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USING OF 3-D PARAMETRICAL BLOCKING CONTOURS FOR OPTIMIZING EXTERNAL CYLINDRICAL GEAR DRIVES ON A "GEOMETRICAL LEVEL"

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1. Introduction

There are standards, manuals and other reference books, which offer Albums of Geometrical Blocking Contours (GBC) in co-ordinates x_1-x_2 of typical gear drives [Болотовская 1965]. Software programs, which enable their automatic creation, are also developed.
The experience suggests that in many cases it is much more advisable the GBC to be elaborated in co-ordinates with a X-axis – the coefficient of addendum modification of the pinion and a Y-axis – the center distance a_w of the gear pair. In this way the relation between x_i and a_w is shown in a clear way (fig.1). This considerably facilitates the use of the presented information and reveals many good opportunities for using this kind of GBC when designing the so called bounded gear pairs as for example those peculiar for planetary gear drives, gear boxes, etc.

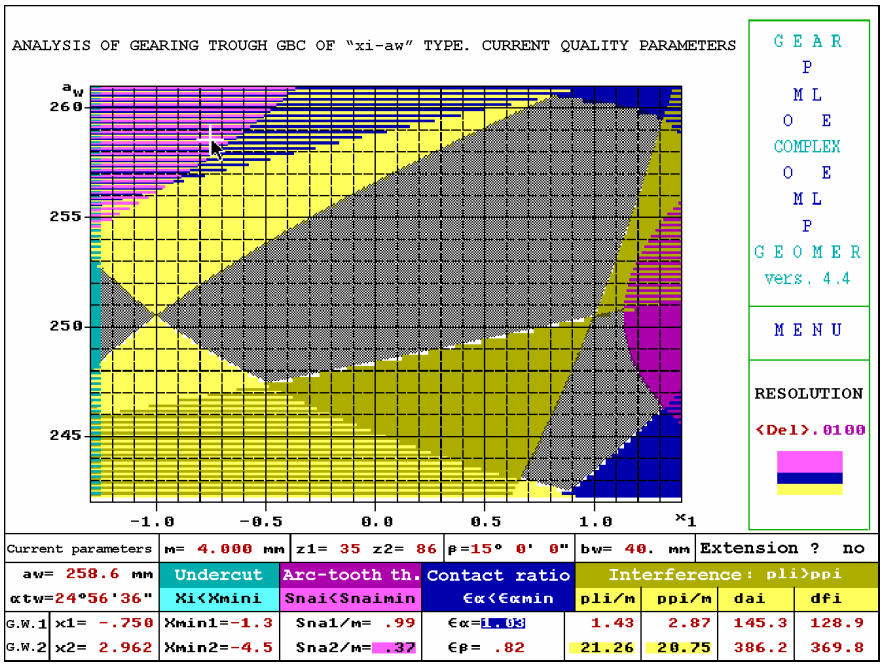

Figure 1. Geometrical Blocking Contour of the type "a_w-x"

Regardless of the certain advantages of this kind of contours [Ангелова 1997] they lack direct information about the correlation between the admissible values of x_1 and x_2 (when a_w is given) and their optimum values, characterizing the geometrical, kinematical and load-carrying characteristics of the gear drive (contact ratio, the arc-tooth thickness at the outside diameter of the gear wheels, the sliding velocities, the admissible power, etc.).
This problem is solved when using the 3-D model of a Parametrical Blocking Contour (PBC) in the process of designing the gear drive.

