ANALYSIS OF SPUR GEAR GEOMETRY AND STRENGTH WITH KISSSOFT SOFTWARE

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Abstract- Transmission is usually very complex with a lot of gear pairs, shafts and bearings in it. Modern transmissions have also several functionalities like shifting without clutch, 4WD/2WD, forward and reverse shuttle and Power take off units. They must work smoothly and quietly like an automotive transmission, but usually working conditions are much more severe. They must also be reliable in different kind of working conditions and fields of applications. Because of the great variety of gears and speeds selectable, calculations for safety factors and component lifetimes becomes usually very complex, time consuming and challenging to manage. This paper describes the parameters to be considered while designing gear pair in KISSsoft software. KISSsoft provides calculation for different toothing types, ranging from cylindrical gears in different configurations

Keywords- KISSsoft software, Gear pairs

Introduction

All vehicles require transmissions in order to convert torque and engine speed. The most powerful engine in the world is of little use unless the power from the engine can be safely and effectively transmitted to the ground. In addition to being able to transmit the torque and power from the engine, the transmission and driveline also must allow the vehicle to operate over a wide range of speeds-from a standstill to the maximum speed of the vehicle. This implies that the system must inherently have some method of disconnecting the engine from the remainder of the driveline to allow the vehicle to remain stationary. The transmission must be designed to satisfy the conflicting requirements of quick acceleration, high speed, and adequate fuel economy. Transmissions are distinguished in accordance with their function and purpose Gears are the most common means of transmitting power in the modern mechanical engineering world. Spur gear are the most common type of gear used for transmitting power between two parallel shafts. Spur gear have their own advantages like they have high power transmission efficiency, have constant velocity ratio, highly reliable and easy to install so it is necessary to check spur gear geometry and strength.

2. The KISSsoft input parameters and analysis of gearbox elements

KISSsoft is a software package for calculating machine elements. While gears are a natural focal point, owed to their central role in transmission, the software also covers shafts, bearings, connecting elements, springs, belts and others. Gears calculations cover all common gear types: cylindrical gears, bevel gears, worm gears, helical gears, hypoid gears and face gears, for cylindrical gears also as planetary sets and gear racks. In addition to the strength analysis according to the respective standards (ISO, AGMA, DIN), the program also offers a number of different design and optimization functions and methods exceeding the standards. And of course all important geometry calculations are carried out, control measures for the manufacturing are provided and the tooth shape is represented in two and three dimensions. Using current standards as its basis, KISSsoft serves as an easy and safe tool for verifying the strength of cylindrical gears and offers a number of different methods. The software calculates resistance to pitting, scoring and breakage at the root of a gear tooth, and, if given a minimum safety factor, can also determine transmittable power and achievable service life. Geometry calculations provide all relevant dimensions and test measures based on applicable standards and under full consideration of relevant tolerances. The pre-sizing feature provides a series of suggestions for gear pairs aimed at solving a transmission problem. On the one hand, this step provides reasonable ranges for the module, centre distance, face width and number of teeth; on the other hand, the concrete solution also serves as a starting point for further optimization work. For cylindrical gears the fine sizing feature, which combs through entire ranges of parameters and validates solutions based on a variety of criteria, offers a powerful tool to find the optimal solution. CAD interfaces allow the user to represent a gear in two-dimensional format as a DXF or IGES file.

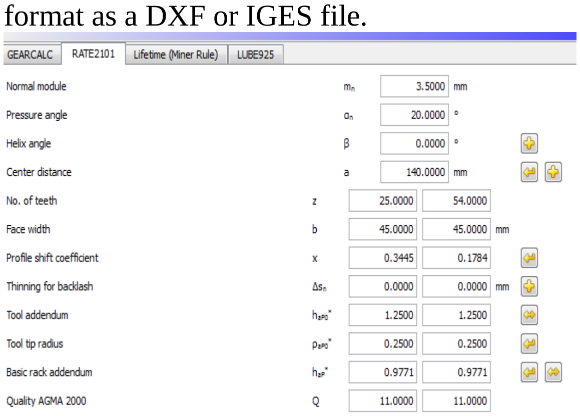

Fig.1. Basic data input window for cylindrical gear pair

The Basic data input window is one of the standard tabs and is subdivided into the two groups Geometry, Material and Lubrication.

a. Normal module

The normal module defines the size of the teeth. A standard series is for example defined in DIN 780 or ISO 54. However pitch is known, the transverse module or the diametral pitch instead of the normal module, click the button to open a dialog window in which the conversion will be performed and to transfer the diametral pitch instead of the normal module, select Input normal diametral pitch instead of normal module by selecting Calculation > Settings > General.

b. Pressure angle at normal section

The normal pressure angle at the reference circle is also the flank angle of the reference profile. For standard toothing the pressure angle is $\alpha_n = 20^\circ$. Smaller pressure angles can be used for larger numbers of teeth to achieve higher contact ratios and insensitivity to changes in centre distance. Larger pressure angles increase the strength and allow a smaller number of teeth to be used without undercut. In this situation, the contact ratio decreases and the radial forces increase.

c. Centre distance

As stated in ISO 21771, the axis center distance for external and internal gears is positive for two external gears and positive for an external gear paired with an internal gear. For internal teeth, the number of teeth on the internal gear and the axis center distance are always negative. If checkbox to the right of the axis center distance unit is selected, the value used in the calculation will remain constant. Otherwise, the axis center distance will be calculated from the profile shift total.

d. Number of teeth

The number of teeth is, by default, a whole number. For internal toothed gears, you must enter the number of teeth as a negative value as stated in ISO 21771. For a pinion-ring internal gear pair, the center distance must also be entered as a negative value The minimum number of teeth is limited by geometric errors such as undercut or tooth thickness at the tip. For spur gears without profile shift there is for example undercut if there are fewer than 17 teeth

e. Face width

Normally the face width shouldn't be greater than 10 to 20 times the normal module, or also not greater than the reference circle of the pinion. The contact pattern deteriorates if the face width is too great. The common width is used to calculate the pressure. A certain amount of overhang is taken into account for the Tooth root strength. The selected pinion width is often somewhat greater than the gear width.

f. Geometry details

To open the Define geometry details window, click the Details button in the upper right-hand part of the Geometry area.

