September 25 – 28, 2008 Xi'an, China

ICCR 2008

Proceedings of the 6th International Conference on Compressor and Refrigeration

Edited by
Xueyuan Peng Yuanyang Zhao Huagen Wu

Sponsored by
Xi'an Jiaotong University

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Chinese Association of Refrigeration
China Refrigeration and Air-Conditioning Industry Association
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PREFACE

The 6th International Conference on Compressor and Refrigeration (ICCR) is a series of conference, originating from the International Compressor Technique Conference (ICTC), which started in 1993. This conference becomes an important academic conference in the field of compressor and refrigeration, offering attendees an opportunity to discuss the current technique, information and products. Its field includes positive displacement and centrifugal compressors for refrigerants, air, and other gases, together with their system analysis, modeling, control and operation.

The goals of the conference are:

- to present the research results in compressors and refrigeration,
- to review the state-of-the-art of compressor and refrigeration development and application,
- to educate engineers starting in the compressor and refrigeration field, and
- to provide an easily accessible reference for compressor and refrigeration engineers.

About over 60 quality academic papers are involved in the conference proceedings.

I would like to thank the members of the organization and academic committee, all authors, and all industrial organizations that have given such generous assistance in many ways.

We highly appreciate International Institute of Refrigeration (IIR/IIF), Chinese Association of Refrigeration (CAR), China Refrigeration &Air-Conditioning Industry Association (CRAA) and National Natural Science Foundation of China (NSFC) for their cooperation.

Prof. Liansheng Li

Liansheng Li

Conference Chairperson
August, 2008

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PART1 COMPRESSORS

PART2 REFRIGERATION AND OTHERS

PART1 COMPRESSORS

Geometry of Screw Compressor Rotors and Their Tools

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Abstract: *Screw compressor is a common type of machine used to compress gases. It consists of a pair of meshing rotors with helical grooves machined in them contained in a casing, which fits closely round them. The rotors and casing are separated by very small clearances. The rotors mesh like gears in such a manner that as they rotate the space formed between them and the casing is reduced progressively. Thus any gas trapped in this space is compressed.*

Although the principles of operation of helical screw compressors have been well known for more than 120 years, it is only during the past 40 years that they have become widely used. The main reasons for that were their poor efficiency and the high cost of manufacturing their rotors. Two main developments led to a solution to these difficulties. The first was the introduction of the asymmetric rotor profile approximately 35 years ago which substantially reduced the blow-hole area, which was the main source of internal leakage, and thereby raised the thermodynamic efficiency of these machines to roughly the same level as that of traditional reciprocating compressors. The second was the introduction of precise thread milling machine tools at approximately the same time which made it possible to manufacture accurately and economically items of complex shape, such as the rotors.

From then on, as a result of their ever improving efficiencies, high reliability and compact form, screw compressors have taken an increasing share of the compressor market, especially in the fields of compressed air production, and refrigeration and air conditioning, and today, a good proportion of compressors manufactured for industry are of this type.

This paper presents a method of general geometrical definition of screw machine rotors and its manufacturing tools. It describes the details of lobe shape specification and focuses on a new lobe profile which yields a larger cross-sectional area and shorter sealing lines resulting in higher delivery rates for the same tip speed. A well proven mathematical model was used to determine its optimum profile, size and the volume ratio and compressor ports to achieve the superior compressors.

Keywords: *Geometry of screw compressors; Rotor lobe profile; Cutting tools*

NOTATION

A	Area of passage cross section surface	**Subscripts**	
C	Rotor centre distance	w	pitch circle
p	Rotor lead	1	main rotor
r	Rotor radius	2	gate rotor
t	Rotor parameter		
x, y, z	Rotor coordinates		
θ	Rotor angle of rotation		
ω	Angular speed of rotation		
Σ	Shaft angle		

1. INTRODUCTION

Screw compressors are reliable and compact machines and, as pointed out by Fleming, Tang and Cook, 1998, represent a success story of the 20th century. The main reasons for that are the developments of novel rotor profiles, which have drastically reduced internal leakage, and advanced machine tools, which can, according to Holmes, 1999, manufacture the most complex shapes to tolerances of 3 micrometers at an acceptable cost.

Rotor profile enhancement is still the most promising means of further improving screw compressors and rational procedures are now being developed both to replace earlier empirically derived shapes and also to vary the proportions of the selected profile to obtain the best result for the application for which the compressor is required.

A screw machine volume is defined by the rotor profile and port shape and size. The gearing algorithm used for the rotor profiling demonstrates the meshing condition which enables a variety of rotor primary curves to be defined either analytically or by discrete points. The most efficient contemporary profiles were obtained from a combined rotor-rack generation procedure.

Screw compressor consists essentially of a pair of meshing helical lobed rotors, which rotate within a fixed casing that totally encloses them, as shown in Fig. 1. The space between any two successive lobes of each rotor and its surrounding casing forms a separate working chamber. The volume of this chamber varies as rotation proceeds due to displacement of the line of contact between the two rotors. It is a maximum when the entire length between the lobes is unobstructed by meshing contact with the other rotor. It has a minimum value of zero when there is full meshing contact with the second rotor at the end face. The two meshing rotors effectively form a pair of helical gear wheels with their lobes acting as teeth. These are normally described as the male or main rotor and the female or gate rotor respectively.

As shown in Fig. 1(a), gas enters through the suction, or low pressure port presented in light shade. It thus fills the spaces between the lobes, starting from the ends corresponding to A and C. As may be seen, the trapped volume in each chamber increases as rotation proceeds and the contact line between the rotors recedes. At the point where the maximum volume is filled, the inlet port terminates and rotation proceeds without any further fluid admission in the region corresponding to the dark shaded area.

Viewed from Fig. 1(b), it may be seen that the dark shaded area begins, from the end corresponding to A and C, at the point where the male and female rotor lobes start to re-engage. Thus, from that position, further rotation reduces the volume of gas trapped between the lobes and the casing. This causes the pressure to rise. At the position where the trapped volume is