Journal of Materials Processing Technology 128（2002）7-18：1510—1515
Elsevier Science B.V.

Knowledge model as an integral way to reuse the knowledge for fixture design process

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Abstract:
The fixture design is considered a complex process that demands the knowledge of different areas, such as geometry, tolerances, dimensions, processes and manufacturing resources. Nowadays, the fixture design process is o-riented to automated systems based on knowledge models. These models describe the characteristics and relationships of the physical elements together withthe inference processes that allow carrying out the activity of fixture design. With the employment of the knowledge models, besides the automation, it ispossible to systematize and structure the knowledge of the fixture design process.

With the use of specific methodologies, as the knowledge template, it ispossible to reuse the knowledge represented in a model, for its use in a different design process. The knowledge template represents a pattern that defines the common entities and inference processes to use in the design process .In this work, with the use of knowledge template we propose the reuse of the knowledge described in the design process of fixtures for machining to other types of fixtures uses like inspection, assembly or welding.

Keywords: Knowledge model; Knowledge template; Fixture design

1. Introduction

The continuous challenge that involves the knowledge representation hasoriented to many different research groups to develop methodologies that describe stages for capture and representation of the knowledge in design and manufacturing systems [1–3]. This has allowed to define knowledge models as a tool that helps us to clarify the structure of intensive knowledge and information-processing tasks. In this sense,

a knowledge model provides a specification of the data and inference processes required by the system of study [4]. A first approach in the development of knowledge models applied to machining fixtures design process has been proposed by Hunter [5].

During the last decade, the use of modelling techniques has allowed usto represent the fixture desig

n process employed in some manufacturing operatio ns, such as machining, assembly and inspection, etc. [6]. Due to the complexity and the wide scope of the fixture design process, different research groups have been focused in the analysis of specific activities of this process,such as fixture configuration, tolerance analyses, stability and accessibility.

A great number of investigations has taken in c onsideration the way inwhich represent the knowledg e used in the fixture design process. These research es are focused in the documentation of the design pa rameters, the structuring of the information of the fixt ure and the description of the fixture elements used i n fixture design [2,7]. On the other hand, the implem entation of the knowledge used in the fixture design can be classified regarding the artificial intelligence t echnique(AI) used [8,9] and on the automation level of t-he design system[2].

However, whatever it is the artificial intelligenc e technique used and the automation level of this type of systems, the proc ess of knowledge modelling in the fixture design is i mportant for several reasons: the need to specify the concepts used in the fixture design; to establish the relationships amongdifferent knowledge groups; to d evelop knowledge based systems (KBS), and finally, to provide a conceptual base for reusing the knowled ge. In this sense, the entities and structures defined i n a knowledge model for design process of machinin g fixtures can be partially reused to develop new mo dels for fixture design process, as the inspection or a ssembly fixture. The entities and structures reused h as been defined using the method of knowledge tem plate[4].

The work presented is a detailed proposition of the knowledge model for machining fixture design and the definition of the knowledge groups that can be reused in the inspecti on fixture design process, using the knowledge templ ate method. Fig. 1 presents a general view of the con tents of this ex

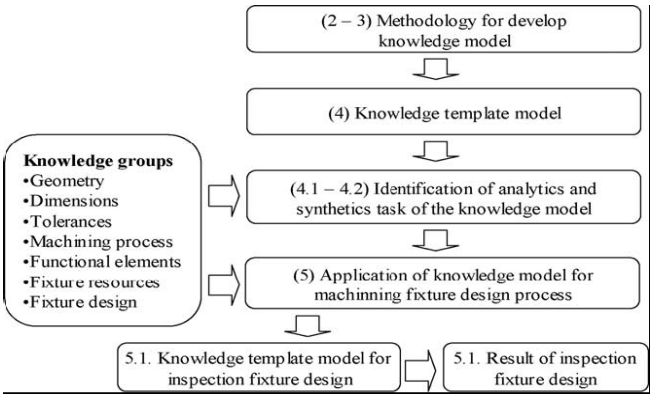


Fig. 1. The structure of the work. planation.

