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A Comparative Study of the Reed Valve Assembly to Optimize Compressor Performance

T. J. Fedorka
The Campbell Group

L. A. Newberg
De-Sta-Co

A COMPARATIVE STUDY OF THE REED VALVE ASSEMBLY TO OPTIMIZE COMPRESSOR PERFORMANCE

Thomas J. Fedorka, P. E.

Senior Development Engineer
The Campbell Group
Harrison, OH U. S. A.

Livingston A. Newberg

Product Manager
De-Sta-Co
Troy, MI U. S. A.

INTRODUCTION

The valve, backer and port are usually treated individually in design and through production. This limits the overall assembly performance due to the individual part restrictions. The interrelationships of the three can be optimized to improve performance in the dynamic operation of the air compressor. Consequently, this comparative study of the discharge valve assembly will show a few key ways the valve, backer and port can be changed to improve the performance of the compressor.

OBJECTIVE

The object of the comparative testing is to establish the theory that the combination of a curved dynamic backer and a peripheral flow port will improve the compressor's performance. This combination will also justify the reduction of valve thickness which will improve the compressor's dynamic response. The compressor's performance will be evaluated by monitoring the amp draw at known pressure loads. This will indicate the compressor's energy improvement using the new valve assembly compared to the old assembly.

TEST SAMPLES

In the assembly, the rectangular valve and backer parts are attached to the valve plate at one end and will operate in the cantilever mode. The valve and backer thicknesses, the backer form, and the port design were changed for each test, the rest of the compressor components remained the same. These design changes will be tested to evaluate the compressor's performance in stages. It should be noted that the dynamic curved backer and the valve are made from flapper valve steel and the valve plate is made from die cast 380 Aluminum (see Exhibit A).

TEST SEQUENCE

The three factors, valve thickness, backer thickness, and port shape, were each assigned two levels and arranged in the test matrix shown in Exhibit B. The run order was randomized and replicated to reduce biasing the data. The input voltage was maintained at a constant level while amp draw, compressor speed and free air delivery data were recorded at various pressure loads. The data was analyzed using graphical techniques and *Technicomp's TARGET-DOE* software to identify which factors affect compressor performance the most. Pressure versus volume curves were also plotted to investigate valve efficiency.

COMPARATIVE TESTS

Chart #1 compares the fixed stop with the dynamic backer using the same round port. The curved backer allowed the valve to open before it dynamically responded with the valve at the tangent point at the base of the port. The dynamic backer proved to be more energy efficient when a thinner valve and backer were used (see curve #8).

Chart #2 compares the round and teardrop ports using the same valve and dynamic backer thickness combinations. The teardrop shaped port proved to be more energy efficient than the round port at all loads. This established the theory that a peripheral flow port reduced the dynamic backer loft height and reduced the energy required to meet the dynamic loads.

Chart #3 compares the baseline fixed stop and round port with the dynamic backer, teardrop port, and thinner valves. The combination of the three changes proved to increase the response and efficiency at all pressure loads. Test #7 met the objective of optimizing the compressor performance.

CONCLUSIONS

You can optimize the operating characteristics of an air compressor by evaluating a dynamic curved backer, a peripheral type port and a thinner valve for the discharge valve assembly. Similar results could be expected by modifying the suction valve assembly; however, this will not be covered at this time. Of course, additional testing is required for each unique compressor design. This comparison proves the value of optimizing the valve assembly.

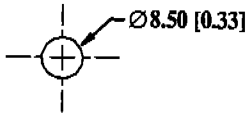
REFERENCES

1. Reineking F. C., United States Patent # 939,549, "Reed Air-Intake Regulator For Carburetors", Nov 9, 1909.

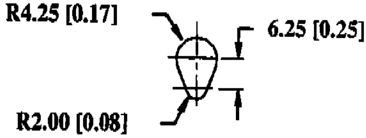
2. Sodel W., Ph.D., "Design and Mechanics of Compressor Valves" Short Course Text Book of Purdue Technical Conference, Ray Herrick Laboratories, Purdue University, 1984.

