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Article

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Energy Reports

Provided in Cooperation with:
Elsevier

Suggested Citation: Kengkamon Wiratkasem; Somchai Pattana; Korrakot Yaibuathet Tippayawong; Nakorn Tippayawong (2020) : Developing the high energy performance standards for oil-injected air-cooled screw air compressor for Thailand, Energy Reports, ISSN 2352-4847, Elsevier, Amsterdam, Vol. 6, Iss. 2, pp. 617-621, <https://doi.org/10.1016/j.egy.2019.11.128>

This Version is available at:
<https://hdl.handle.net/10419/243941>

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The 6th International Conference on Power and Energy Systems Engineering (CPESE 2019),
September 20–23, 2019, Okinawa, Japan

Developing the high energy performance standards for oil-injected air-cooled screw air compressor for Thailand

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Received 7 October 2019; accepted 23 November 2019

Abstract

The objective of this work was to develop the high energy performance standards (HEPS) for oil-injected air-cooled screw air compressors in Thailand. Based on the data from the Customs Department in 2018, it was found that Thailand imported a great number of air compressors with total value of more than 60 million USD. In this study, the energy performance of the air compressors was evaluated from standardized tests, and the energy performance data was used to analyze the energy efficiency standards using statistical principles of normal curves and standard scores. The criteria used in determining the HEPS was that about 30% of the products must have the specific power higher than the HEPS value. The HEPS value was shown in the form of equations to be able to use with all the power input. If it is promoted to adopt this HEPS, Thailand will have the potential to save energy by about 37,305,000 kWh/year.

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Peer-review under responsibility of the scientific committee of the 6th International Conference on Power and Energy Systems Engineering (CPESE 2019).

Keywords: Energy efficiency; Screw air compressor; Air-cooled oil-injected; HEPS

1. Introduction

Since 2007, Department of Alternative Energy Development and Energy Conservation (DEDE), Ministry of Energy of Thailand has investigated and developed energy efficiency standards for several industrial products sold in the country. As the results of these studies, the High Energy Performance Standard (HEPS) for 66 products of equipment, machineries and materials have been developed and adopted into the Ministerial regulations. Meanwhile, the Minimum Energy Performance (MEPS) products that had been announced by the ministerial regulations of 19 products (2018). Examples of products that have been studied and used to develop the HEPS were electric frying pan by Pattana and Wiratkasem [1], water dispenser by Wiratkasem and Pattana [2], hair dryer by Pattana et al. [3], industrial fan by Tantakitti et al. [4], motorcycle tires Wiratkasem et al. [5], etc [6].

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<https://doi.org/10.1016/j.egyr.2019.11.128>

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Air compressors are widely used in industrial sector, service sector, medical sector, etc. In 2018, based on the data from the Customs Department [7], it was found that Thailand imported air compressors with a value of more than 60 million USD. From the survey data, air-cooled oil-injected screw air compressors were the air compressor type with a large number of applications. Thailand has studied and promoted the use of high energy efficiency standards for reciprocating air compressors which power input less than 11 kW by conducted a test to find the energy efficiency according to TIS 1252-2537 [8]. In other countries, there are also energy efficiency standards that cover the large air compressors such as GB 19153-2009 of China [9]. But Thailand still does not have a standard for air-cooled oil-injected screw air compressors. If there is a promotion to use the high energy efficiency standards of the air compressor, consumers can choose to use products that are highly efficient, resulting in energy savings.

2. Methodology

Study of energy efficiency standards starting with the survey of technical data and marketing of each type of air compressor. Then select the appropriate type of air compressor to study the energy efficiency standards. After that, use the energy efficiency data of the air compressor to analyze the value of the appropriate energy efficiency standard by applying the principle of statistics. The standard values obtained from this analysis will be used to inquire opinions from importers, manufacturers and related agencies. Finally, the results were used for composing the preliminary version of Ministerial Regulation. The methodology details are described as follow.

