Elaboration of Compressor Working on R134a

I. N. Krasnovsky  
*NORD Association*

E. S. Muravia  
*NORD Association*

V. P. P. Onistchenko  
*Odessa State Academy of Refrigeration*

Follow this and additional works at: https://docs.lib.purdue.edu/icec
ELABORATION OF COMPRESSOR WORKING ON R134a

I.N.Krasnovsky¹, E.S.Muravia¹, V.P.Onistchenko²

¹ "NORD" Association, Ukraine
² Thermophysical Engineering Department Odessa State Academy of Refrigeration, Petra Velikogo str. 1/3, Odessa 270100 Ukraine

Abstract

This work is devoted to modernization of serial compressor of domestic refrigerator having worked on R12, in order to work on R134a. Modernization of electric motor was happened to be the most effective. It permitted to elaborate compressor which had slightly low cold production but higher specific one, to shorten energy supply of turned out domestic refrigerators. Procedures of the studies are presented together with the results which are the tables of electric motor and compressor characteristics in common.

Nomenclature

T Temperature, K (°C)
P Power, W 
I Magnitude of current, A
U Voltage, V
η Efficiency
n Rotational speed, min⁻¹
Q Cooling capacity, W
k Specific cooling capacity, W/W
R Ohmical resistance of windings, Ohm
Index
¹ used
² effective
b main
a ancillary
s starting
sc short-circuited

Introduction

NORD association has produced domestic refrigerators of various modifications on the base of serial electric motor DAO 130-125 (125 W) which was a part of the compressor XKB 6.65-1M (6.65 cm³) working on R12. Turn to domestic refrigerators working on refrigerant R134a with lubrication oil Insematic SW22 of CASTROL demanded the modernization of the compressor. Studies when modernizing the compressor were made in two various directions:
- changing of design parameters of mechanical part of the compressor in order to possible rise of cold productivity;
- elaboration of electric motor with more high efficiency in the region of real working regimes of the compressor without changing the design of mechanical part of it.

Results of our investigations and subsequent tests showed that second way of the modernization was more effective. The main part of this work was given just to it.

Investigation methods

Compressor XKB 6.65-1M (similar to that with the USA patent N4573880, 04.03.1986) was an object of our investigations. It has a crank-link moving mechanism, start-and-defence relay with
using posistor, cold productivity of 185 W at \( T_0 = 253 \pm 0.2 \) K and \( T_k = 328 \pm 0.2 \) K when working on R12, asynchronous electric motor DAO 130-125 having the power of 125 W at the efficiency on the level 0.7-0.74. Frequency of the supplying current and one of synchronous rotating of the rotor is 50 Hertz, current voltage is 220 V. When working on R12 a lubrication oil \( \Phi - 12 \)-18 is used.

Modernization of the mechanical part of the compressor was made in several directions. There are the following among them:
- lowering the dead space;
- lowering the temperature of sucked-in vapour for the expence of its input in sucking muffler;
- lowering of thermal tension in compressor cylinder for the expence of the additional heat drain.

Due to the replacement of the R12 by R134a and replacement of the lubrication oil all thermodynamic properties of refrigerant were changed. Many working characteristics of the compressor and, first of all, compressor axle load were changed too. So the main criterion in choosing new electric motor was the correspondence (on R134a) of the axle loads and nominal power of electric motor at maximum value of its efficiency.

Computational determination of technical requests to new electric motor (nominal strengths of currents, moments of rotation and power on axle) was made by the graphico-analytical method. Compressor indicated power was calculated, then energetical losts in various rotating and rotatory-translational friction couples of the compressor were summarized, then energetic losses in the electric motor parts (in the stator and rotor) were summarized. On this base the expressions for absorbed power \( P_1 \), effective power \( P_2 \), current strength \( I \), rotation number \( n \), efficiency \( \eta \), \( \cos \phi \) of electric motor were plotted as the functions of \( M \), rotation moment on the axle. Then the range of boiling temperatures \( T_0 \) was determined relatively to the rotation moments' scale (diapason). On the base of temperature scales the values of nominal currents, rotation moments and axle powers were obtained.

