RESEARCH AND DEVELOPMENT OF KNOWLEDGE BASE FOR INSPECTION PLANNING PRISMATIC PARTS ON CMM

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Abstract:

The objective of this paper is to develop knowledge base model for inspection planning prismatic parts on CMM in digital manufacturing. The digital manufacturing is a novel approach to manufacturing in which all elements of manufacturing process are built using computer based simulation with a 3D visualization. For each element in the process (product/part, tool, fixture, machine, measuring sensor, CMM) a solid model is built and the whole manufacturing process is simulated in order to provide digital verification. Our research model is related to the CMM and its digital environment. The animation of the inspection process on CMM provides a realistic assessment and verification of the inspection process. In order to achieve so high level of integration, it is necessary to incorporate inspection planning knowledge into such a system. This paper describes a model of knowledge base as a main part of intelligent inspection system, with examples for prismatic parts (PP).

Keywords: Inspection, CMM, Knowledge Base, Intelligent Model

1. INTRODUCTION

Development of knowledge based systems of inspection is imperative and a prerequisite for development of a new generation of technology systems and digital quality based on a global interoperable model of products. Interoperable model integrates the CAD-CAM-CAI information in digital environment and it is base for the virtual simulation and inspection planning of prismatic parts of CMM.

The conceptual plan of inspection of PP presents the essence work with the CMM. Based on experience, training and acquired knowledge a engineer metrolog generate concept of plan for the inspection each of the PP from the beginning. This approach was overcome because of limited abilities predicting of a engineer metrolog. Subsequently were developed CAI systems based on Expert systems [1]. Today's systems are based on feature-base techniques [2, 3]. Metrological recognizing using of feature – base techniques is based on metrological features which consist the metrological part. MF is composed of one or more geometrical feature (GF) and presents a link between tolerances and the GFs from which consist PP. An example of defining MF from the geometrical standpoint is given in [3]. If we know that the only real holder metrological information is technical drawing, the term metrological feature is introduced as a link between tolerance and geometry whose holder is a CAD model of the part. For generating of conceptual plan inspection or metrology sequences, on the basis of MFs, it is needed to define the rules of decomposition of the MF on GFs.

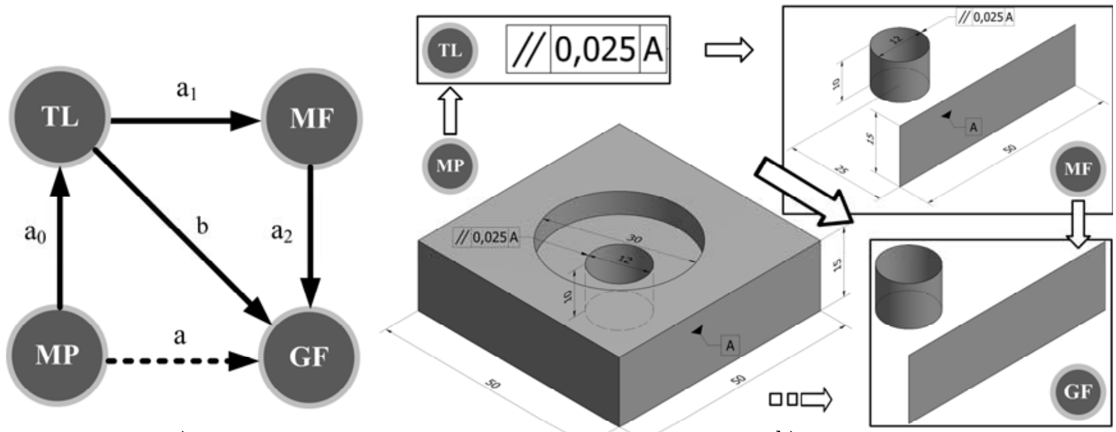
One of approach to the development of the knowledge base can be engineering ontology. The term of engineering ontology are detailed discussed in [5]. On the basis defined classifications, reuse and sharing of knowledge some domain, can build the logical structure of the knowledge base by defining its basic components. The basis for the development of a conceptual plan inspection can be feature - based ontology [4].

This paper presents concept inspection planning based on the knowledge base (KB). KB is defined entities and relations between entities. The development of the KB presented in this paper is based on a graph that consists of four member. Links between members of the graph or relations (rules) between entities of the knowledge base, are rules for decomposition of the measuremt part at the tolerance features, rules for decomposition of the tolerance feature at the metrological features and rules for decomposition of the metrological feature at the geometrical features. The final goal is decomposition of the measuring part into geometric primitives which indirectly, through tolerance, participate in the planning inspection.

2. THE DEVELOPMENT OF KNOWLEDGE BASE MODEL

The knowledge bases model consisting of entities and relations or rules that define the possible states of the problem for which the design system. The knowledge base is necessary to develop in order to application of search technique and use of the computer memory, can find the solution to any given problem in advance.

