GERJESZTŐ HATÁSOK HENGERES FERDE FOGÚ FOGASKERÉK KAPCSOLÓDÁSBAN

EXCITER EFFECTS IN CYLINDRIC HELICAL GEAR MESHING

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ABSTRACT
Automotive industry needs more and more quiet and vibration free drive systems. Cylindric helical gear pairs are suited to complete such claims of a power train, if the sources of vibration excitation can be reduced. The source of the vibration excitation is the contacting field, whose shape and dimension besides the characteristics depending on the direction of rotation can be influenced effectively. This article presents eventuality that reducing of vibration exciting in meshing is how can be forwarded by contacting field modification and tooth shape symmetry ending, and how can it be achieved.

1. INTRODUCTION

Function of energetic systems which have toothed element pairs, without intermediary elements decreases several cases in the past decades. These systems however couldn't loose its importance. One reason is the correct, and continually more correct, transmission of energy components (load and motion). Those dynamic systems, among the power trains in automotive industry, which contain gear contact, have to meet increasingly difficult expectations. Expectations can be traced back to vibration and acoustic effects. Drive systems take an important role in the function of systems (products), it can be expected to be unrecognizable, unidentifiable. A household appliance has to assimilate itself to that acoustic environment where it is used. It mustn't be loud, mustn't cause unhealthy vibration. These expectations be valid for other applications, e.g. underwater vehicles should not be recognised. This article presents some problems, which originate from meshing of cylindric external toothed helical gear pairs (see later CEH).

2. INFLUENTIAL PARAMETERS IN MESHING

Meshing problems of gear pairs, within CEH, have always appeared in different form during the technical development [1, 2]. It is caused by:

- qualitative improvement of the material properties, reliability of its documentation,
- increasing improvement of the tooth surface structure mapping,
- improvement of design operations' accuracy, appearing of alternative calculation methods,
- appearing of environmental influence,
- possibility of hiding some applications

Assignment of design is to solve and eliminate raised problems. Designer can effect on three tasks:

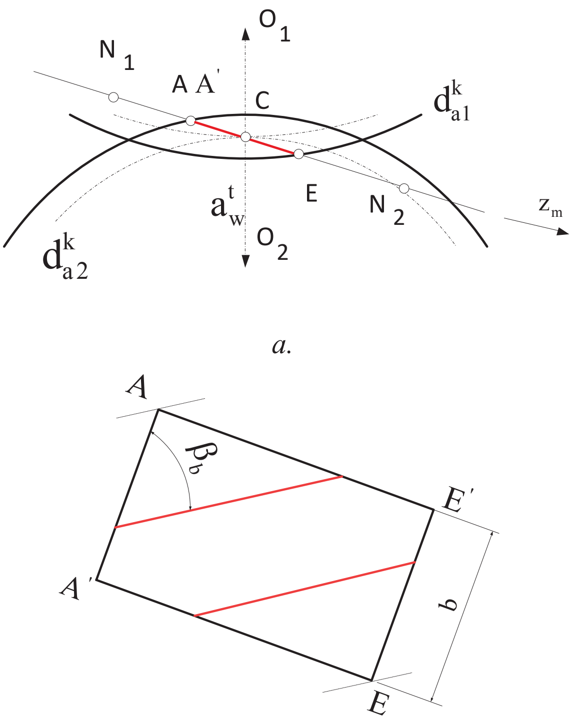
- installation ambiance of gear pair,
- meshing field and it's characteristics with the help of teeth geometry,
- expected accuracy of manufacture.

The installation environment of gear pair with deformation (angular motion / banking and torsion) caused by loading influence, locates the spatial position of the gear bodies. This change has an influence on the characteristic of load distribution in the meshing field (the distribution of load develops on the line of contacting teeth), in addition on extent of load distribution among the lines. Figure 1. shows derivation of the meshing field. Characteristics of load distribution can be seen on Figure 2.

3. CHARACTERISTICS OF THE GEAR PAIR MESHING

Meshing of the helical gear pairs (CEH) has several advantages in the meshing process [1, 2]. It is typical for the meshing process:

- fluctuation of the contact ratio is smaller between the entering and the leaving gear pairs,
- bending stiffness of the tooth rises because of the helix angle,
- total length of the contacting components becomes more equable, but it changes during meshing (Figure 3.).



a.

b.