EXHIBIT A

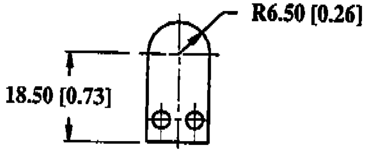
ROUND PORT



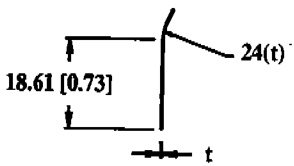
TEARDROP PORT



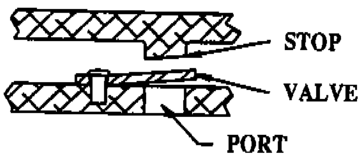
VALVE DIMENSIONS



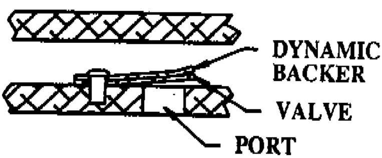
SIDE VIEW OF FLEXIBLE BACKER



OLD (CURRENT) ASSEMBLY SKETCH



NEW (TEST) ASSEMBLY SKETCH



ALL DIMENSIONS ARE IN MILLIMETERS.
DIMENSIONS IN [ ] ARE INCHES.

EXHIBIT B

TEST DATA

TEST NUMBER	CANTILEVER VALVE THICKNESS	DYNAMIC BACKER THICKNESS	PORT SHAPE
A (STD)	.305 [.012]	RIGID STOP	ROUND
1	.305 [.012]	.305 [.012]	TEARDROP
2	.305 [.012]	.305 [.012]	ROUND
3	.305 [.012]	.152 [.006]	TEARDROP
4	.305 [.012]	.152 [.006]	ROUND
5	.152 [.006]	.305 [.012]	TEARDROP
6	.152 [.006]	.305 [.012]	ROUND
7	.152 [.006]	.152 [.006]	TEARDROP
8	.152 [.006]	.152 [.006]	ROUND

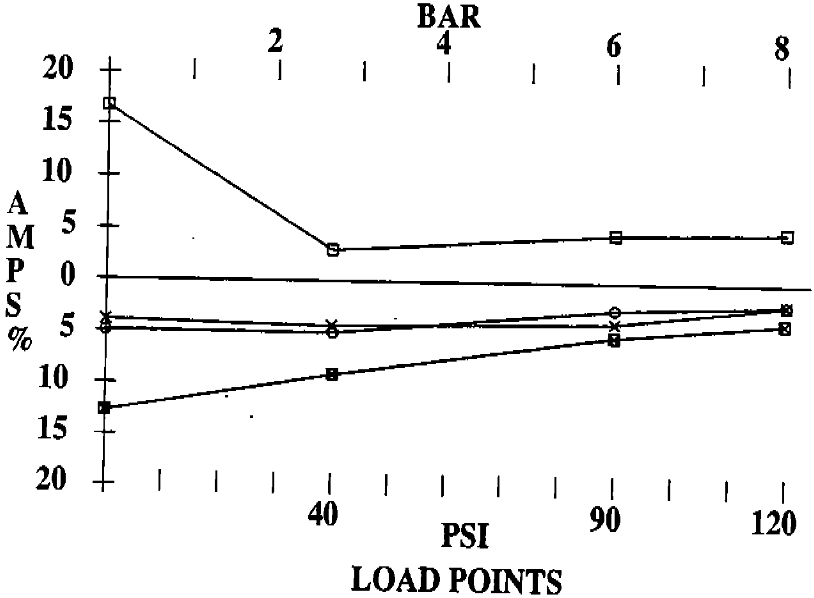
MEASURED DATA AT LOAD POINTS

- COMPRESSOR FREE AIR FLOW
- COMPRESSOR SPEED
- MOTOR AMP DRAW
- P-V CURVES
- INPUT VOLTAGE

ALL DIMENSIONS ARE IN MILLIMETERS.
DIMENSIONS IN [ ] ARE INCHES.