The development KB presented in this paper is based on the graph shown in Figure 1. The graph is composed of members and links between them. Members of the graph or entities of the knowledge base, are: MP – measuring part, TL – tolerances, MF – metrological feature, GF – geometrical feature. Links between members are rules for decomposition (a_0, a_1, a_2, a, b).



a) b)

Figure 1 The graph of knowledge base (a) and illustration overall purpose of knowledge base model (b)

2.1 The rules for decomposition

The rule a_0 defines decomposition of MPs on forms of tolerances defined by ISO standard. The following types of tolerance are consideration: tolerance length (TL), tolerance form (TF), tolerance orientation (TO) and tolerance location (TLC).

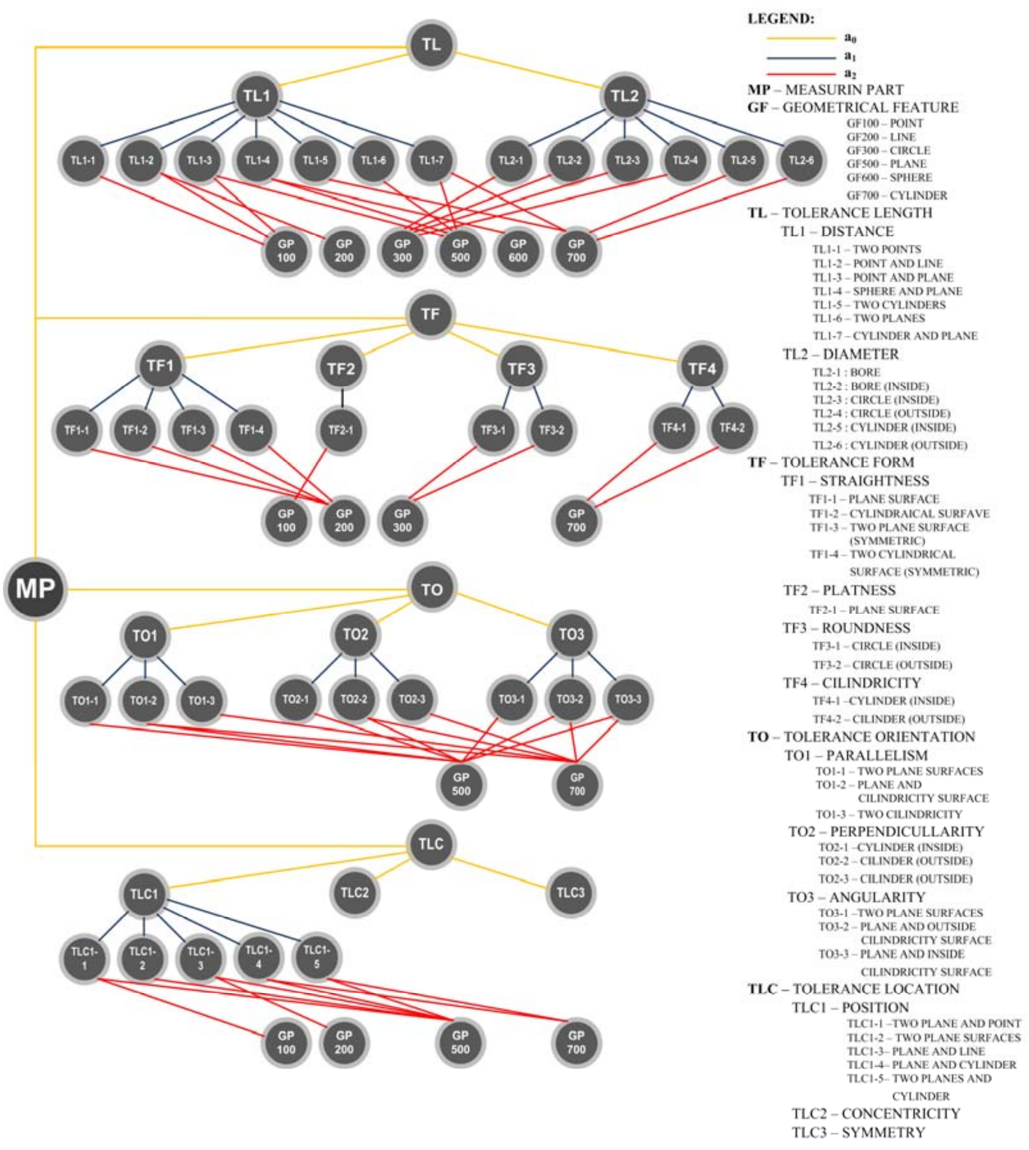


Figure 2. **Rules for decomposition**

The rule a_1 defines extension of tolerances decomposition on specific forms which also defined by standard. For example the tolerance orientations can decomposition on tolerance parallelism (TO1), tolerance perpendicularity (TO2) and tolerance angularity (TO3).

