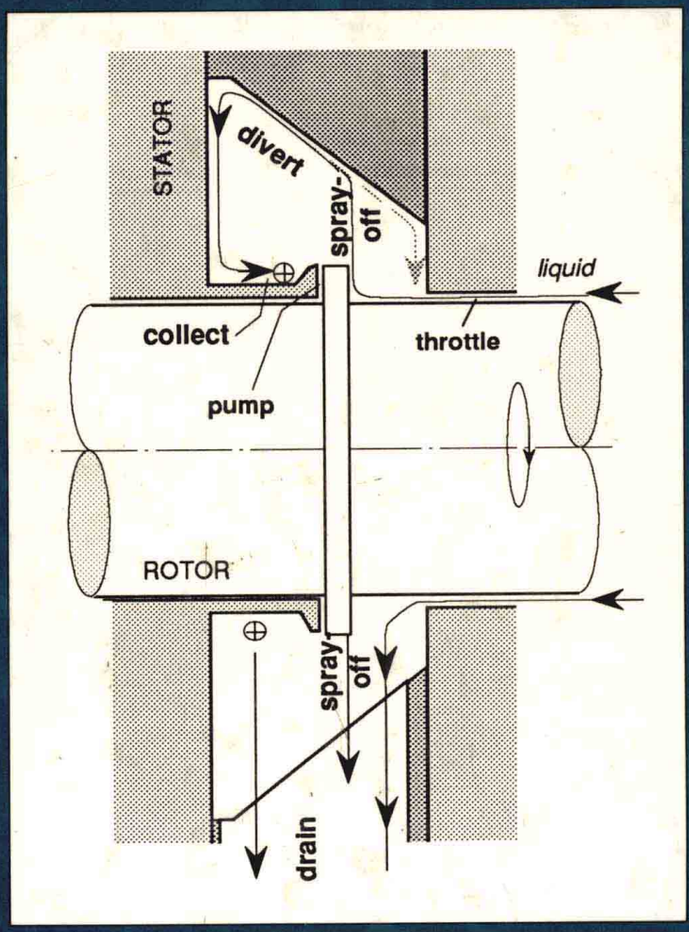
FLUID MECHANICS AND ITS APPLICATIONS

Dr. B. S. Nau
editor

Fluid Sealing



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FLUID SEALING

FLUID MECHANICS AND ITS APPLICATIONS
Volume 8

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Aims and Scope of the Series

The purpose of this series is to focus on subjects in which fluid mechanics plays a fundamental role.

As well as the more traditional applications of aeronautics, hydraulics, heat and mass transfer etc., books will be published dealing with topics which are currently in a state of rapid development, such as turbulence, suspensions and multiphase fluids, super and hypersonic flows and numerical modelling techniques.

It is a widely held view that it is the interdisciplinary subjects that will receive intense scientific attention, bringing them to the fore[illegible]vance-ment. Fluids have the ability to transport matter[illegible]ll as transmit force, therefore fluid mechanics is a subject that is particulary open to cross fertilisation with other sciences and disciplines of e[illegible]ginee[illegible]g. T[illegible]subject of fluid mechanics will be highly relevant in domains such as chemical, metallurgical, biological and ecological engineering. This series is particularly open to such new multidisciplinary domains.

The median level of presentation is the first year graduate student. Some texts are monographs defining the current state of a field; others are accessible to final year undergraduates; but essentially the emphasis is on readability and clarity.

For a list of related mechanics titles, see final pages.

ACKNOWLEDGEMENTS

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FOREWORD

With this 13th in the series of International Conferences on Fluid Sealing these meetings move into their third decade. To be precise it is now thirty-one years since BHRA, as it then was, convened, with no little trepidation, the first of these Conferences in Ashford, England. The massive set of proceedings now occupies a considerable length of shelf in my bookcase and represents a tremendous technological resource - over 400 separate papers. It is interesting that I seem to refer most often to the earlier volumes, probably most of all to the very first. Perhaps this is because this volume marks the beginning of "historic times", AD 0, for fluid sealing technology. There were of course important publications in this field even before 1961. A notable example is the seminal work of my predecessor at BHRA, Dr D.F.Denny, whose researches on reciprocating fluid power seals, "The sealing mechanism of flexible packings", was published in 1947 by a long since defunct government department, the Ministry of Supply. Another notable source is the Proceedings of the Institution of Mechanical Engineers' 1957 Conference on Lubrication and Wear. However, there is more to fluid sealing technology than just tribology, as we must now call lubrication and wear, interest in static seals has really come to the fore in recent years - witness the large batch of papers dealing with this subject in the present Conference. Much of our developing understanding of this branch of fluid sealing technology, a trivial design problem to the uninitiated, has largely resulted from the results of research carried out on a co-operative basis by users, suppliers and research organisations in groups variously centered in North America, continental Europe and the UK. Such collaborative projects are a cost effective way of advancing technology, sharing the cost to achieve a desirable common goal. Here at BHR Group Ltd (formerly BHRA) the Fluid Sealing Technology Group has such collaborative activities in such diverse areas as mechanical seals, fluid power seals, elastomer seal life prediction and, not least, high-duty bolted joints. These grew out of partly government funded projects for UK Companies but have long since extended to encompass pan-European and global projects. This broad geographical scope is also reflected by the authorship of the papers printed in this volume, who come from very diverse regions of the world,but united by a common interest in fluid sealing technology and a common desire to play a part in making industry more efficient and the earth a better place to live.