2.1. Survey data

From the survey data, it was found that Thailand has widely used air compressors in 4 types including screw-type reciprocating-type turbo-type and other-type as shown in Fig. 1. Based on this data, it is found that the screw air compressors are the most used especially oil-injected air-cooled screw air compressors. In this study, we will draft the high energy efficiency standards of this type of air compressor.

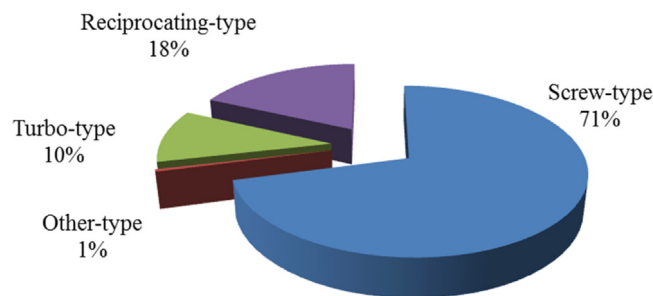


Fig. 1. Ratio of air compressor used.

2.2. Testing results

The oil-injected air-cooled screw air compressors were selected to find the energy performance. The specific power according to ISO 1217-2009 [10] have been used as energy efficiency values of air compressors. The specific power is define as Eq. (1).

$$SPC = P/q_v \quad (1)$$

where,

SPC	Specific power, kW/(m ³ /min).
P	Power input at the reference state, kW.
q_v	Air volume flow rate at the reference state, m ³ /min.

The reference state is delivery air pressure from air compressor which has a value of 0.7 MPa, 0.8 MPa, 1.0 MPa and 1.25 MPa. The number of samples used of 0.7 MPa, 0.8 MPa, 1.0 MPa and 1.25 MPa are 246, 219, 205 and 176 respectively. The specific power of each reference states are shown in Fig. 2.