2. Present state of fixture design process knowledge modelling

The fixture concept arises from the need to est ablish a physical connection between part, and tool, and part and machine-tool. This connection should fu lfil some requirements for support the machining ope ration to carry out. The mainly functionality of the fixt ure is to support, locate and clamp the part to the ma chine tool. However, in order to interpreting correctly the needed knowledge for develop the fixture design process, it is necessary to define the basic informatio n related with this process according to the classificat ion exposed in Table 1.

All this information has been represented in mo dels that describe the entities, attributes and relation ships between each knowledge group in the fixture d esign process. The definition of these models can be carried out using methodologies that describe the ac tivities to capture, represent and reuse the knowledg e of a design system, for example MOKA and Comm onKADS.

The MOKA methodology is based on the defin ition of two models.

These models allow to capture and to structure the k nowledge of a system. The first model, uses a group of forms (ICARE: Illustrations, Constraints, Activities, Rules,Entities) that allow to capture and to represent the knowledge in a semistructured way; the second

model allows to represent knowledge ina structured way, using the extension of UML [10].

The CommonKADS methodology proposes th e use of tools and techniques to carry out the captur e and representation of the knowledge. In the case o f reusing knowledge, CommonKADS proposes the u se of the knowledgetemplate: a knowledge template i s a piece of a knowledge model, in which the data and reasoning processes can be employed i n the development of other applications [3].

3. Methodology for development a knowledge model: structural model

The methodology proposed for development o f a knowledge model includes the realization of two s tages. The first stage represents the knowledgeof th e objects like part geometry, machining process, func tional and detailed fixture design,and fixture resource s (see Table 1). The second stage describes the inference process (design and interpretation rule s) needed to obtain a firstsolution for the machining fi xture. These two stages allow to describe the structu ral model and behaviour model of the objects that co mpose the knowledge model for machining fixtures. This work is focused mainly in the descriptionof the s tructural model for machining fixture design process.

Table 1
Knowledge group for machining fixture

Knowledge group	Characteristics
Part geometry	Geometry: holes, slots, etc. Dimensions Tolerances
Machining process	Type of machining process Machining phase and sub phase Machining operation
Functional and detailed fixture design process	Methodology of design Design rules Interpretation rules Design constrains
Fixture resources	Type of fixture (modular, general, or dedicated)
(functional elements and commercial elements)	Type of fixture elements (support, locate, clamp)
	Type of machine tool (vertical milling machine, horizontal milling machine, etc.)

The proposed structural model contains a gen eral structure of the knowledge groups related with th e fixture design process. The description of theaspec ts related with the knowledge groups are presented i n Table 1. Fig. 2 shows the general structure of the knowledge groups for machining fixture design process.

Due to the complexity of the fixture design pro cess, the fixture design cannot be considered as an i ndependent process with respect to the manufacturin g process. In this sense, the information of the manuf acturing process isdirectly represented in the fixture design process. In a similarway, the resources involv ed in the manufacturing process have a narrow relati onship with the fixture resources, in terms of machin e tools and commercial elements of fixture. The defin ition of each knowledge groups (see Table 1) has tak en into consideration the attributes and necessary operation s to represent the knowledge relative to these knowle dge groups. The applications of these models are pr esented in the following sections.

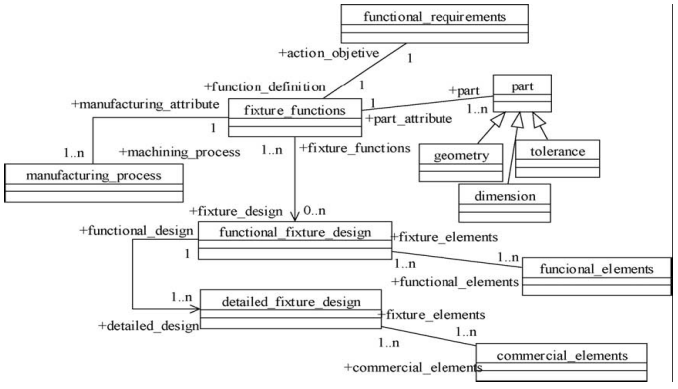


Fig. 2. Structural model for machining fixture.