The rule a_2 defines extension of tolerances decomposition on more specific form. These forms can be called MFs. With the metrological standpoint MF consist from one or more GFs. In Figure 2 is shown the graph where are presents rules for decomposition in general case. For example TL1 consists from six metrological features: TL1-1, TL1-2, TL1-3, TL1-4, TL1-5, TL1-6 and TL1-7. Each of them can be described with five GFs (GF100, GF200, GF500, GF600 and GF700).

The main goal is decomposition of the measuring part into geometric primitives which indirectly, through tolerance, participate in the planning inspection (rule a). The minor goal is decomposition of tolerances into GFs (rule b). GFs obtained in this way represent a subset of primitives that define the geometry of the measuring part. From the metrological aspects, analysis of all metrology primitives have sense only in the context of the analysis of the collision between the measuring prob and measuring part.

3. IMPLEMENTATION OF THE MODEL ON THE REAL PRISMATICS PART

Implementation of the developed KB model was performed on the example of a real metrological part (Figure 3). According to the rules of decomposition of previously exposed, tolerances of the part are reduced to the GFs. On this way, obtained are all necessary MFs witch create of tolerances of part. Given measuring part consists from four of tolerance forms. The first form is the tolerance length (TL), second tolerance form (TF), third tolerance orientation (TO) and fourth form is tolerance locations (TLC). Tolerance length is consisting from four tolerances of linear dimensions (TL1-6^1, TL1-6^2, TL1-6^2 and TL1-7) and five of tolerance diameter (TL2-1^1, TL2-1^2 TL2-1^3 TL2-1^4 and TL2-1^5). Tolerance form is TF2-1. The tolerances orientation is tolerance perpendicularity (TO2-1^1, TO2-1^2, TO2-1^3 TO2-1^4, TO2-1^1 and TO2-1^2) and tolerance parallelism (TO1-1^1, TO1-1^2, TO1-1^3 and TO1-1^4). Tolerance location is TLC1-4.