Dr Bernard Nau, Cranfield, January 1992

13th International Conference on
FLUID SEALING
Brugge, Belgium : 7-9 April 1992

FLUID POWER

VALVE EMISSIONS AND CLEARANCE SEALS

SEALS - MACHINE ELEMENTS OF INCREASING IMPORTANCE

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ABSTRACT

With the advent of the Industrial Revolution, moving machinery, containment of pressure, separation of fluids and many other conditions which require what we collectively call sealing, arose. Seals that were used in those days are the forefathers of the many types of modern seals that comprise one of the most frequently used machine elements.

The evolution of seals and their development in the future reflects the technology of the day and consequently the needs of society. Societies are undergoing rapid changes. The population growth is coupled to the high growth of information and communication systems, leading to an explosion of knowledge. The consequence of this is the speeding up of the rate of technological breakthroughs but also more sophisticated and demanding customers and end users.

When the above is coupled to the intense competition in today's markets, it follows that products (and, by implication, their components such as seals) are required to have higher reliability in order that they fulfil the "trouble-free operation" demands of the end user. At the same time, because of the strong competition, there is an increasing demand for "downsizing", that is, scaling down of machinery or increasing the power throughput for the same size. These two requirements of reliability and downsizing apply to seals as components but also provide a clue to the increasing use of seals as a protective element to obtain the best performance out of machinery. A notable example is the sealing of rolling element bearings where the exclusion of particulate contamination

can increase the life of the bearing by two orders of magnitude. In recent years there has been a strong increase in the demand for sealed-for-life bearings and some 70% of the smaller size deep groove ball bearings are produced in this manner. Moreover, the protection of our fragile environment is today of global concern. In many cases it is therefore necessary to provide the reverse protection, that is, protect the environment from fluids used in machinery and various installations. This is another reason for increasing demands for effective sealing.

Finally, the market competition requires faster product development. This in turn calls for effective research activities. This is particularly true for seals as in many cases even the basic tribological mechanisms that govern the performance of seals are not well understood. It is therefore important to continue exchanging valuable information on the results of research in conferences like the present one, and to maintain the progress in a difficult but promising field.

LIP SEALS

UNDERSTANDING THE SEALING MECHANISM OF THE RADIAL LIP SEAL FOR ROTATING SHAFTS

DR. LESLIE A. HORVE

INTRODUCTION

The elastomeric radial lip seal has been used throughout industry for many years to retain lubricants and exclude contaminants in rotating shaft applications. (Figure 1)

The sealing concept appears to be simple. The flexing of the elastomeric lip and the spring as they are installed over the shaft generates a force between the lip and the shaft that acts as a dam to keep fluid in and contaminants out of the sump. In actual practice, the sealing mechanism is not understood even though elastomeric lip seals have been used since the 1940's. This lack of understanding leads to trial and error in seal design, material compounding, and processing. The net result can be seals that leak instantly for no apparent reason. A different seal design and material may have sporadic performance with early leakers combined with long-lived seals. Trial and error can also result in a seal design and material that will function smoothly until the ultimate wear out mode is reached when the material loses its flexibility and can no longer follow the dynamics of the shaft. Garter springs are often used to add additional force which compensates for the load and flexibility loss that occurs when rubber materials are exposed to hot oil for extended periods of time. The many variables of lip design, material compounding, manufacturing processes and application conditions combine to make a complete understanding of the sealing mechanism a difficult task. Fortunately, many researchers have been studying the phenomena since the mid 1950's and progress has been accelerating recently.