Figure 1. Derivation of the meshing field

This contradiction of meshing originates from that width of the meshing field (b), specified by the common tooth width, determines current total contacting apex distance and its character (ΣL).

$$\Sigma L = f\left(\sum L_i(dz), b\right) \qquad (1)$$

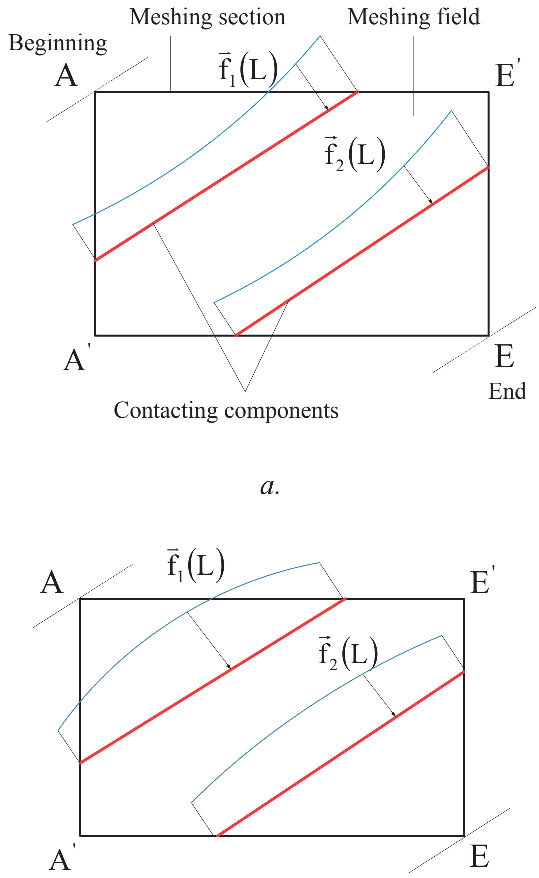
Above reasons can't be considered complete, because meshing has other characteristics, which are determined by the accuracy of manufacturing as well.

The load distribution cases shown in Figure 2, with the refinement of the manufacturing technology and the surface modifications made on the tooth, result in a situation whereby the load distribution on the tooth pairs becomes uniform over the contacting component.

It can also mean that the result of the load transmitted by the tooth pair can be placed in the middle of the component length and the load can be proportional to the component length [3].

Several researches deal with developing of the drive systems. Numerous conclusions are drawn from investigation of the meshing field. Typical for these are the follows:

- The torsional vibration excitation from the meshing can be stopped, if the axial contact ratio (overlap: ε_β) is set to an integer. Then the total length of the component is permanent throughout the whole meshing process [2].
- In the meshing process strength analytical studies have begun to deviate from the integer axial contact ratio. The tooth width has to be set that the fractional part of the axial pitch provides the additional tooth width [4].
- Japanese researchers have found, on the basis of purely experimental results, that no integer axial contact ratio should be sought [5].



a.

b.

Figure 2. Characteristics of load distribution in the meshing field

4. INFLUENCING OF THE MESHING CHARACTERISTICS

The size and shape of the meshing field is a challenge because the designer should answer why and how to choose the common tooth width. If it is appropriate, why the shape of meshing filed deviates from the rectangular shape.

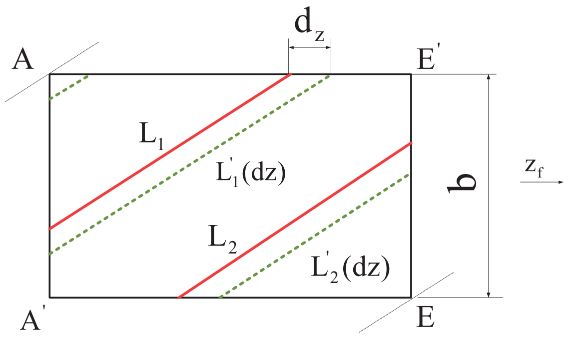


Figure 3. The length change of the contacting components

4.1. Effect of meshing field size

In the meshing field, the total length of the contacting components varies as the period of the base pitch of the meshing in the transverse plane. This change varies with the current common tooth width. The tooth width can always be written as the integer multiple of the axial pitch (p_x) and the sum of its fractional units (db)

$$b = k \cdot p_x + i \cdot p_x = (k+i) \cdot p_x, \; db = i \cdot p_x \quad (2)$$

where k = 1, 2, … n (integer) and i is any value from 0 to 1.

The literature has contradicted the results of research in choosing the value of i. Previous research and theoretical ideas have suggested that for i = 0, the value of the resulting contact length is constant [1, 2], because the change of the torsional stiffness is zero. Others inferred from measurement results [5] but did not theoretically justify their results. Another line of research concluded that it is theoretically possible to deduce from the real tooth stiffness change that i = 0 cannot be justified [4]. The purely experimental and theoretical approaches have gone beyond the previous one, but their results have not reinforced each other.

