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Roughness and materials in concurrent engineering systems

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Abstract

The choice of a manufacturing process in the design process takes into account many parameters. The surface roughness, the dimensional tolerance and the material of a mechanical part are essential data, influencing the behaviour and the mechanism lifetime. The algorithm presented in this paper allows the integration of surface quality into a CAD/CAM system, via models to predict surface roughness. Different theoretical and empirical roughness models are presented. They allow to estimate the manufacturing parameters.

Keywords: Manufacturing; Design; Integration; Roughness

1. Introduction

The "Concurrent Engineering" goal [4,8] is the design and manufacturing time reduction and the cost reduction. It leads to new design methodologies, materials' choice (for manufacture and recycling) and process planning. New software tools are given to the designer to help it throughout his work. Some design and manufacturing knowledge are formalised and integrated into a CAD/CAM software.

The tools which we develop constitute the assistance bricks in the simultaneous engineering design system [5]. They make it possible to integrate manufacturing knowledge, materials' knowledge and surface qualities in a CAD/CAM system. They use the designer choices and the designer decisions, propagate data, propose alternative solutions and check coherence between the various designer choices.

The surface quality and the dimensional quality of a mechanical part are significant parameters. They result from functional dimensioning and are necessary to correct mechanism life. They are directly related to the manufacturing process and selected material ("matter-tool concept"). On the basis of this report, we set up three algorithms to link surface qualities, the technological solutions and the manufacturing processes.

The first uses the designer data (functional surfaces resulting from the technological solutions) and the manufacturing processes parameters (operations, tools, part material, cutting conditions, etc.). It estimates, thus the maximum realizable surface quality and suggests the result to the designer.

The second always uses the designer data and an imposed surface quality value. It proposes a manufacture solution list, which can carry out the requested surface quality and an alternative solution list where the surface quality values are very close to the imposed values, given by the designer.

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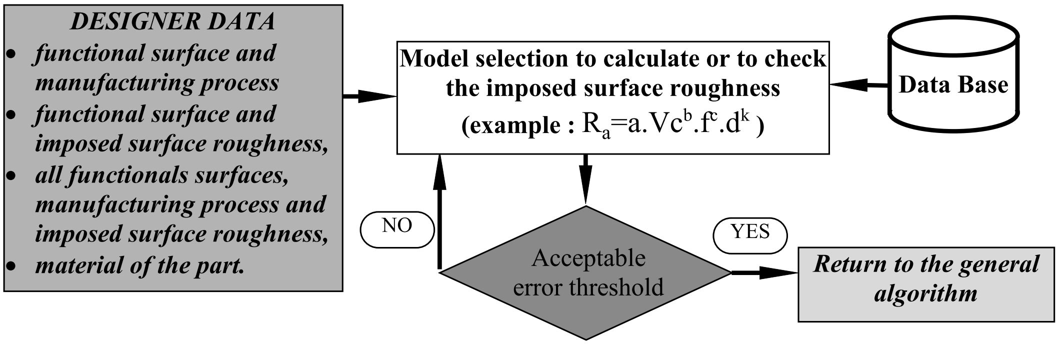

Fig. 1. Surface roughness algorithm structure.

The third analyzes the coherence between the choices of the designer for all functional surfaces composing a part. This algorithm looks for minimizing the number of manufacturing operations and proposes, also alternative solutions where the surface quality values are very close to the imposed values, given by the designer.

We only detail the general algorithm structure and the models used for the surface qualities calculation.

2. Structure of the three algorithms

The three algorithms structure is presented in Fig. 1. On the designer data basis and a complementary database (design data, manufacturing data and calculation models), the system chooses and uses the model which returns the closest surface roughness values (the error between the calculated value and the imposed value must be minimal). The choice of the algorithm design is carried out via "trades cards" and formalised with "methods" (the structure is computing in oriented object programmation) associated with a "resolution tree". An error analysis makes it possible to validate the obtained results and to return to the general algorithm of design.

3. Knowledge databases

Many works were carried out on the surface qualities and the obtained qualities of the mechanical parts during a machining process and on the link between these parameters (materials, machining parameters, surface quality, etc.

The manufacturing knowledge integration related to surface qualities is carried out by a database where we find experimental and theoretical roughness models. This database is made up of models found in the literature. We present only some of them.

3.1. Experimental models

The first models, developed by Fang [7] were based on the experimentation. Various materials, various inserts and various cutting conditions were taken into account in three different models to predict arithmetic surface roughness: linear model, quadratic model and exponential model. These models are similar to the Taylor's law. A regression method and correlation analysis allowed to validate the obtained results. These models were generalised by correcting coefficients which make it possible to estimate the material surface quality according to a reference insert and a reference material.

Alauddin [2] has established models for end milling process of 190 HBN hardness steel. Factorial designs of experiments gave the experimental results to built models. These models were also identifiable with Taylor models. This technique is also used by Choudhury [6] for a high resistance steel turning process.

The predictive model based on the cutting edge geometry and the machining conditions developed