4. Knowledge template model

In this section, we describe those pieces of th e knowledge model thatcan be reused in other applic ations using the method of knowledge template.From a conceptual point of view, a knowledge template de

scribes a piece of the knowledge model in which the i

nference and the knowledge tasks are defined with the objective of reuse this knowledge in other si milar applications. In this sense, it is necessary to dis tinguish among the analytic and the synthetic tasks. The analytic tasks define the classification of the obj ects involv

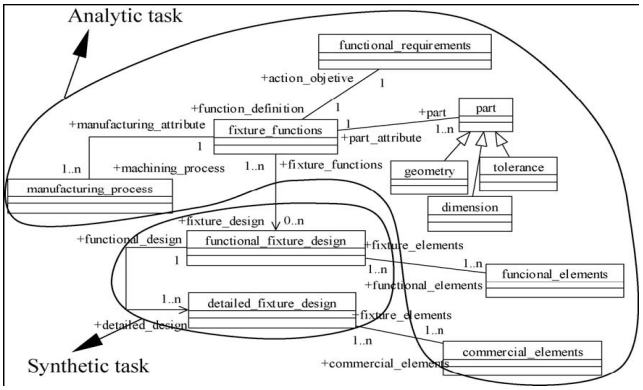


Fig. 3. Knowledge tasks based on the s tructural model.

ed in the fixture design process. The synthetic tasks have relationship with the reasoning way procedure f rom which a fixture solution is obtained.

Using these two types of tasks, a first approac h has been established to define the knowledge grou ps that can be classified under the analytic and synth etic tasks. Fig. 3 shows the objects of the structural model that describe the analytic and synthetic tasks of the machining fixture design process.

The division of these two tasks allows to set in a first level the knowledge groups, that it objects and attributes that can be employed in the development of new applications. Also, this separation allows us to identify those knowledge groups that describe infere nce procedures in the design process,as the function al fixture design and the detailed fixture design. This section presentsthe definition of the tasks of the kno wledge model classified under theconcept of analytic and synthetic tasks that can be reused in other appli cations.

4.1. Analytic task definition

The entities (or classes) defined under this cat

egory can be classified regarding the level of dependence level that present the objects involved in

the machining fixture design. The first level defines th ose knowledge groups that are not consequence of t he fixture design process, as geometry, dimensions a nd tolerances of the part. In this level, the entities tha t compose these knowledge groups can be totally re used in their structure, relationships and attributes. Fi g. 4 shows an example of the knowledge group of ge ometry that can be reused in other applications.

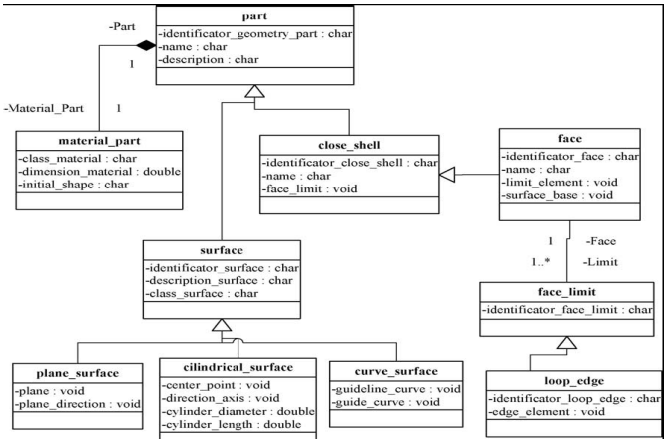


Fig. 4. Knowledge template for part entity (a nalytic task).

The second level describes those entities that pr esent a similar structure and relationships in the fixtu re design process(fixture functions and commercial e lements for machining fixtures). In this level, can be r eused only a portion of the structure and relationship s that are not conditioned by the fixture design proce ss.

The third level describes those entities that pr esent a complete dependence to the fixture design pr ocess. In this level, cannot be reused the knowledge previously defined (structures, relationships and attri butes), due to dependence of the process developed.

