AMERICAN GEAR MANUFACTURERS ASSOCIATION

A Rational Procedure for the Preliminary Design of Minimum Volume Gears

AGMA INFORMATION SHEET

(This Information Sheet is NOT an AGMA Standard)

AGMA 901–A92, A Rational Procedure for the Preliminary Design of Minimum Volume Gears

ABSTRACT:

A simple, closed–form procedure is presented as a first step in the design of minimum volume spur and helical gearsets. The procedure includes methods for selecting geometry and dimensions, considering maximum pitting resistance, bending strength, and scuffing resistance. It also includes methods for selecting profile shift.

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FOREWORD

[The foreword, footnotes, and annexes are provided for informational purposes only and should not be construed as a part of AGMA 901–A92, *A Rational Procedure for the Preliminary Design of Minimum Volume Gears.*]

Gear design is a process of synthesis where gear geometry, materials, heat treatment, manufacturing methods, and lubrication are selected to meet the performance requirements of a given application. The designer must design the gearset with adequate pitting resistance, bending strength, and scuffing resistance to transmit the required power for the design life. With the algorithm presented here, one can select materials and heat treatment within the economic constraints and limitations of manufacturing facilities, and select the gear geometry to satisfy constraints on weight, size and configuration. The gear designer can minimize noise level and operating temperature by minimizing the pitchline velocity and sliding velocity. This is done by specifying high gear accuracy and selecting material strengths consistent with maximum material hardness, to obtain minimum volume gearsets with teeth no larger than necessary to balance the pitting resistance and bending strength.

Gear design is not the same as gear analysis. Existing gearsets can only be analyzed, not designed. While design is more challenging than analysis, current textbooks do not provide procedures for designing minimum volume gears. They usually recommend that the number of teeth in the pinion be chosen based solely on avoiding undercut. This information sheet, based on the work of R. Errichello [1]*, will show why this practice, or any procedure which arbitrarily selects the number of pinion teeth, will not necessarily result in minimum volume gearsets. Although there have been many technical papers on gear design (for example [2] and [3]), most advocate using computer–based search algorithms which are unnecessary. Tucker [4] came the closest to an efficient algorithm, but he did not show how to find the preferred number of teeth for the pinion.

This information sheet includes the design of spur and helical gears. Other gear types could be designed by a similar algorithm with some slight modifications to the one presented here.

AGMA 901–A92 was approved by the Helical Gear Rating Committee in March, 1992 and approved by the AGMA Board of Directors as of May, 1992.

Suggestions for the improvement of this information sheet will be welcome. They should be sent to the American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, Virginia, 22314.

* Numbers in brackets [ ] refer to the list of references in annex E.

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A Rational Procedure for the Preliminary Design of Minimum Volume Gears

1 Scope

This information sheet is intended for the student or beginning gear designer, to provide an outline of a preliminary design procedure which will lead to a rational design for spur and helical gear pairs within constraints such as:

- required gear ratio;
- required torque capacity;
- specified center distance;
- material selection.

This method could be extended to other gear types given the appropriate constants and factors.

1.1 Procedure

The simple closed form of the procedure allows the designer to explore options with a minimum of computation so that the important design decisions regarding loads, overloads, material, and tooling selections are not obscured by the need to spend a long time calculating each possibility.

This information sheet will demonstrate to the user that the traditional beginning point for gear design, selecting the minimum number of pinion teeth to avoid undercut, will rarely lead to the best design.

As this procedure is approximate, it is necessary to audit the design (see clause 6).

1.2 Exceptions

The procedure described herein incorporates major design considerations and leads toward minimum volume gear designs based upon the criteria chosen. For the final gear design, additional influencing factors beyond those in this information sheet include shaft deflection limits, sound level, cost, etc. Any of these could influence the design of the gear envelope and final volume.

It is not the intent of this information sheet to include the calculation of the profile shift coefficient (addendum modification coefficient). It is, however, necessary to inform the reader that profile shift exists, how it can affect gear design, and where it comes into play in designing a gearset. Some of the important factors relating to profile shift are discussed in 7.4.

Overhung pinions or gears are not covered by this information sheet because of the difficulty in determining an accurate value for the load distribution factor.

2 Definitions and symbols

2.1 Definitions

The terms used, wherever applicable, conform to the following standards:

ANSI Y10.3–1968, *Letter Symbols for Quantities Used in Mechanics of Solids*

ANSI/AGMA 1012–F90, *Gear Nomenclature, Definitions of Terms with Symbols*

AGMA 904–B89, *Metric Usage*

2.2 Symbols

The symbols used in this information sheet are shown in table 1.

NOTE – The symbols, definitions and terminology used in this information sheet may differ from other AGMA publications. The user should not assume that familiar symbols can be used without a careful study of these definitions.

3 Input variables

This clause discusses the significant parameters relating to a preferred gear design. It is not intended to be all inclusive, but to be limited by the scope of this information sheet.

3.1 Materials and heat treatment

Many materials have been used in gearing, but the most common today is steel. This information sheet only applies to steel gearing. There are two commonly used types of heat treatment for steel gear materials, surface hardening and through hardening. The choice of steel alloy must be compatible with the chosen heat treatment process.