Publications / *Technical Articles*

Why does the world need a new bearing company?

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Back in 2002 when Donald Bently closed a chapter of his life with the sale of Bently Nevada Corporation assets to General Electric, few people believed he would open a new one with Bently Pressurized Bearing Company. As the global sales and marketing manager, I often get asked the question "Why a new bearing company?"

The global bearing market is large by any measure. Estimates put the total value of yearly bearing sales at around 40 billion USD per year. Worldwide, there are over 200 companies competing for this market with every type of product from simple and cheap rolling element bearings to complex and expensive magnetic bearings. To be successful in a competitive marketplace a company needs to offer something better. What can the Bently Pressurized Bearing Company offer better than anyone else can?

Load carrying capacity

Most of the bearing applications in industry today use rolling element bearings. A much smaller number of applications use fluid film bearings. In rolling element bearings, the load is carried on a very small contact surface (typically a ball or a cylinder). In contrast, the fluid bearing spreads the load out over a large contact surface. It is not unusual to see fluid bearings that have an L to D (length to diameter) ratio of one or greater. Fluid bearings are often used to carry large loads that would otherwise damage rolling element bearings. Fluid bearings are commonly found on high speed, high load applications such as large industrial gas or steam turbines for power generation.

Traditional fluid bearings, most of which operate at low pressure, are not suitable for low speed applications. At low speed, the internal lubricant pressure created by the rotation of the journal in the bearing clearance is not high enough to support large loads. The Bently pressurized bearing operates at low speed like a hydrostatic (externally pressurized) bearing. In a hydrostatic bearing, the load is carried on a film of pressurized oil supplied from an external source such as a pump or static head. Therefore, what the Bently pressurized bearing can do very well is support high load at low speed. This is something that rolling element bearings and low pressure fluid bearings are not very good at.

High Speed Stability

So far, we have seen that the Bently pressurized bearing has an advantage for low speed, high load applications. What about operation at high speed? Compared to rolling element bearings, fluid film bearings are almost always superior for high speed applications. Fluid film bearings are used in high speed machinery applications because they offer lower mechanical losses (lower friction) and better heat removal than roller bearings.

However, fluid bearings can suffer from fluid induced instability at high speed. Fluid induced instability is a condition that is caused by rotor interaction with the surrounding fluid. It can produce large amplitude, usually sub-synchronous, self-excited vibration capable of damaging many machine components.

Stability in a fluid bearing system is controlled by dynamic stiffness. Dynamic stiffness is the term that determines the response of the rotating system to static or dynamic forces. We can see from the following equation that when the dynamic stiffness approaches zero, the response of a system to force becomes very large.

The dynamic stiffness of a fluid bearing system depends on many variables; the rotating speed, vibration frequency, mass, damping, direct stiffness, and

$$\overrightarrow{\text{Vibration}} = \frac{\overrightarrow{\text{Force}}}{\overrightarrow{\text{Dynamic Stiffness}}}$$

circumferential fluid velocity (lambda). The Bently pressurized bearing allows the bearing designer to control both the direct stiffness and the circumferential fluid velocity. Control of these two critical bearing parameters allows the design of a bearing that will be stable over the range of expected operating conditions.

We understand that the pressurized bearing is more stable than competing technologies, but how do we communicate this to others? Root locus analysis (see newsletter article) is how. Root locus is a powerful technique because it shows graphically how close a rotating system is to instability. Graphs or families of graphs can be plotted to show how stable a system is with changing operating conditions or design parameters.

Shifting Paradigms

A paradigm is a set of assumptions or rules. Paradigms provide the framework for problem solving. In the world of rotating machinery we can say that the current paradigm is biased toward rolling element and low pressure fluid bearings. Since paradigms are problem solving tools, we must assume that the current bearing technologies have been successful in solving most machine design problems. Human nature will resist change if current technology has a history of successful problem solving.

This makes the job of introducing the pressurized bearing (the paradigm shift) difficult. In order to sell the paradigm shift, we need to demonstrate to our customers that we have the ability to solve problems that the current paradigms can not. We have seen that the pressurized bearing can solve at least two problems that other bearing technologies can not do well. The pressurized bearing can carry high load at low speed and be designed for high speed stability. The more machinery problems the pressurized bearing can solve, the closer it will become to replacing old bearing paradigms.

Why a new bearing company? Because there are still many machinery problems that need to be solved. Bently Pressurized Bearing Company, with its long history of machinery diagnostics and understanding of fundamental rotordynamics is uniquely positioned to offer something new and better to the marketplace: A 21 st century approach to bearing design that is focused on solving problems not being addressed by 20^{th} century bearing technology.

> *Fluid bearing technology has been around for a long time (more than 100 years). It was demonstrated in the 1878 Paris Industrial Exposition that a heavy statue could be "floated" on a thin film of pressurized oil. The pressure was supplied by columns of oil inside the legs of the statue. The externally pressurized bearing was born! Around the same time, a gentleman named Beauchamp Tower did some experiments with an oil lubricated bearing around a rotating shaft. He discovered that the oil in the bearing clearance supported the load of the shaft by developing an internal pressure. This was the genesis of the internally pressurized bearing. Today, the internally pressurized bearing is commonly known as a hydrodynamic bearing and the externally pressurized bearings is known as a hydrostatic bearing. Over the next century, the hydrodynamic bearing was popularized for*

turbomachinery applications and the hydrostatic bearing was all but forgotten except for a few special applications. We can trace the premature demise of the hydrostatic bearing to a few early technical papers that predicted that the hydrostatic bearing would be unstable if operated at high speed.