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Tool Design Influence on the Thermal Effects Appearing during Bevel Gear Processing

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Abstract

Toothing of bevel gear is a crucial operation for the automobile industry. To achieve the required performance characteristics of the gear it is essential to optimize the toothing process. Herewith, the task of understanding the proceeding the heat processes during cutting is important to forecast of the tool wear, accuracy, and undulation of the processed surface. In the article the results of numerical simulation of thermal processes appearing during processing of bevel gear are considered. This paper presents the results of numerical modeling of thermal processes occurring in a tool, workpiece, and chips during bevel gear cutting. Also the influence of the design parameters of the cutting tool on the value of maximum temperatures and heat flows occurring in the process of cutting was investigated. The approaches which were used in that paper can also be applied to other cutting processes with the removal of a complex U and / or L shaped chips (gear shaping, broach etc.)

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Keywords: в cutting; numerical simulation; bevel gear; facing formation.

1. Introduction

Processing of bevel gears is one of the most critical procedures in the automobile industry. The main goal of this procedure is to reach required running qualities of toothed gear.

The reference and scientific literature lacks the data based on the results of analysis of heat processes, which allow predicting the durability of the special cutting tool, accuracy and the quality of producing the toothy profile of bevel gear.

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Understanding the mechanisms of occurrence and conveying of heat effects in the tool, blank and facing during the bevel gear cutting is crucial for prediction of tool wear, accuracy, and undulation of processing surface [1].

Forecasting of the thermal processes occurring in cutting can be carried out with using various types of models: the analytical [2-6], combining analytical approach and the theory of slide curves [7]; numerical, based on the finite difference method; numerical, based on the finite elements method [8-11].

Modeling by means of numerical methods allows to expand a range of the tasks that are solved by the model, thus calculation can be successfully executed for both small and big temperatures. Methods also allow to solve stationary and non-stationary problems in two - and three-dimensional space.

The widespread use of numerical methods for solving the problem of temperature fields modeling became possible since recently due to development and availability of special software and computing capacities.

Nowadays, studies in the field of modeling of the thermal effects of the cutting process are still undergoing. Researches are aiming at the investigation of dry and high-speed cutting as well as cutting the special constructional material [12-14]. Besides, numerical methods are widely used in modelling of cutting process including cutting of cogwheels. K.D. Bouzakis used a complex technique of modeling of gear hobbing [15-18]. Modeling of cutting process with swarf removal by the technique of finite elements (FEM) serves as the basis of the approach. Calculations with the use of FEM allow authors to predict temperatures, deformations, tension and some other the physical variables which characterize the processes emerging in a cutting zone and to predict on its base the wear of the cutting tool.

2. Process model

The scheme used for modeling of processing of conic cogwheels is presented in the Fig. 1. The geometry and the considered conditions of cutting are typical for processing of a bevel gear in the middle of a cut, geometrical parameters of facing are calculated by G. A. Kharlamov's technique [19].

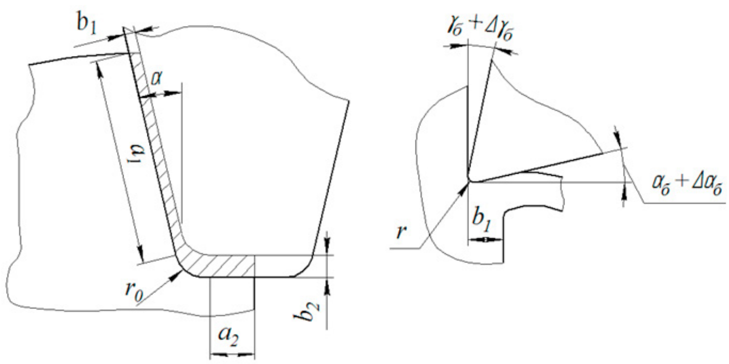

Fig. 1. Structural model for numerical simulation.

The following assumptions were made:

- blank is fixed;
- the tool made all movements that are necessary for generation of geometry;
- the tool is absolutely homogeneous and absolutely rigid;
- the surface of the tool has homogeneous structure;
- processing material has a geometrically and physically nonlinear structure;
- blank deflection is described using the Johnson-Cook's method by using Mises' yield criterion.

Choice of precise and effective model for the description of blank deformation process is important when using FEM for modeling the cutting action. In the paper, the Johnson-Cook model was used [20]. The model permits to provide a sufficiently precise description of material behavior under large deformations combined with high temperatures.