2. Nature of the problem

In the general case the 3-D Parametrical Blocking Contour (PBC) is a three-dimensional image, which base is a geometrical blocking contour of the type "a_w-x" and raised above it planes presenting in a clear and illustrative way the kinematical and load-carrying characteristics of the gear drive.
From the definition of the term GBC follows that every combination of the center distance a_w and the coefficient of addendum modification of the initial contour x_i selected from the area of admissible solutions, has a corresponding gear drive. When the conditions of work, materials, heat-treating, precision of the machining, etc. are given, all its kinematical and load-carrying characteristics (for example admissible power) can be estimated with a given punctuality. The exceeding of the lowest load-carrying limits on the upper part of the model would mean a premature loss of load capacity due to the breach of one or more of the criteria of bending stress or contact stress. Therefore all limited surfaces of the examined three-dimensional model in the general case express a definite limitation (geometrical, kinematical or load-carrying) of some of the fundamental parameters of the gear drive. The suitable presentation of the PBC offers in a synthesized way extremely rich visual and easy for use information about the characteristics of the gear drive. The experience suggests that such information is very useful and it can facilitate the searching of the optimum values of the center distance and the coefficients of addendum modification x_1 and x_2, especially in the cases, when the task imposes the acceptance of compromise solutions. The improvement of the characteristics of one gear drive can be achieved in the stage of design, through the use of a 3-D parametrical blocking contour. The question with its modeling in a numerical mode is already solved. The solution is found in the continuous accumulation of numerical information about the separate two-dimensional sections, which can be considered by the designer as a set of values or as a graphic image of the corresponding two-dimensional section. The plane representation of the separate sections of PBC doesn't give an opportunity the characteristics of the gear drive to be estimated universally. Much more convincing is to base on a elaboration, which represents a three-dimensional image and presents the kinematical and load-carrying characteristics of the drive for all admissible solutions from geometrical point of view, i.e. for the whole field of GBC. The problem can be solved by the creation of the PBC by hand [Ненов 1980], but this operation is expensive or by a 3-D visualization with a software package [Ангелова 1997]. Unfortunately in the last case the process of automatic design is intermittent, i.e. "entering of input data – presenting the PBC on a graph", which breaks the automatic searching of the optimum solution.
With the presented work the authors stress the attention on the elaboration of the created by them software package GEOMER in its part about the visualization of the 3-D parametrical blocking contour. In order to create a better graphical hardiness, as well as to give an account of the aims of the design, the three-dimensional models can contain in its superstructure specific parameters and appear in a different way (fig.2, fig.3). It is of great importance that the figure is perspective and the process for an automatic choice of an optimum solution is uninterrupted.
The opinion of the authors is that the last version of the software package GEOMER is a step forward in this respect. The disposed graphical information is accessible and easy to understand. Provided are resources for painting in shadows, for bringing out in an ostensible way the co-ordinates of a randomly chosen point of the graphic, for spinning in the space (fig.4). It enables the design of a gear drive with optimal parameters on a geometrical level. The presented information facilitates the searching of optimal values of the centre distance and the coefficients of addendum modification by a complex criterion, especially in the cases, when the task imposes the acceptance of compromise solutions in one or other direction.