The direction of the research, which started from the exploration of the source of vibration excitation [6], concluded that the result of the experimental research can be well approached and theoretically supported if we choose (db) determined by the value of i such that the value of the given contact ratio (ε_γ) must be an integer. The basis of this research was the examination of the displacement of the resulting tooth force on the contacting components in the meshing field. The result of the research found that the range of motion of the resultant of the tooth forces can be minimized, but not reduced to zero. Research has proven to be a wise choice of common tooth width, makes the acoustic recognition of a drive difficult.

4.2. Changing the shape and effect of the meshing field

The change of shape of the meshing field was based on the fact that the shape can influence the total length of the instantaneous contacting components throughout the meshing phase. Changing the shape of the contacting field is possible by modifying the meridian curve of the head cylinders. This possibility is also important because, in the case of gears with asymmetrical tooth shape, a change in the direction of rotation results in different meshing field parameters [7].

There are two ways to modify the contacting field:

- modifying the meridian of the head cylinders to map the meshing field,
- modifying the meshing field freely and generating head cylinder meridians from it.

The goal of both methods is to reduce the tooth force moving that generates the vibration excitation in the contact to an absolute minimum instead of a local minimum.

Without changing the meshing field, it will take the shape of Figure 4. Changing the direction of rotation and changing the base cylinders also changes the size of the contacting field [7]. Changing the meridian of the head cylinder changes the shape of the meshing field as shown in Figure 5. Changing the direction of rotation in the drive changes the size of the modified field [8], distorting its shape only. It can be seen from the figure that the contact ratio is slightly reduced due to the theoretical meshing length (H), the sum of the theoretical instantaneous meshing component length (L_i) is also reduced, but the substantial change is observed in the decrease of the L_i fluctuation over time. The trajectory of the resultant tooth forces formed on the meshing members can be effectively influenced within a period of meshing.

This type of modification of the meshing field affects both the torsional excitation of the meshing and the radial and axial excitation of the bearings. The study of this effect is becoming more and more important for toothed pairs as the precision becomes more important.

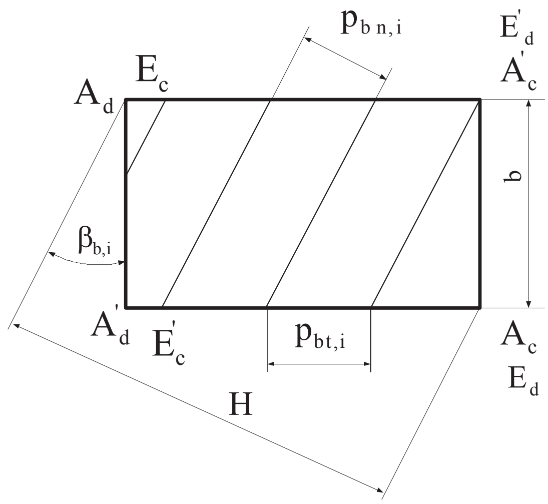


Figure 4. Regular meshing field

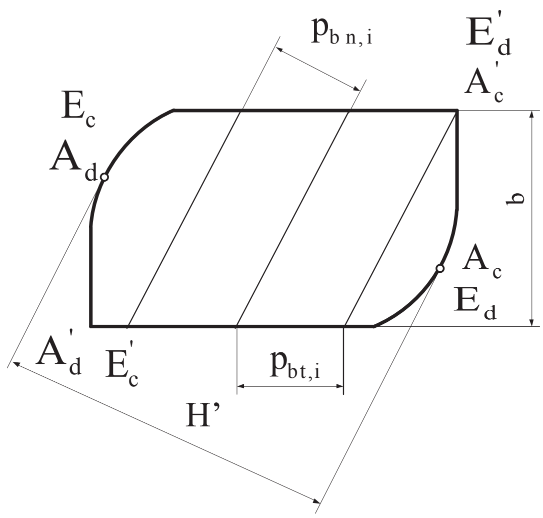


Figure 5. Modified general meshing field

In this case, we should consider what solution we recommend to the designer. These are the following:

- defining a regular rectangular contacting field with excitation at the local minimum,
- modifying the meshing field with one of the two recommended methods to minimize (absolute minimum) the excitatory effect.

5. SUMMARY

The aim of the article is to draw the attention of gear developers to the specific requirements of a drive system that they can follow during the development and design phase. We have presented a suggestion regarding the acoustic recognition of the drive chains. We have presented a research process that will show the way to a solution. We have raised some questions that induce further research.

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