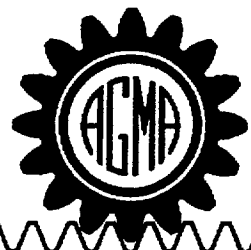


Initial Design of Gears Using Artificial Neural Net

by: T. Jeong and T. P. Kicher, Case Western Reserve;
and R. J. Zab, Joy Technology

American Gear Manufacturers Association



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[The Statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

ABSTRACT:

Most mechanical engineering design problems require both the computational and decision making aspects. Those decision making tasks can be performed by an artificial neural net. The adaptability of the artificial neural net for initial gear design was demonstrated and the detailed application is explained throughout the paper.

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INITIAL DESIGN OF GEARS USING ARTIFICIAL NEURAL NET

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INTRODUCTION

Many CAD (Computer Aided Design) systems have been developed and implemented to produce a superior quality design and to increase the design productivity in the gear industry. In general, it is true that a major portion of design task can be performed by CAD systems currently available. However, they can only address the computational aspects of gear design that typically requires decision making as well. In most industrial gear design practices, the initial design is the critical task that significantly effects the final results. However, the decisions of estimating or changing gear size parameters must be made by a gear design expert.

To move one step forward, two new system developing techniques have been investigated. One is the artificial neural net and the other is the expert system known as artificial intelligence. The former is well suited for estimating initial gear size while the latter is the choice for changing parameters. The adaptability of artificial neural net for the initial gear design is demonstrated in this paper, which is a part of the Intelligent GearCAD system under developing that emulates the entire gear design procedure including the decision making tasks.

INITIAL GEAR DESIGN

In figure 1, a model of the mechanical design procedure is illustrated. Similar models have been used to

develop mechanical engineering CAD and expert systems [10][11]. This simplified design model is adaptable to most mechanical element designs including gear design. A specific model representative of gear design which corresponds to figure 1 is shown in figure 2.

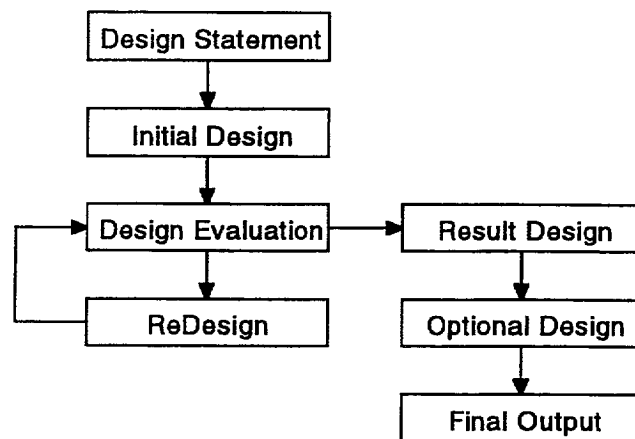


Figure 1. Simplified Mechanical Design Stages

The first stage of designing a gear set is estimating the necessary gear size parameters based on user specified requirements. Once these parameters are selected, gear and tool geometries will be calculated and evaluated by the AGMA (American Gear Manufacturers Association) power rating standard [8]. If the power

rating result is unsatisfactory, the result will be analyzed and the necessary parameters will be changed. The second and the third stages will be repeated in an iterative manner until the AGMA power rating is satisfied. The final stage is designing a gear blank, which is customarily done after a successful power rating is achieved.

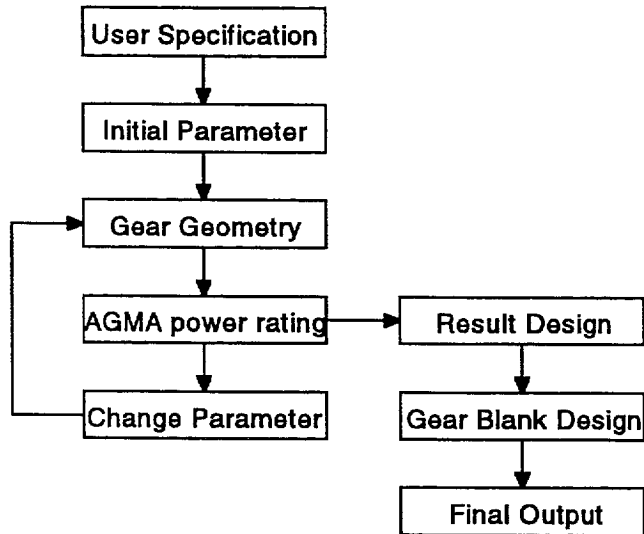


Figure 2. Modeled Gear Design Stages

In practice, engineers go through the initial design stage only once during the entire design procedure. The number of iterations carried out to complete the gear design depends upon how well the gear size parameters are estimated in the initial design stage. Consequently, an efficient gear design can only be achieved by properly estimating the initial gear size parameters.

The parameters required to be estimated for the initial design stage consist of the center distance, diametral pitch, pinion teeth number and gear teeth number, or alternately the total number of teeth. These four parameters are the essential parameters among the many parameters of gear design that are necessary to carry out the AGMA power rating procedures. Equation (1) illustrates how these four parameters are related to each other while assuming the helix angle is zero.

$$DP = \frac{N_T}{2 CD} \quad (1.a)$$

$$N_T = N_P + N_G \quad (1.b)$$

where, DP Diametral Pitch
 CD Center Distance
 N_G Gear Teeth Number

N_P Pinion Teeth Number
 N_T Total Teeth Number

The determination of one parameter in expression (1.a) is dependent on the two other parameters. Therefore, at least two parameters must be estimated by the engineer. There may be many combinations of solutions which satisfy the equation (1) for a single example. Finding a superior solution among a myriad of possibilities depends upon the ability of an engineer. Proper initial parameter estimations usually requires years of experience as well as an organized knowledge of the field. In most cases, the accumulated design data through the history of a company is also an essential factor. This type of design task is known as decision making. Figure 3 shows the factors involved in a gear engineer's decision making.

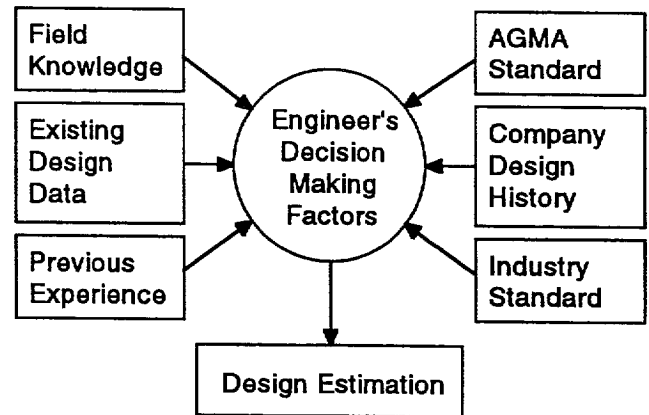


Figure 3. Engineer's Decision Making Factors

TWO STEPS OF INITIAL GEAR DESIGN

The initial gear design stage consists of two steps. First, an engineer refers to a standard product catalog to identify the proper model. The selection is based on the user's specifications which include horsepower, speed ratio, and input RPM. At this step, the center distance is obtained with the proper selection of model size. Next, the number of pinion and gear teeth will be estimated by a trial and error method. The ratio of estimated number of pinion and gear teeth must not exceed the pre-determined percentage of error over the required speed ratio. The diametral pitch can then be calculated using these estimated values. This procedure is only one example of a number of initial gear design methods used in the industry. The method shown here was obtained from an engineer actively working in the