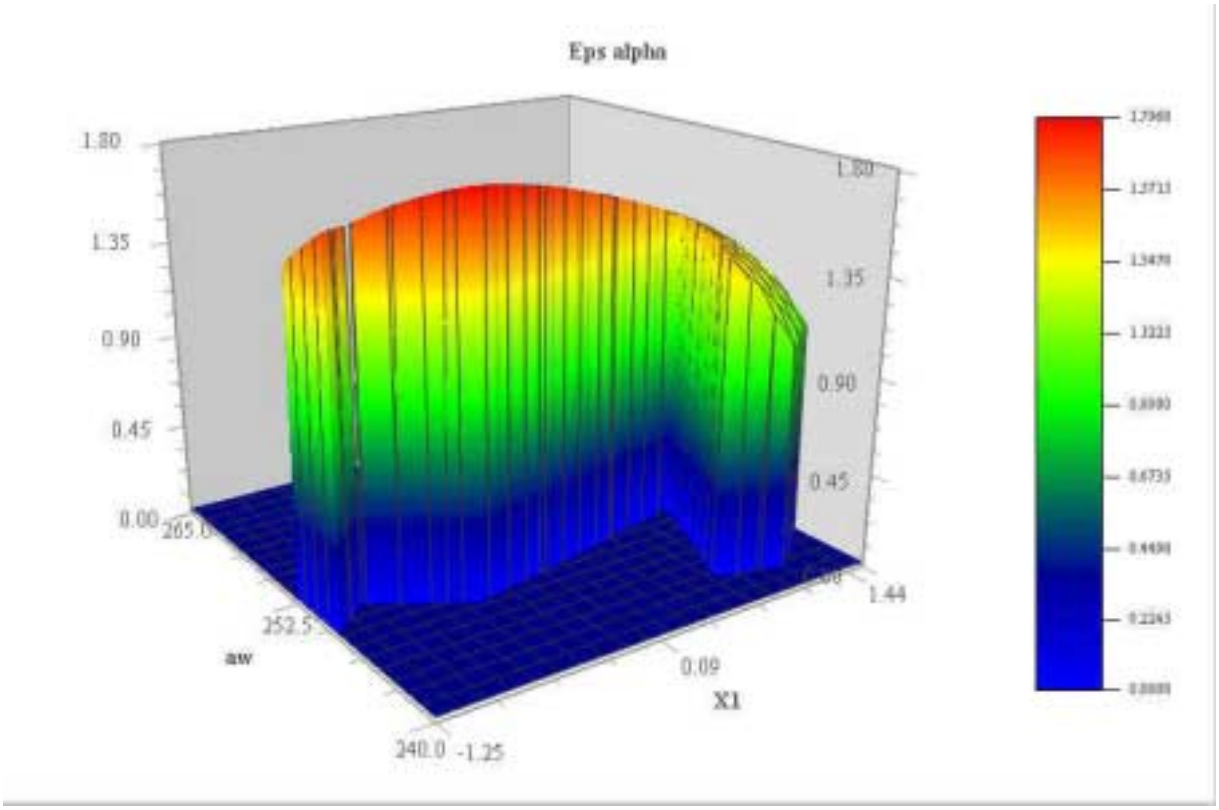

Figure 2. Three-dimensional PBC on a geometrical level comprising the GBC presented on fig. 1 and representing the corresponding values of contact ratio

