An Expert System for the Design and Selection of Ball Bearing Parameters

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Abstract
Artificial Intelligence (AI) is an emerging technology. Research in AI is focused on developing computational approaches to intelligent behavior. The computer programs with which AI could be associated are primarily symbolic processes associated with complexity, ambiguity, indecisiveness, and uncertainty. One of these computer programs is referred to as Knowledge-based Expert System as it represents knowledge acquired from various experts in a particular field of interest to the user. The expert system emulates human behavior in solving problems thought to require experts for their solution by utilizing computer programs that incorporate experts’ heuristic reasoning. In this paper, the application of Knowledge-based Expert System to aid the design of ball and roller bearings is discussed. The precision rolling-element bearings of twentieth century is a product of exacting technology and sophisticated science. A bearing supports radial and axial loads, at the same time allowing relative motion between two elements of a machine. Various requirements and steps in the design of ball and roller bearings are discussed. Equations are developed for the relevant design parameters and input into the expert system shell called VP-Expert. The expert system rules are also provided.

Introduction
Artificial intelligence (AI) has been applied to engineering problems, speech recognition and image analysis problems, medical consultation systems etc. Expert systems are considered a sub-group of AI. An expert system (ES) is a computer program that achieves high levels of performance on problems that normally require years of special education and training for human beings to solve. Expert systems use AI, problem-solving, decision-making and knowledge-representation techniques to combine human expert knowledge of a problem and methods of conceptualizing and reasoning about that problem.

An expert system consists of three components, the knowledge-base, the inference engine and the knowledge-acquisition shell. A knowledge-base represents facts
and heuristic knowledge in the form of rules in the IF-THEN format. The inference engine concludes on a goal or data based on the knowledge described in the rules and a method of reasoning. There are two methods in practice today, namely, forward chaining and backward chaining. Forward chaining involves reasoning from data to goal while backward chaining finds data to conclude on a goal. As the name implies the knowledge-acquisition shell acquires the pertinent knowledge for the problem at hand from the user. In this paper a rule based expert system shell is utilized to demonstrate expert system application in the field of design of ball and roller bearings.

**Ball & Roller Bearings**

The purpose of a bearing is to support a load while permitting relative motion between two elements of a machine. The term rolling contact bearing refers to the wide variety of bearings that use spherical balls or some type of roller between the stationary and the moving elements. Eschmann [1] has given a complete treatise on the design of ball and roller bearings. Mott [2] discussed the general concepts in the design and applications of roller bearings. Matsumori [3] discussed the application of CBN abrasives in advanced ball bearing manufacture. Ashburn [4] provided a rare look at the manufacture of roller bearings at a bearing plant.

The most common type of bearing supports a rotating shaft, resisting purely radial loads or a combination of radial and axial loads. The essential parts of a ball bearing are inner and outer ring, the balls, and the separator. The inner ring is mounted on a shaft and has a groove in which the balls ride. The outer ring is usually the stationary part of the bearing and also contains a groove to guide and support the balls. The separator prevents the contact between the balls and thus reduces friction, wear and noise from the regions where sliding conditions would occur. There are three types of ball bearings, one that support only radial loads, only thrust loads, and a combination of both loads. Here only those bearings are considered that support radial loads.

The design of a bearing requires consideration of the following, 1.) Characteristics of the bearing load, 2.) Relative motion between the bearing elements, 3.) Geometry of the bearing surfaces, 4.) Physical and chemical properties of the lubricant and bearing metals. The requirements that a bearing must satisfy are, 1.) Factor of safety, which depends on the bearing application, 2.) Bearing life, reliability and ambient conditions, 3.) Bearing precision, 4.) Power consumed in the bearing, 5.) Bearing installation and maintenance cost.