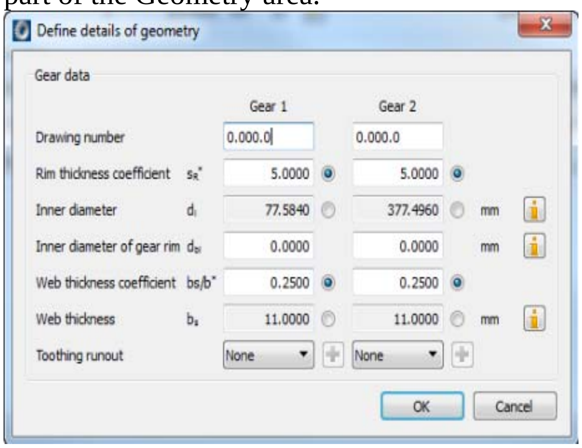

Fig.2. Geometry details for cylindrical gear pair

Values like Drawing number, Rim thickness coefficient , Inside diameter, Inside diameter of rim, Web thickness coefficient , Web thickness can be changed. The drawing number is only used for documentation purposes. The inside diameter is needed to calculate the mass moment of inertia. In accordance with ISO or AGMA, the gear rim thickness, defined by the inside diameter of rim, affects the strength. If no gear rim thickness is present, enter a value of 0. In this case the gear rim thickness will be determined.

g. Service life

Enter the required service life directly in the input field. Based upon the minimum safety value for the tooth root and flank strength, this process calculates the service life (in hours) for every specified gear and for every load. The service life is calculated in accordance with ISO 6336-6:2006 using the Palmgren-Miner Rule. The system service life and the minimum service life of all the gears used in the configuration is displayed.

h. Application factor

The application factor compensates for any uncertainties in loads and impacts. When deciding which application factor should be selected, you must take into account the required safety values, assumed loads and application factor in one context..

3. Calculation method

In the drop-down list, various calculation methods can be selected as follows :

a. Geometry calculation only

If the Rating module is not selected in the Calculation menu, only the geometry is calculated.

b. Static calculation

In a static calculation, the nominal stress is usually compared with the permitted material parameters like yield point and/or tensile strength. This runs a static calculation of cylindrical gears in KISSsoft where the nominal stress in the tooth root which is calculated by tooth form factor YF and compared with the yield point and tensile strength. Each coefficient such as application factor, face load factor, transverse coefficient, dynamic factor is set to 1.0. The load at the tooth root is calculated in accordance with ISO 6336 method B with the tooth form and the helix angle without the stress correction factor.

c. AGMA 2001-C95

This edition of the AGMA 2001-C95 American national calculation guideline replaces AGMA 2001-B88. However, the new edition does include the service factor calculation. The standard is implemented in its complete form and the dynamic factor and the face load factor are calculated in accordance with AGMA recommendations. The geometry factors (for tooth root and flank) are calculated entirely in accordance with ANSI/AGMA 908-B89.In addition to all the relevant intermediate results, the following values are also supplied: Pitting Resistance Power Rating, Contact Load Factor, Bending Strength Power Rating, Unit Load for Bending Strength, Service Factor. This calculation can also be used for every other cylindrical gear configuration including planetary stages. However, it is remarkable that AGMA Standards do not permit the direct calculation of tooth root strength in internal gear pairs. In this case the calculation must be performed using the graphical method

4. Theoretical Safety Factors

As with every gear, a validation of the strength is given as safety factors for pitting and root strength. In order to evaluate these factors, it is important to know the minimal required values. This is a general problem associated with machine construction. Minimum safety values can be very different, and should be determined most of all on the basis of experience and proven results from a test rig. In cases where nothing similar is known, the following values can be used as a starting point:

Minimum root safety factor : 1.4

Minimum flank safety factor : 1.0

These factors are impressively low. The gear used was a ground face gear of very high precision. The face load co-efficient chosen in this case was set much too high. A validation through ISO 10300 with these factor gives a flank safety factor of 1.0, and root safety factor of 0.80. The flank safety factor corresponds roughly to expectation, but the root safety is so low that a break in the root can be expected.

4. Conclusion

The spur gears are simplest tooth elements offering maximum precision so recommended for all the gear meshes, except where very high speeds and loads or special features of other types, such as right angle drive. The availability of software for sizing spur gears and their associated tooling, it is now possible to efficiently overcome special calculation and manufacturing problems associated with tooth forms of this type in arriving at a practical, alternative solution. In this paper we have gone through pre-processor phase, where along with pre processing the geometry of the structure, the constraints, loads and mechanical properties of the gear pairs are defined. This paper describes about how spur gear pair is modeled in KISSsoft calculation software which is useful for final design of transmission.

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