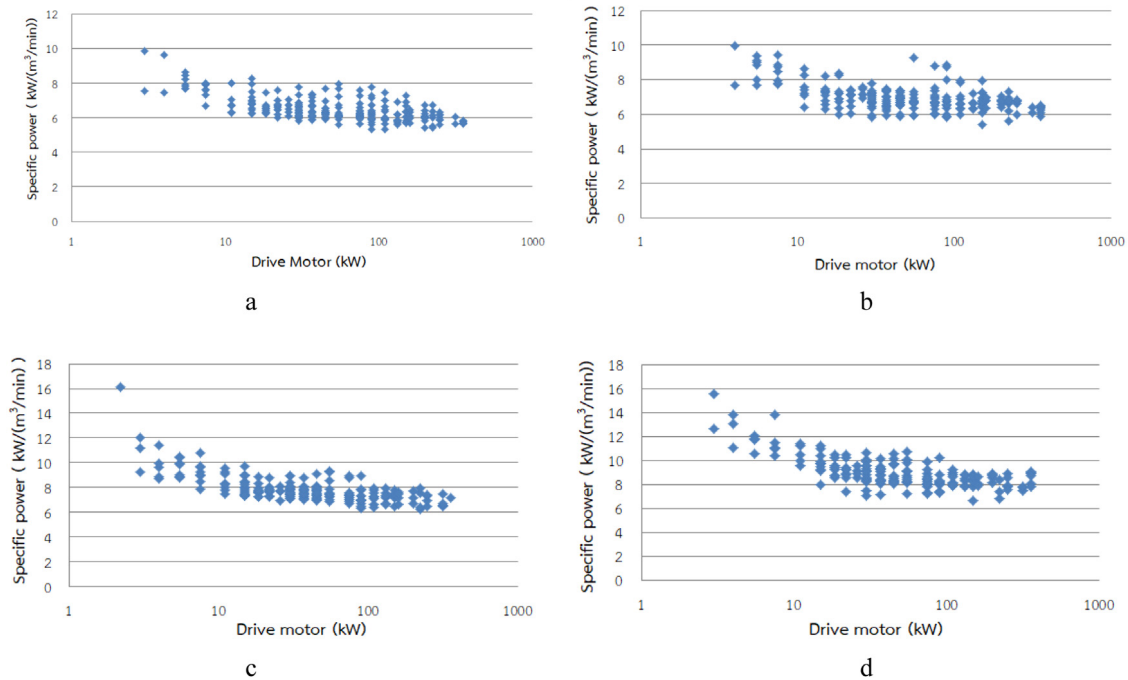


Fig. 2. Specific power vs. power input in each reference state (a) 0.7 MPa ; (b) 0.8 MPa ; (c) 1.0 MPa ; (d) 1.25 MPa.

3. Results and discussion

The high energy efficiency standards (HEPS) value was determined from the percentage of the area under the normal curve. Then using the standard score (z score) as a means to determine the HEPS. The criteria used in determining the high energy efficiency is that about 30% of products have the specific power higher than HEPS value. The HEPS value was calculated from Eq. (2).

$$HEPS = \bar{x} + z_{HEPS}\sigma \quad (2)$$

where,

<i>HEPS</i>	High energy efficiency standards
\bar{x}	The average value of specific power, kW/(m ³ /min).
σ	Standard deviation
z_{HEPS}	Score of the area under the normal curve for HEPS

The normal curves of specific power of each reference state are shown in Fig. 3.

Due to specific power depended on power input as shown in Fig. 2. In order to simplify the HEPS values to be able to be used with all the power input, therefore the HEPS values were shown in the form of equations as shown in Table 1.

Table 1. The HEPS value for each reference state.

Reference state (Air pressure, MPa)	Equation for HEPS value (kW/(m ³ /min))
0.7	$HEPS = -0.428 \ln(x)^a + 7.866$
0.8	$HEPS = -0.428 \ln(x)^a + 8.366$
1.0	$HEPS = -0.428 \ln(x)^a + 8.976$
1.25	$HEPS = -0.428 \ln(x)^a + 10.062$

^ax value is power input, (kW).