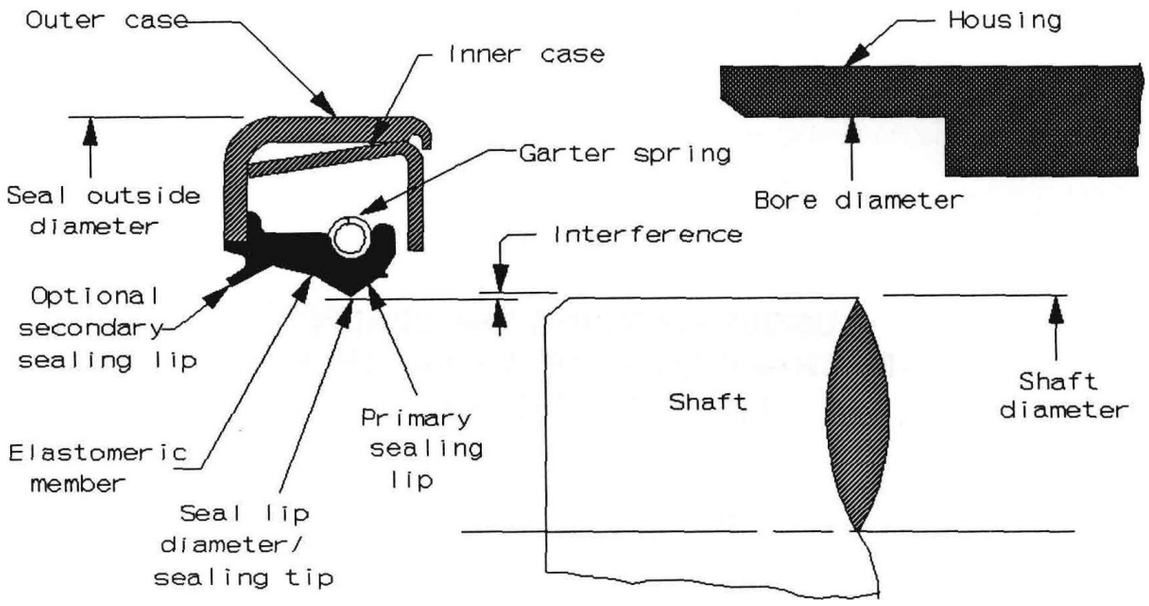

Figure 1. Typical Radial Lip Seal

COMPLEXITIES OF DEFINING THE SEALING MECHANISM

The sealing mechanism is that process that allows a lubricating film to exist between the seal lip and the rotating shaft without allowing leakage. This process is not completely understood even though researchers have been studying the problem for over 35 years. It is a fascinating research subject because many disciplines of engineering and science must be considered and there are many variables that may affect the sealing mechanism.

The field of mechanics is used to model the seal lip and predict the beam and stretch forces generated when the seal lip is placed on the shaft. Fluid dynamics is required to predict the flow of lubricant near and under the seal lip as the shaft rotates. Elastohydrodynamic theories must be employed to explain the formation and character of the thin lubricating film that exists between the shaft and the seal lip. The properties of the elastomer used to form the seal lip must be measured and studied to explain how the lip follows the dynamics of the eccentric, vibrating and rotating shaft. Both seal macrogeometry and the microgeometry found in the shaft and seal lip wear tracks must be considered when defining the sealing mechanism. The seal lip and shaft wear mechanism must also be studied. All of these complex phenomena must be considered and interfaced when formulating a model to understand the sealing mechanism.

COLLECTING CLUES

Many researchers have studied the radial lip seal and formulated theories to explain the sealing mechanism. Not all of these researchers have agreed because the problem is so complex and dynamic measurements to verify theories are difficult to make in the minute area between the seal lip and the shaft. There are observations and clues from the literature and experience that will simplify the problem and help focus research.

MACROSCOPIC EFFECTS AND OBSERVATIONS

(a) Properly functioning seals will transfer or pump oil from the airside into the sump even if there is no oil in the sump [13].

(b) Changes in seal lip length, seal lip thickness and lip to shaft interference do not significantly affect the sealing mechanism.

(c) The oil side angle must be larger than the air side angle. Reversing these angles or installing the seal backwards causes the seal to leak profusely [1], [2]. (Figure 2)

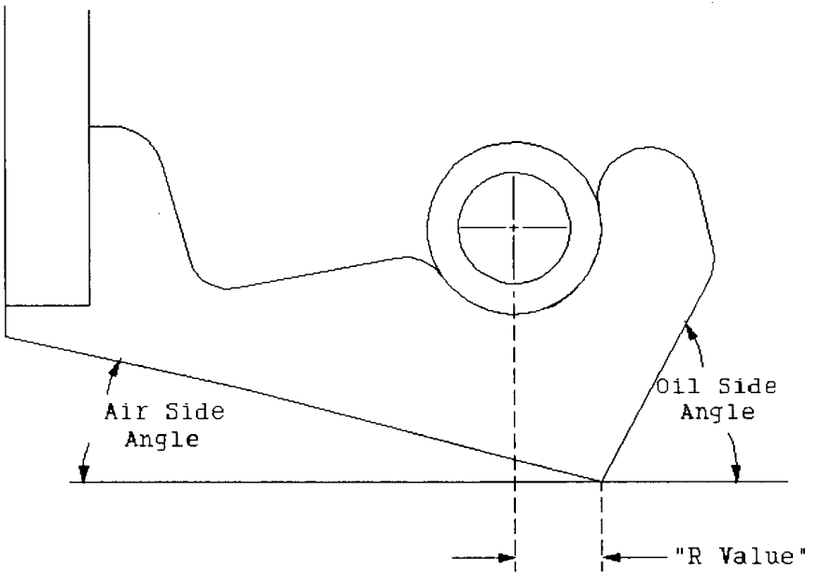

Figure 2. Seal macrogeometry affects the sealing mechanism