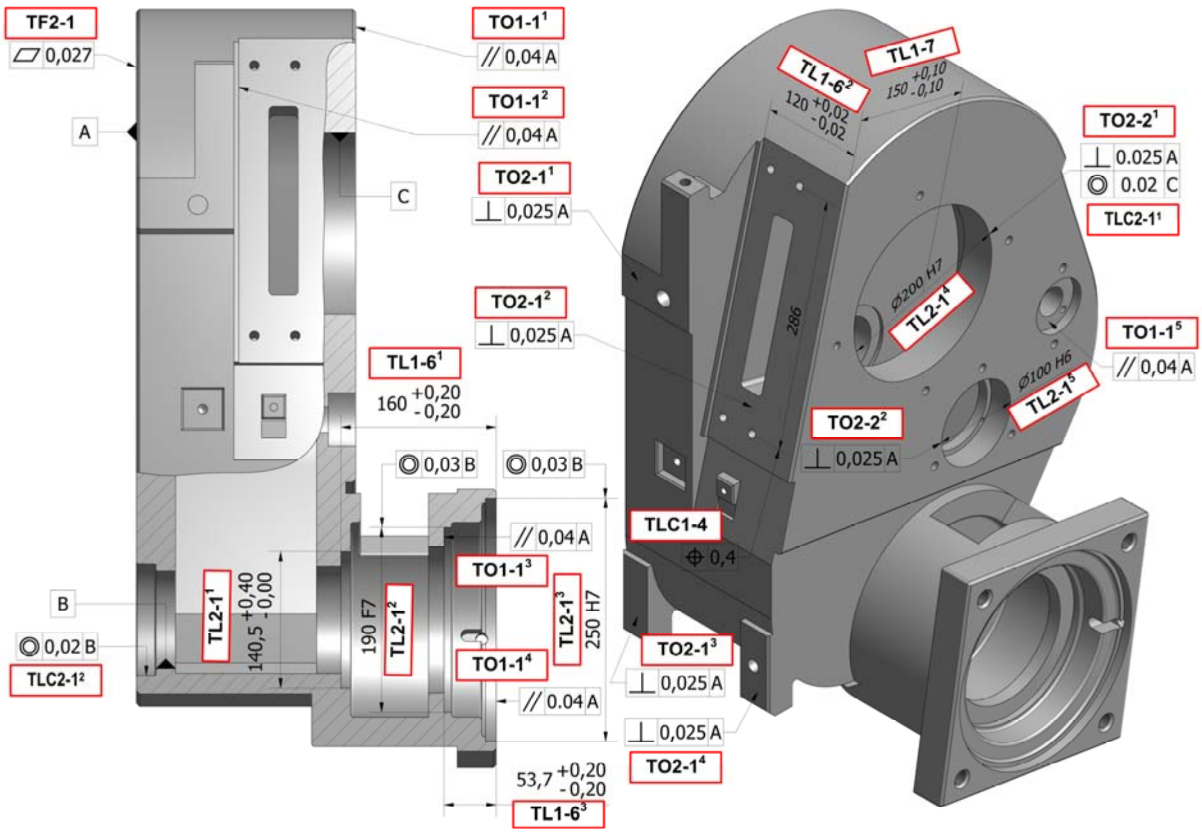


Figure 3. **The real metrological part**

In Figure 4 is shown decomposition MP on the GFs. It starts from the decomposition MP on the general standard forms of tolerances, which participating in the definition of tolerance on the part such as in this case the tolerance TL, TF, TO and TLC it is. Next decomposition of tolerances on more specific forms is done by ISO 1101:1983. Respect of this procedure is necessary due to connecting specific forms of tolerance with tolerance which appear in practice. In the next iteration of decomposition receive are MPs as most specific of forms tolerance. MFs are consisting from one or more GFs and presented link between form of tolerances and geometrical shape of the MP. In other words, if knows that the only real holder metrological information is technical drawing, the term metrological feature is introduced as a link between tolerance and geometry whose holder is a CAD model of the part. Software for CAD modeling has possibility to enter only one form of tolerance (TL), while others do not. This fact affects that the CAD model of the part in the process planning inspection is used only with the aspect of geometry. In support of this, is the fact that the software for the CMM loads geometry as a STEP or IGES file.

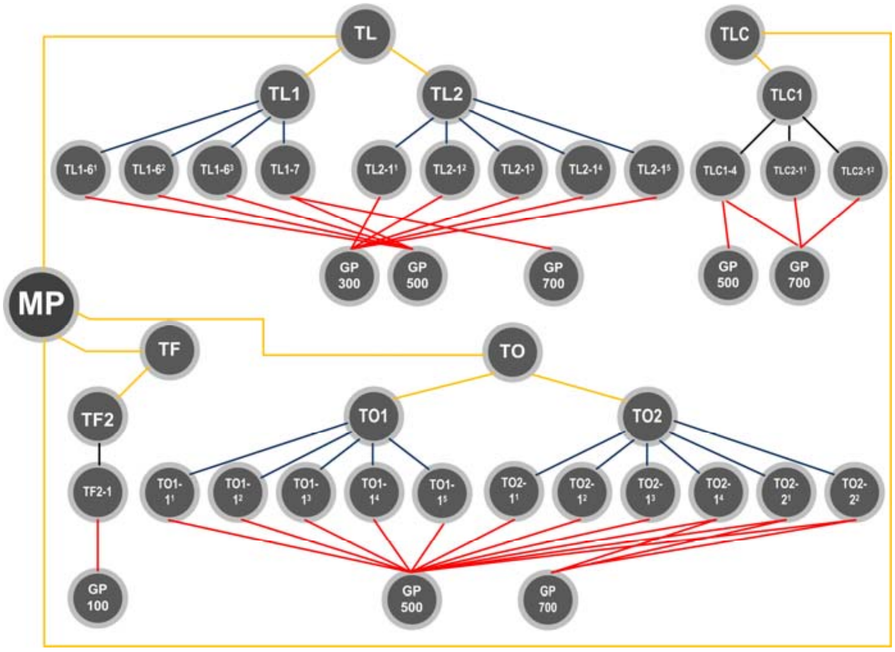


Figure 4. **Decomposition of the MP at the geometrical features**

As said, tolerances of the part are reduced to GFs, and then the GFs described by the parameters given in [4]. These parameters uniquely determine all GFs.

4. DICASCUSSION AND CONCLUSION

Uniform plan inspection for prismatic measurement parts is a special problem which depends on metrological complexity and knowledge of the inspection planner. This paper presented the knowledge base for conceptual inspection planning prismatic parts on CMM in order to solve this problem and develop intelligent system for planning inspection. The presented knowledge base defines entities and relations between them. Relations are present with rules for decomposition.

The development of the KB is based on a graph that consists of four member. Links between members of the graph are defined by rules: a_0 defines decomposition of MPs on forms of tolerances defined by ISO standard, a_1 defines extension of tolerances decomposition on specific forms, a_2 defines extension of tolerances decomposition on more specific form. The final goal is decomposition of the measuring part into geometric primitives (rule a) which indirectly, through tolerance, participate in the planning inspection and defining initial plan of inspection MFs.

The result of this approach is defining belong GFs to a particular form of tolerance through searching of the knowledge base graph. Searching of the graph, the general forms of tolerance defined by standard are linked with GP and in that way set the foundation for defining metrological sequence and intelligent planning path of the measuring sensor.

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