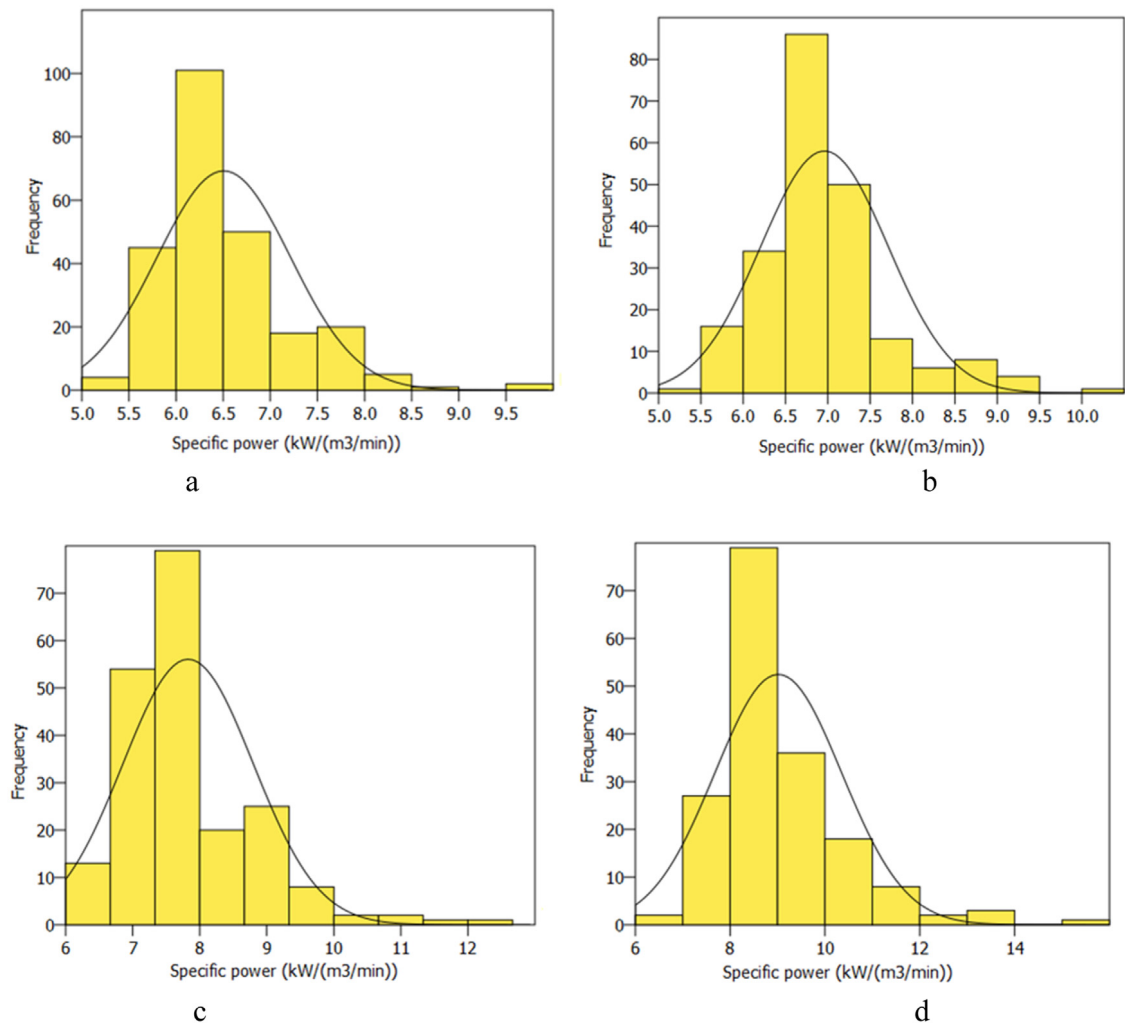


Fig. 3. The normal distribution curves of specific power in each reference state (a) 0.7 MPa ; (b) 0.8 MPa ; (c) 1.0 MPa ; (d) 1.25 MPa.

If promoting the use of high-performance air compressors will cause energy savings. The energy saving potential can be obtained from Eq. (3). and shown in Table 2.

$$\text{saving potential} = \frac{(\text{Average performance} - \text{HEPS value})}{(\text{Average performance})} \times \text{powerinput} \quad (3)$$

Table 2. The energy saving potential.

Drive motor size	Average power (kW)	Specific power (kW/m ³ /min)		Saving power (kW)	Quantity	Saving energy	
		Average	HEPs			(kWh/year)	(ktoe/year)
<37 kW	15	6.9	6.7	0.43	890	612,939	0.053
37 kW	37	6.5	6.3	1.14	3560	6,419,830	0.552
37–75 kW	55	6.4	6.2	1.72	2373	6,460,492	0.556
75 kW	75	6.2	6.0	2.42	3560	13,642,839	1.173
>75 kW	110	6.1	5.9	3.61	1780	10,168,761	0.874

4. Conclusions

The high energy efficiency standards (HEPS) values obtained from this study will be drafted into the high energy efficiency standards for oil-injected air-cooled screw air compressors. If promoted to use this energy efficiency standard, Thailand will have the potential to save energy 37,304,861 kWh/year or 3.208 ktOE/year. In order to save energy from the use of high-performance equipment, future study should be conducted to find the high energy efficiency standards of other types of equipment.

Acknowledgments

Supports from the Department of Alternative Energy Development and Energy Conservation (DEDE), Ministry of Energy of Thailand and Chiang Mai University are highly appreciated. The authors also wish to thank the CMU Department of Mechanical Engineering, and the Energy Research and Development Institute Nakorping.

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