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CAD/CAM SYSTEM FOR VIRTUAL MACHINING, MACHINE TOOL MOCK-UP AND KNOWLEDGE BASE MACHINING

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Abstract: *This application with ESPRIT software has been developed in the work shop of the mechanical department of INSA-Lyon. Because of the usual use in education and in industries of many CAD software systems such as Catia, Pro Eng, IDEAS etc., was decided 3 years ago to implement a powerful CAM software system completely independent of these. The objectives were: friendly data communication with CAM system; to increase the development of applications in the production and manufacturing fields; to develop formation and training for education and industries with the help of information and communication technologies. This paper rapidly presents the implementation and the actual exploitation. In paragraph 1, ESPRIT software and the used functions are presented. The CAM formation of the INSA mechanical engineers is detailed in paragraph 2. The paragraph 3 presents the future developments. The KBM (Knowledge Based Manufacturing) function is described so as his use for the process planning. To conclude, the benefits expected for education and industry with virtual machining and e-manufacturing are highlighted.*

Key words: *CAD/CAM, virtual machining, knowledge base machining, training for education.*

1. THE ORGANIZATION OF PROJECTS IN CAM-NC EDUCATION

Projects CAM-NC (Computer Aided Manufacturing and Numerical Control of the machine tools) are currently integrated into the course of training of the engineers in Mechanical Engineering, of the INSA -Lyon, (students from the fourth year) [1, 2]. These projects, consisting in two hours/week during one six-month period, are divided out in 2 parts, conferences and a project. At the time of the conferences the teacher looks further into certain parts of a soft-copy version distributed on-line and a hard-copy version (preparation CAM-NC and ranges of machining, interpolators, numerical definition and machining of the free surfaces...).

The part project (20 hours) is held in autonomous work. A whole group (25 students) is accommodated in a room comprising 20 computers. The teacher is present 40% of time. In more of the software of CAD (Computer Aided Design) SOLID EDGE V15 (PLM Solutions) and of CAM ESPRIT 2005 (DP Technology), each student has on-line the course, a set of instructions, the ESPRIT help assistance software, the “Coroguide” of the SANDVIK company, a connection and Internet addresses for the manufacturing domain.

Three exercises of the different types are required during the project:

1) Simple exercise of the beginning at the workstation (two hours – drawing of a free surface (NURBS) and simulation of machining with a spherical tool and only one setting for the workpiece);

2) Complete exercise with complex surface and drillings (four hours; importation of the files CAD of the workpiece and the finished part, partial development of the operations of a simple range with 2 settings and choice of 3 tools: a cutter for the roughness process, one

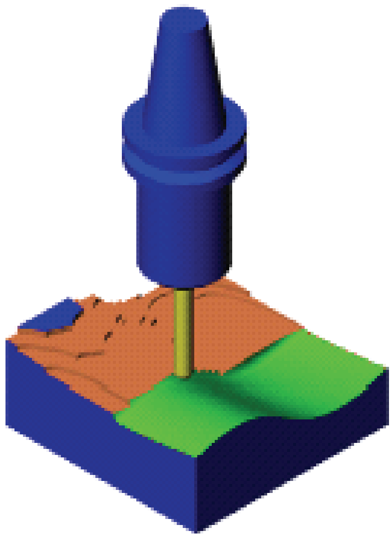

Fig. 1a. Simulation roughing and finishing of free surface (exercise 1).

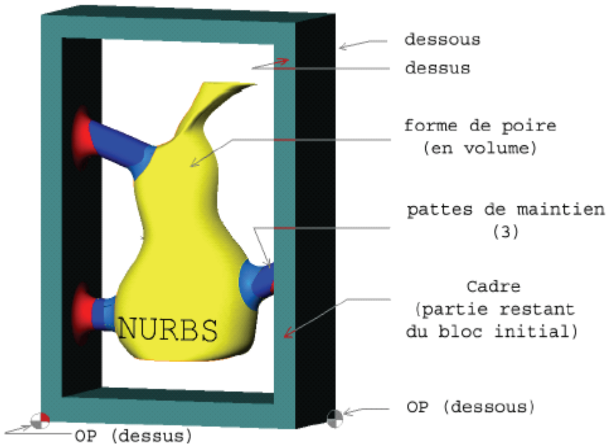

Fig. 1b. Example of a free project (exercise 3).

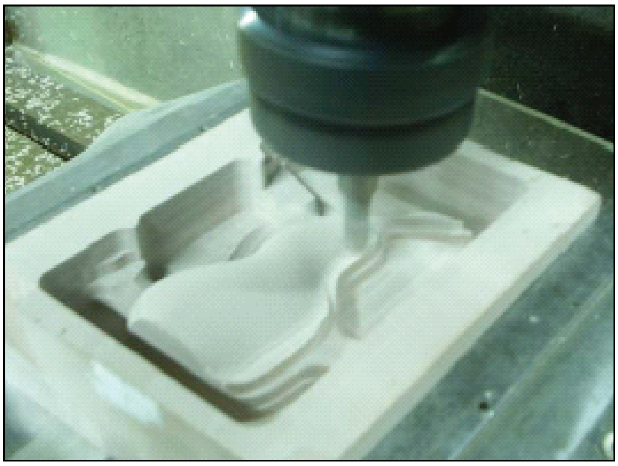

Fig. 1c. Machining in 3 axes.