Seven experimental samples of electric motor have been made having characteristics in wide vicinity of their computed values. It has been done for checking the accordance between computed demands to new electrical motor and its real (on R134a) characteristics. These motors differ by characteristics of the main and ancillary stator winding, by the rotor package length. Start-and-defence relay with posistor, working condensers of 0-7 \( \mu \)F capacity were used. Electro-mechanical investigations of these motors were made on the experimental stand, and induction moment-meter was used as a loading device. Conditions of mounting of the stator on the experimental stand were near to ones in the compressor. These tests permitted to correct the technical demands to the electric motor, and on this base five experimental samples of new electric motor were made. They have been installed in compressors which were chosen by chance from the plant conveyer. Studies of the thermoenergetical parameters of the five compressors were carried out on the experimental calorimetric stand. Cold productivity \( Q \), absorbed power \( P_e \), specific cold productivity \( K_e \), current strength \( I \), stator winding temperature \( T_w \) were determined.

These investigations were carried out at the following conditions:
- back pressure at the boiling temperatures 253 K, 243 K;
- delivery pressure at the condensation temperature 328 K;
- supercooling temperature 305 K;
- suction temperature 305 K;
- ambient temperature 305 K.
Results

All the directions of the modernization of mechanical part of the compressor have resulted in negligible effect on rising its thermoenergetical characteristics in common.

New electric motor having the working condenser capacity of 6.8 μF and shortened to 34 mm length of stator package at wire diameters of 0.63 mm in main winding and 0.40 mm in the ancillary one gave the means to reach satisfactory thermoenergetical characteristics of the compressor in common. It was discovered that obtained dependence of the electric motor efficiency on loading has horizontal part in the region of maximum efficiency in wide loading diapason. Remembering that sufficiently irregular character of loading is the way of domestic refrigerator working then the result is of no low importance. Characteristics of new electric motor in idling, starting regime, one of nominal loading are presented in Tab. 1-3.

Table 1. Characteristics of electric motors in idling

<table>
<thead>
<tr>
<th>Motor's No</th>
<th>U, V</th>
<th>I, A</th>
<th>P, W</th>
<th>( R_b ), Ohm</th>
<th>( R_s ), Ohm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>220</td>
<td>0.3</td>
<td>30</td>
<td>14.38</td>
<td>22.92</td>
</tr>
<tr>
<td>2</td>
<td>220</td>
<td>0.3</td>
<td>31</td>
<td>15.12</td>
<td>23.87</td>
</tr>
<tr>
<td>3</td>
<td>220</td>
<td>0.25</td>
<td>26</td>
<td>14.80</td>
<td>22.80</td>
</tr>
<tr>
<td>4</td>
<td>220</td>
<td>0.3</td>
<td>30</td>
<td>14.76</td>
<td>22.57</td>
</tr>
<tr>
<td>5</td>
<td>220</td>
<td>0.3</td>
<td>24</td>
<td>14.90</td>
<td>22.62</td>
</tr>
</tbody>
</table>

Table 2. Characteristics of electric motors in starting regime

<table>
<thead>
<tr>
<th>Motor's No</th>
<th>( M_s ), Nm</th>
<th>( I_s ), A</th>
<th>( P_{sc} ), W</th>
<th>( K_{ms} = M_s / M_N )</th>
<th>( K_s = I_s / I_N )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.68</td>
<td>4.1</td>
<td>840</td>
<td>2.00</td>
<td>6.1</td>
</tr>
<tr>
<td>2</td>
<td>0.72</td>
<td>4.0</td>
<td>840</td>
<td>2.12</td>
<td>5.97</td>
</tr>
<tr>
<td>3</td>
<td>0.71</td>
<td>4.1</td>
<td>840</td>
<td>2.09</td>
<td>6.21</td>
</tr>
<tr>
<td>4</td>
<td>0.69</td>
<td>4.0</td>
<td>840</td>
<td>2.00</td>
<td>6.06</td>
</tr>
<tr>
<td>5</td>
<td>0.73</td>
<td>4.0</td>
<td>860</td>
<td>2.09</td>
<td>6.06</td>
</tr>
</tbody>
</table>

