2014

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ABSTRACT

In recent years, various frequency compressors are developed rapidly and successfully in household air conditioner area. However, it is difficult to make advance progress on compressor performance, noise and reliability. The innovation of structure and technique are indispensable impetus to make a breakthrough.

This paper presents a novel structure of high efficiency rotary compressor, which focuses on the connection mode between roller and vane of a compressor. On one hand, the leakage gap between roller wall and vane tip is eliminated, which upgrades the capacity of compressor. On the other hand, through changing movement type of compressor parts, the mechanical state is meliorated and frictional loss is decreased. Several analysis are studied to validate the rationality of the above amelioration, which include strength and deformation simulation, frictional loss and leakage loss calculation. By comparison with conventional compressor, the performance of the novel compressor is improved obviously. In the end, the results of reliability and durability experiments reveal that they satisfy the national standard.

1. Introduction

In recent years, rolling piston type rotary compressors have greatly been utilized for home air-conditions and refrigerators because of their special advantages relative to reciprocating compressors. However, considering the demand of energy save and security, it is important and significant to improve performance efficiency and reliability of compressors.

Based on this consideration, a high efficiency compressor with new articulated structure is introduced in this paper. Through hinge blade and roller, the frictional loss is reduced as the result of optimized mechanic status, further more, when the contact type between blade and roller is changed from line to surface, leakage between this clearance is greatly cut down. In other words, the performance and reliability are both advancing in comparison with the compressors of traditional structure.

2. Structure principles

2.1 structure comparison

The representative difference is the connection type between the two structures. The former blade and roller are connected by a hinge joint, as fig 2-1 shows; a cylinder slot is axially opened through the roller, into which insert the pin at the top of the special blade. On the other hand, the latter structure is common, that is, blade tip withstands the outer arc surface of the roller due to the force of gas pressure at the end of the blade and the blade spring. The contact type between them is line contact.

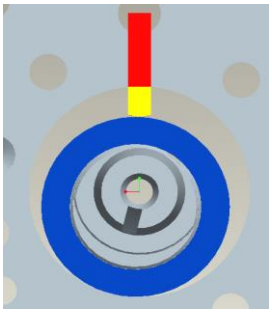

Fig 2.1-a

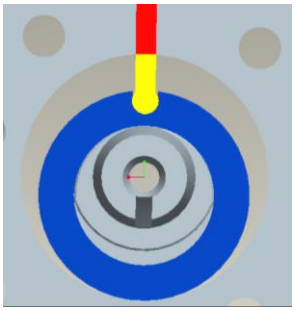

Fig 2.1-b

2.2 mechanic analysis

For the novel structure, the vane can be assumed to simply supported beam, one side of the vane has been fixed by articulate slot of the roller and the other fixed by groove of the cylinder. Meanwhile the traditional blade can be considered as a cantilever beam. As Fig 2.2 shows.

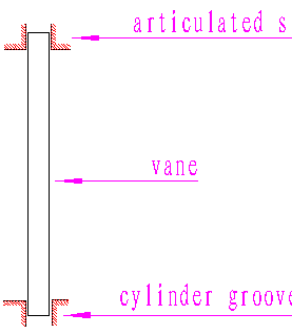

Fig 2.2-a vane simply supported beam

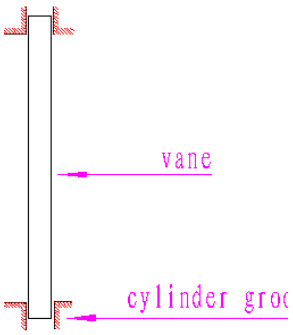

Fig 2.2-b vane cantilever beam

Through simplify the mechanic vane model, we can easily educe that the mechanical state of the novel structure vane is meliorated, and the deformation of the vane is less than the traditional one, which can be also proved by simulation calculate results. The deformation of the vane tip is only one third of the traditional one.

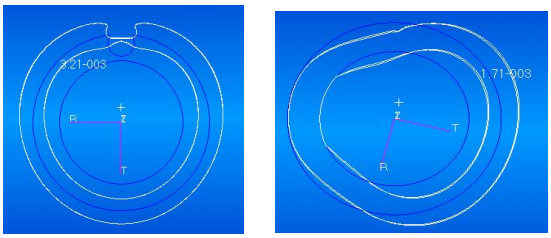

Fig 2-2-c Roller deformation contrast

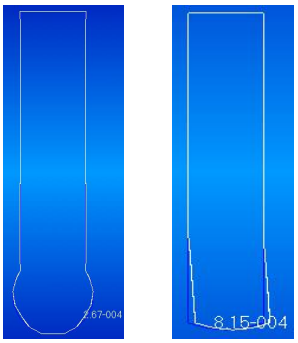

Fig 2-2-d Vane deformation contrast

3 Frictional loss and leakage loss

Various losses in a hermetic compressor have been divided into two broad categories: the energy losses and the mass flow losses, especially frictional loss and leakage loss are the most significant losses. Refrigerating capacity and Power consumption of a representative rolling compressor in standard working condition are calculated by professional calculation software. The traditional compressor and the novel structure retain the same parameters, and then both compressors performance are measured in standard working condition. Because refrigerant leakage is directly related to refrigerating capacity, we can compare the hermetic ability when evaluate refrigerating capacity of the compressors.