CHART #1

ENERGY IMPROVEMENT OF FIXED STOP vs. DYNAMIC BACKER



$$\text{AMPS\%} = \left(\frac{\text{STD - TEST}}{\text{TEST}} \right) 100\%$$

☒ = TEST #2

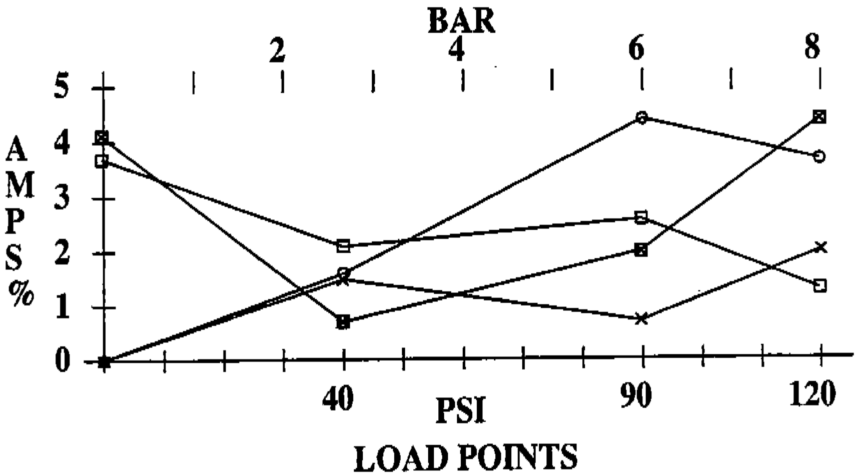
○ = TEST #4

× = TEST #6

☐ = TEST #8

CHART #2

ENERGY IMPROVEMENT
OF TEARDROP PORT
vs. ROUND PORT



$$\text{AMPS \%} = \left(\frac{\text{ROUND - TEARDROP}}{\text{TEARDROP}}\right) 100\%$$

□ = TEST #1 vs. TEST #2

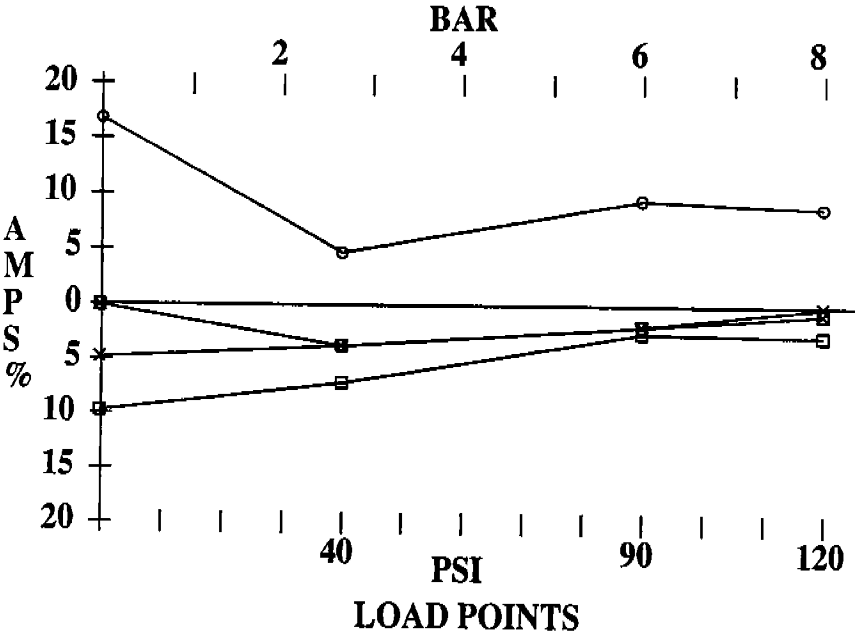
× = TEST #3 vs. TEST #4

⊠ = TEST #5 vs. TEST #6

○ = TEST #7 vs. TEST #8

CHART #3

**ENERGY IMPROVEMENT
OF OPTIMIZED VALVE ASSEMBLY
vs. ORIGINAL VALVE ASSEMBLY**



$$AMPS\% = \left(\frac{STD - TEST}{TEST} \right) 100\%$$

□ = TEST #1

× = TEST #3

⊠ = TEST #5

○ = TEST #7