Table 3. Characteristics of electric motors at nominal loading

<table>
<thead>
<tr>
<th>Motor's No</th>
<th>( P_1 ), W</th>
<th>( P_2 ), W</th>
<th>( \eta ), %</th>
<th>( I_N ), A</th>
<th>( n ), min(^{-1} )</th>
<th>( \cos \varphi )</th>
<th>( M_{max} ), Nm</th>
<th>( M_N ), Nm</th>
</tr>
</thead>
</table>
Analysis of the results presented in Tab. 1-3 shows that new electric motor has satisfactorily high efficiency and low strengths of current.

Results of electric and thermoenergetic performance tests of the obtained compressor in common are presented in Tab. 4.

Table 4. Results of electric and thermoenergetic performance tests of modernized compressor

<table>
<thead>
<tr>
<th>Compressor's No</th>
<th>Boiling temperature of refrigerant</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>- 20 °C</td>
<td></td>
<td></td>
<td>- 30 °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Q, W</td>
<td>P_e, W</td>
<td>Ke</td>
<td>I, A</td>
<td>t_w, °C</td>
<td>Q, W</td>
<td>P_e, W</td>
<td>Ke</td>
<td>I, A</td>
<td>t_w, °C</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>159.7</td>
<td>132</td>
<td>1.21</td>
<td>0.62</td>
<td>98.7</td>
<td>63.4</td>
<td>95</td>
<td>0.67</td>
<td>0.44</td>
<td>96.3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>165.1</td>
<td>139</td>
<td>1.19</td>
<td>0.65</td>
<td>101.0</td>
<td>69.9</td>
<td>102</td>
<td>0.69</td>
<td>0.48</td>
<td>98.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>165.7</td>
<td>132</td>
<td>1.26</td>
<td>0.62</td>
<td>93.8</td>
<td>71.8</td>
<td>96</td>
<td>0.75</td>
<td>0.45</td>
<td>93.8</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>170.0</td>
<td>137</td>
<td>1.24</td>
<td>0.63</td>
<td>100.0</td>
<td>63.0</td>
<td>97</td>
<td>0.67</td>
<td>0.42</td>
<td>102.4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>170.3</td>
<td>136</td>
<td>1.25</td>
<td>0.62</td>
<td>96.2</td>
<td>73.8</td>
<td>98</td>
<td>0.75</td>
<td>0.45</td>
<td>93.0</td>
<td></td>
</tr>
<tr>
<td>average</td>
<td></td>
<td>166.2</td>
<td>135.2</td>
<td>1.23</td>
<td>0.63</td>
<td>97.9</td>
<td>68.4</td>
<td>97.6</td>
<td>0.71</td>
<td>0.45</td>
<td>96.8</td>
<td></td>
</tr>
</tbody>
</table>

Generally, in comparison with serial compressor XKB 6.65-IM on R12 it was discovered that new compressor have good working characteristics:
- cold productivity was lowered by 10%;
- absorbed power was lowered by 18%;
- specific cold productivity was increased by 8%;
- temperature of stator windings was lowered by 20 K (18%)

Additionally, mass of the compressor was lowered including copper parts.

Conclusions
New modernized compressor, due to its cold productivity, was installed in the most powerful domestic refrigerators of NORD association. Good energetic characteristics of the compressor permit to lower the electricity consumption for the turned-out domestic refrigerators. Scientific and methodical aspects of this paper can be used for modernizing compressors of domestic refrigerators with another refrigerants.