Table1 Refrigerating capacity and Power consumption comparison

		capacity/W	Power/W
simulation		2985.2	731.9
measurement	Traditional	2883	734.9
	Novel	2960	746.3

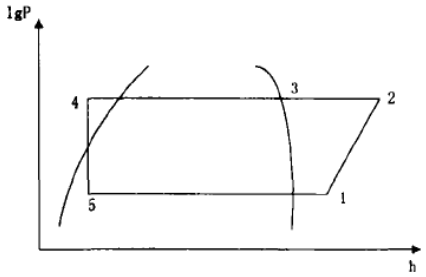

Fig 3.1 the cycle principle of P-h

Table 1 show that refrigerating capacity is 2.35% higher and save more power consumption. The formal is due to surface contact of the articulated structure, which eliminates the refrigerant leakage between blade tip and roller. On the other hand, as section 2.2 analyzed mechanics statuses of blade side face and blade tip are improved, articulated structure can reduce frictional loss, which is demonstrated by experiment result, as table 1, power consumption decreases by 1.55%.

The novel structure decreases the leak between the vane and roller, which is equal to improve mass flow of compressors. As fig 3-1shows, in a cycle, refrigerating capacity of unit mass and compress power maintain the same value, so the refrigerating capacity of compressor and compress power are increased due to the novel structure.

4 Performances and reliability

Compressor performance and reliability are two most important evaluation targets, we test the compressors performance of the new structure and traditional ones for comparison, as is shown in table 3. The comparison results reveal that, because of less leakage of the novel compressors, the capacity increases for about 400 watts in light condition, 500 watts in standard condition and 700 watts in heavy condition. On the other hand, due to the frictional loss, the power decreases for about 100~150 watts in the three different conditions,. To sum up, the novel structure compressor has a comprehensive better performance than traditional compressors, especially in heavy condition, performance advantage is more distinct.

Table 2 Performance comparison of novel and traditional compressors

	Light			standard			heavy		
Condition	Capacity	Power	COP	Capacity	Power	COP	Capacity	Power	COP
Traditional	4801.8	1177.3	4.079	4346.3	1265.5	3.434	2681.5	1506.2	1.780
Novel-1	5223.1	1062.5	4.916	4894.3	1140.6	4.291	3452.0	1367.6	2.526
Novel-2	5167.5	1064.6	4.854	4850.5	1137.7	4.263	3369.0	1355.5	2.485
Novel-3	5139.9	1061.3	4.843	4783.6	1133.7	4.216	3324.1	1354.9	2.453

Compressor reliability is related to safety and using life when operating compressors. We have tested the novel compressors for 1000 hours in heavy conditions. After the test, the performance is re-tested. We consider that the compressors meet the reliability demand if twice performance tests data are in the tolerance of 3%.

Table 3 Performance contrast before and after reliability tests

	condition	light	standard	heavy	light	standard	heavy
1#	capacity	4916.2	4552.1	3194.4	4842	4512.1	3119.8
	power	1133.2	1202.1	1454	1131.6	1200	1447.8

	COP	4.338	3.787	2.197	4.279	3.76	2.155
	Q-change	1	1	1	-1.50%	-0.90%	-2.30%
	P-change	1	1	1	-0.20%	-0.20%	-0.40%
	COP-change	1	1	1	-1.40%	-0.70%	-1.90%
2#	condition	light	standard	heavy	light	standard	heavy
	capacity	5069.1	4694.6	3341.2	5090.4	4728.3	3419.2
	power	1127.3	1196.6	1446.3	1129.6	1204.2	1454.1
	COP	4.497	3.923	2.31	4.507	3.927	2.351
	Q-change	1	1	1	0.42%	0.72%	2.33%
	P-change	1	1	1	0.20%	0.64%	0.54%
	COP-change	1	1	1	0.22%	0.10%	1.77%
3#	condition	light	standard	heavy	light	standard	heavy
	capacity	4928.5	4531.9	3180.2	4878.3	4520	3111.5
	power	1143.1	1217.2	1474.6	1137.5	1211	1469.7
	COP	4.312	3.723	2.157	4.289	3.733	2.117
	Q- change	1	1	1	-1.02%	-0.26%	-2.16%
	P- change	1	1	1	-0.49%	-0.51%	0.33%
	COP-change	1	1	1	-0.53%	0.27%	-1.85%

From the figure above, we can make the conclusion that the novel structure compressors meet the reliability demand.

5 Conclusions

The novel structure compressors have advantages in contrast with traditional compressors in many aspects. From above analysis and comparison, we can get some useful conclusion.
(1) The leakage gap between roller wall and vane tip of the novel structure compressor is eliminated, compressor capacity is increased;
(2) The mechanical state of the novel structure is meliorated and frictional loss is decreased
(3) The novel structure compressor has a comprehensive better performance than traditional compressors, especially in heavy condition, performance advantage is more distinct.
(4) The novel structure compressors meet the reliability demand.

6 Application Prospecting

Because of unique advantages of the novel structure, it is probably widely used in the area of high pressure compressors. The highest working pressure in carbon dioxide compressor is above 100 bars, so it is rigorous for leakage and parts strength demand. Traditional structure compressor cannot meet the demand, the novel structure maybe solve these problems.
The machining technics of the novel structure seems to be immature; especially the rigorous precision control of dimension is very difficult. Generally speaking, we will take further research about the novel structure about the application prospecting and machining technics.

7 References

[1] Guoyuan Ma, Hongqi Li ‘Rotary Compressor’ [M]. Beijing: Mechanic Industry Publishing Company. 2001.