the summary of the test results obtained for all seven companies products installed on coolers in comparison with the specifications of conventional coolers in the

TABLE. 2. Test results of 3/4 hp electromotors of different companies along with cooler test and comparison with its conventional type

No.	Companies		1	2	3	4	5	6	7	Conventional cooler
	parameters									
1	Motor type (rotor)		external	internal	internal	external	internal	internal	internal	internal
2	Dynamometric test at the INSO Laboratory at high speed	High speed (rpm)	400	2211	2200	400	1435	1500	1430	1425
3		Efficiency (%)	81.6	89.4	85.4	76.3	87.1	85.9	85.3	57.2
4		International Energy Classification	A (IE5)	A (IE5)	A (IE5)	B (IE4)	A (IE5)	A (IE5)	A (IE5)	NA (under IE0)
5		Input power (W)	696	519	683	796	644	641	540	962
6		Output power(W)	566	462	563	412	588	551	458	550
7		Input power factor	0.997	0.995	0.99	0.94	0.99	0.99	0.97	0.79
8		Drive input THD (%)	6.8	9	4.5	4.5	6.85	3.54	6.32	
9		Input Current (A)	3.18	2.36	3	4	2.87	2.9	3.44	5.5
10		Dynamometric test at the INSO Laboratory at low speed	Low speed (rpm)	270	1398	1475	270	950	1000	950
11	Efficiency (%)		80.1	87	80	76.3	84.2	82	84	44.7
12	Input power (W)		240	212	252	264	225	244	224	403
13	Output power(W)		191	183	191	191	189	201	190	180
14	Input power factor		0.99	0.994	0.98	0.99	0.99	0.99	0.98	0.63
15	Drive Input Current (A)		1.1	0.96	1.22	1.17	1.03	1	1.06	2.9
16	Drive input THD (%)		8.3	5	7	7.2	7.83	6.35	5.38	
17	test in Lorch laboratory at high speed (7000 cfm)	Air flow at Free D. pressure (m ³ / h)	8155	8096	8027	8261	8010	8256	7970	8000
18		Motor input power at Free D. pressure (W)	472	655	602	538	551	564	595	

market that have split-phase motors for 3/4 hp can be seen in TABLE.2 as an example.

For this project with aim of comparing operation of electromotors in wide range, 1/3, 1/2 and 3/4 hp motors and coolers with 3500, 5000 and 7000 cfm capacities are considered and results are summarized in the following. As the results show, in all cases the BLDC motors tested in the INSO electromotor Laboratory are categorized as the IE4 or the IE5 International Standard. Also, as can be seen, the power factor of all of them is about 1 and their efficiency has increased by about 6 to 7 energy grades compared to the conventional electromotors. The results of this project are summarized as follows:

- In 6 of the 7 participating companies, the whole process of designing and manufacturing the product was done in Iran.
- The products energy label of these companies had an upgrade of 6 to 7 grades compared to the conventional electromotors of coolers. The average efficiency is increased from 42.5 (one grade below IE0) to 80% (IE5).
- The tests were performed in three ranges: 3500, 5000 and 7000 cfm. The average consumption of designed BLDC electromotors installed in evaporative cooler, with consideration the same capacities and operating hours (the low-speed operating hours are twice the high-speed operating hours) was about 280 watts which is 510 watts in conventional coolers. Therefore, the use of high-efficiency permanent magnet motors will improve energy consumption by 45% compared to the current state.
- The products of all 7 companies have standard acoustic noise and vibration.
- The products of all 7 companies have standard harmonic pollutants.

4. Conclusion

In this paper the optimization of energy consumption in evaporative coolers by upgrading electromotors into high-efficiency electromotors (BLDC) and localizing the technology of this type of motors have been investigated. After the construction of this type of electromotors by seven companies in the country and reviewing the results of tests performed on them in reputable laboratories under the same conditions, it can be

said that these BLDC motors and drives of all seven companies meet the latest requirements in the world and their efficiency is higher than the most up-to-date MEPS rules in the world.

As well, the average optimizations at fast and slow speeds of each group of coolers are calculated based on these tests. these parameters are equal for 3500 cfm coolers 171 and 121 watts, for 5000 cfm coolers 254 and 179 watts, and for 7000 cfm coolers 316 and 166 watts, respectively. According to the explanations at the beginning of the article, this change will save 4600 MW of demands.

Based on tests and investigated results, it can be concluded that changing the type of electromotor in evaporative coolers from induction to BLDC results in saving 33 to 36 percent at fast speeds and 41 to 53 percent at slow speeds. Correspondingly, if the consideration operating time of slow speed as twice of fast speed is taken into account, the average energy saving of coolers in case of changing the technology of its electromotors will be about 45%.

5. References

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