4.2. Synthetic task definition

The definition of the synthetic tasks involves t

he identification of those objects linked with the infer ence procedure carried out in the fixture design proc ess. In this type of tasks, it cannot have a total reutili zation of the knowledge, because the inference proc ess carried out using a group of production rules that depend of the type of process executed.

Under this classification, the knowledge group of functional design establish the functional solution of the fixture definition: the supporting surfaces,locati ng and clamping of the part. The definition of these s urfaces is depending to the manufacturing process d eveloped. This last characteristic makes thatthe funct ional design possesses depend of the machining pro cesses developedduring the manufacturing of the pa rt. In this sense, the sharing knowledge ofthis group i s limited to the definition of the surfaces and supporti ng points,
locating, clamping for machining fixture and to selecti on of the functional elements. However, the knowled ge group of functional elements can be reused

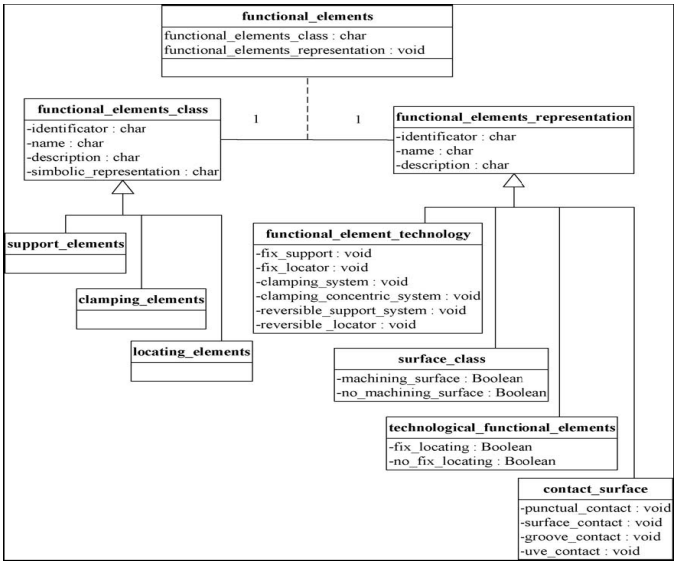
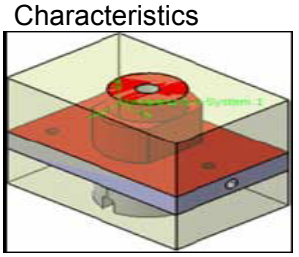
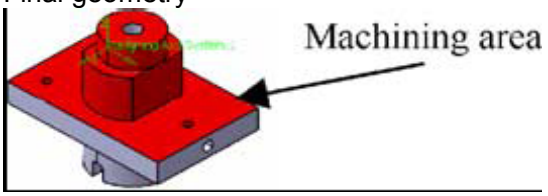


Fig. 5. Knowledge template for functional el ements entity.

in other applications, due to the functional elements can be employed in multiple domains in the fixture d esign process. Fig. 5 shows an example of the knowl edge template for functional elements used in the fixt ure design process.

In the detailed design occur similar situations t o those of the functional design. In this case, the det ailed design depends on the fixture functional design through a correspondence between functional and co mmercial elements.The knowledge group for fixture e lements can be partially reused to define a
new group of fixture elements. For it, we must use th e structure, relationships and entities defined for the f ollowing categories, base, support, locate, clampand auxiliary elements.

Table 2
Initial information for fixture machining

Information	Characteristics
Initial geometr	
Final geometry	
Machining operations	Face milling Side milling Drilling
Manufacturing resources	Vertical milling mach ine
Fixture resources	Modular fixture element s

5. Application of the knowledge model

In the next two sections, we present the applic ation of the knowledge model for machining and insp ection fixture design. These models taking into consi deration two different parts, because we wish expres s the potentiality of the use of knowledge template. The implementation of the structuralmodel,discussed in Section 3, isbased on the instantiation of each attribute defined defined in the knowledge groups that compose this model. The instantiation is defined as the assignment of a concrete value for a specific attribute. For it, the initial conditions are exposed for

the application of the knowledge model, which include the description of the initial geometry, final geometry, lists of machiningoperations,machine-tool and fixture resources. Table 2 shows the initial information for the application of the knowledge model for machining fixture.