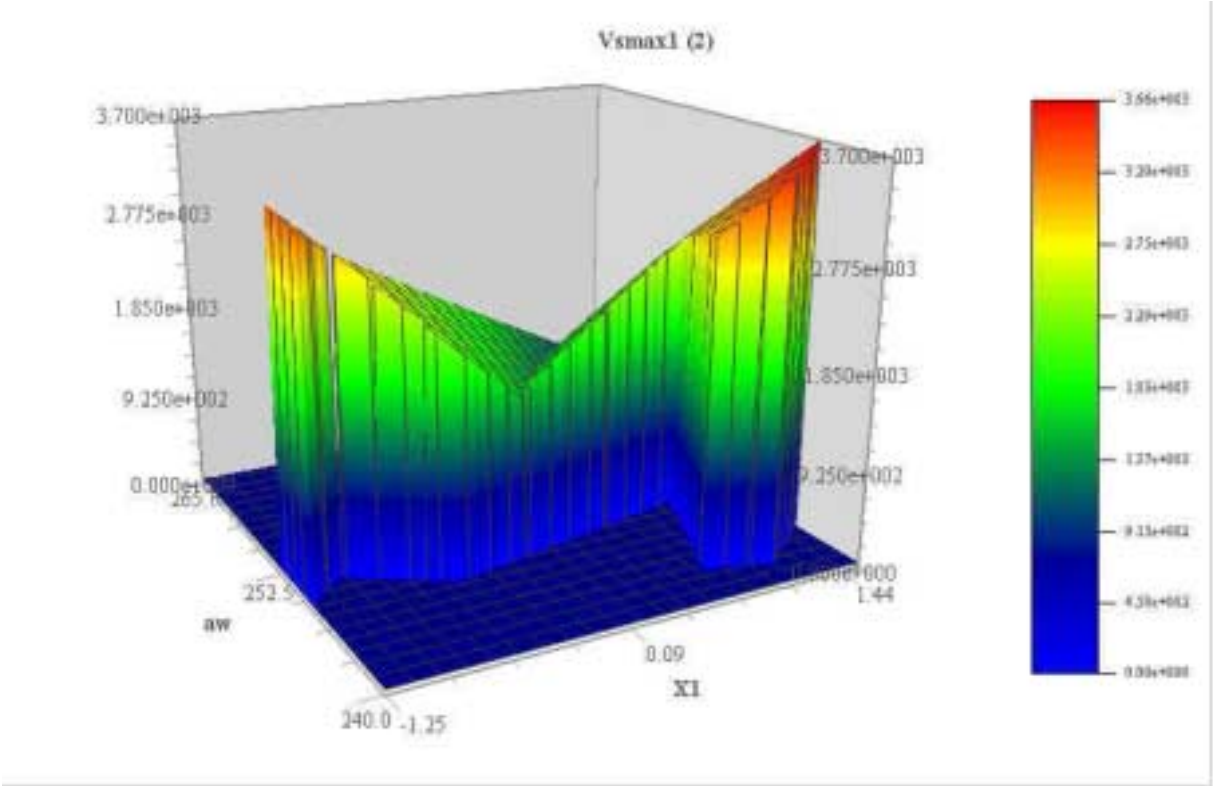

Figure 3. Three-dimensional PBC on a geometrical level comprising the GBC presented on fig. 1 and representing the corresponding values of sliding velocities

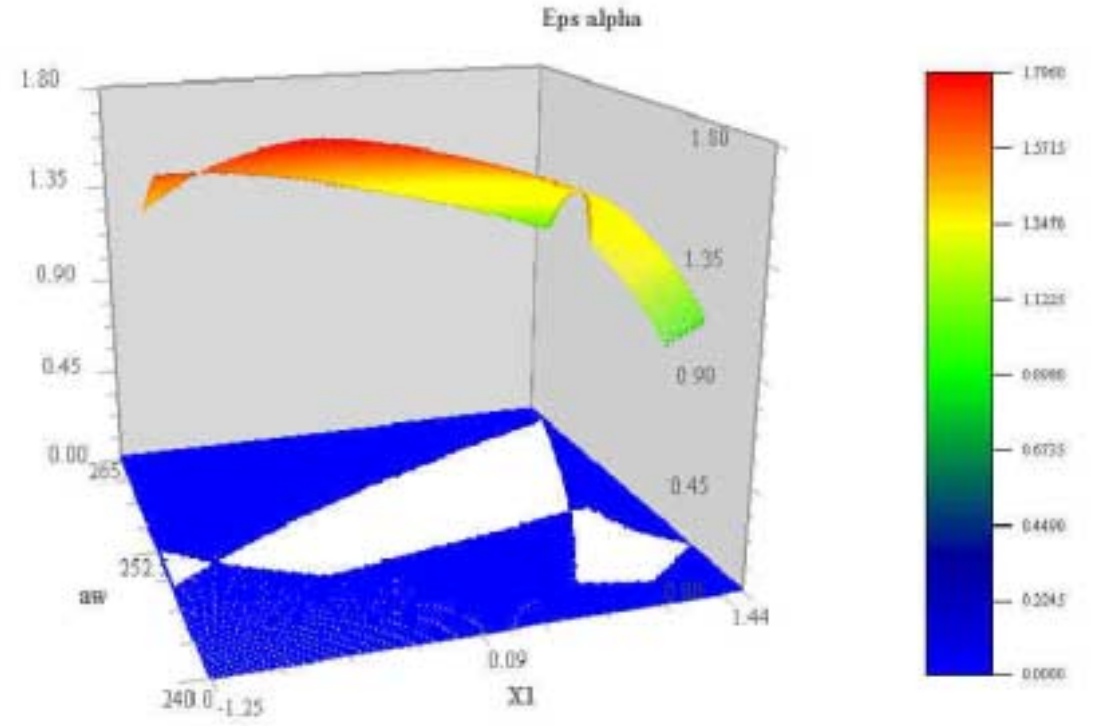

Figure 4. The three-dimensional PBC of fig. 2 after spinning in the space

3. Conclusion

The approach of using 3-D parametrical blocking contours of numerical kind and in the mode of different two-dimensional sections for optimising external cylindrical gear drives is tested for a long time. It has been implemented in the design of full-scale production families of gear trains and geared motors. The algorithms elaborated for that purpose are the basis of a powerful software package for optimisation calculations of gear drives, whose geometrical and kinematical parts are completely compatible with the European and international standards in this field. The software package is optimised in its part visualisation of 3-D parametrical blocking contours.

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