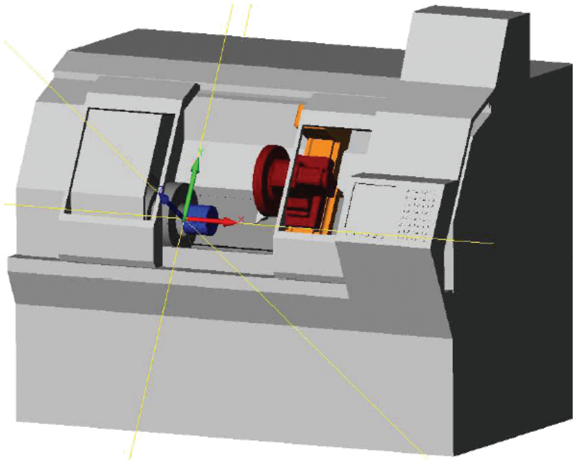

Fig. 2a. Machine tool mock-up. 2 NC axes lathe.

spherical tool to finish and a drilling tool; simulation of machining, generation of an ISO code program) [3];

3) Free project (12 hours; drawing under complete SOLID EDGE and manufacturing of a mould in a block of 120×100×50 mm^3; tools to be imposed, cutting conditions to be defined) [4, 5].

At a last meeting of two hours, one of the projects is chosen and transferred towards milling machine with 3 axes for machining. Fig. 1 illustrates some exercises of this project.

2. COMMENTS ON THE ESPRIT SOFTWARE ACTIVATED FUNCTIONS

2.1. Exchanges of CAD file

The possible standards used by ESPRIT software in Import/Export procedure are numerous and work rather well. To develop the teaching program above we did not meet blocking. The multiple possibilities available make it possible to sensitize the students with the problems on this point of the CAD/CAM data exchanges. The workpiece in format STL, necessary in simulation, obliges to make a change of format to perform the data exchanges.

2.2. Numerical machining

The various parameters of a sequence (selection of surface to machine choice of the operation, geometry of tool, cutting condition...) are rather easy to program. Students do not have difficulties and even some understand the software advance very quickly to perform the results. They are also guided by the bibliography [6, 7]. We programmed models of machine tool (Fig. 2a – lathe with 2 NC axes and Fig. 2b – milling machine tool with 3 NC axes).

The digital simulation is well appreciated by the students and trainers to anticipate the problems in real machining and to give first information on the surface quality.

2.3. The post-processing and real machining

The post-processors are not the subject of work of students. In this case they have been developed by the

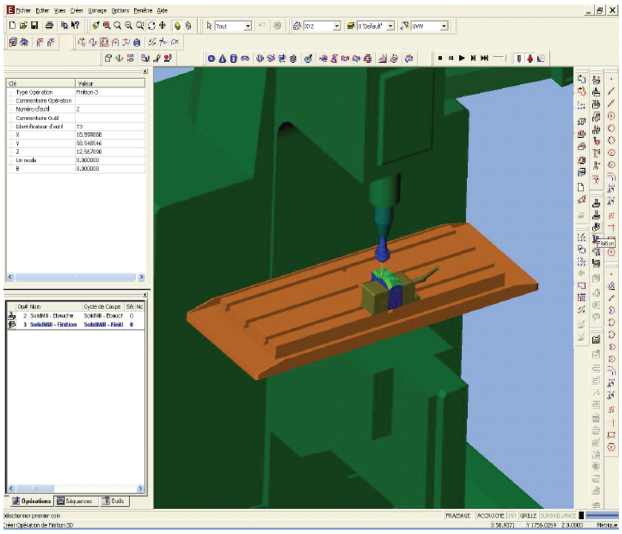

Fig. 2b. 3 NC axes milling machine.

teachers. Note that they were rather easy to develop. This point will be to observe closely at the time of the future work under consideration for a machine (HSM) with 5 NC axes in the course of acquisition at the INSA.

2.4. Assessment

The setting in work of the software ESPRIT it is revealed rather easy. It was carried out by teachers, with the assistance of various trainees. Also let us note specific relations with DP Technology in France (Hot line) and in the United States (one trainee per annum since 3 years). The exploitation led for 3 six-month periods in formation has been well accommodated by the students. The modes of control of acquired knowledge changed (examinations, then a project). However, one can estimate that with this project in partial autonomy, the quantity of the assets doubled in term of know-how but also of knowing, compared to the former organization based on 8 hours of course, exercises and 4 meetings each of them consisting in 4 hours in practical work. The motivation and the responsibility for a spot in binomial seem to be the engines of this progress.

The next stage of development, towards the integration of the aspects of machining process planning through Knowledge Based Manufacturing (KBM) on one

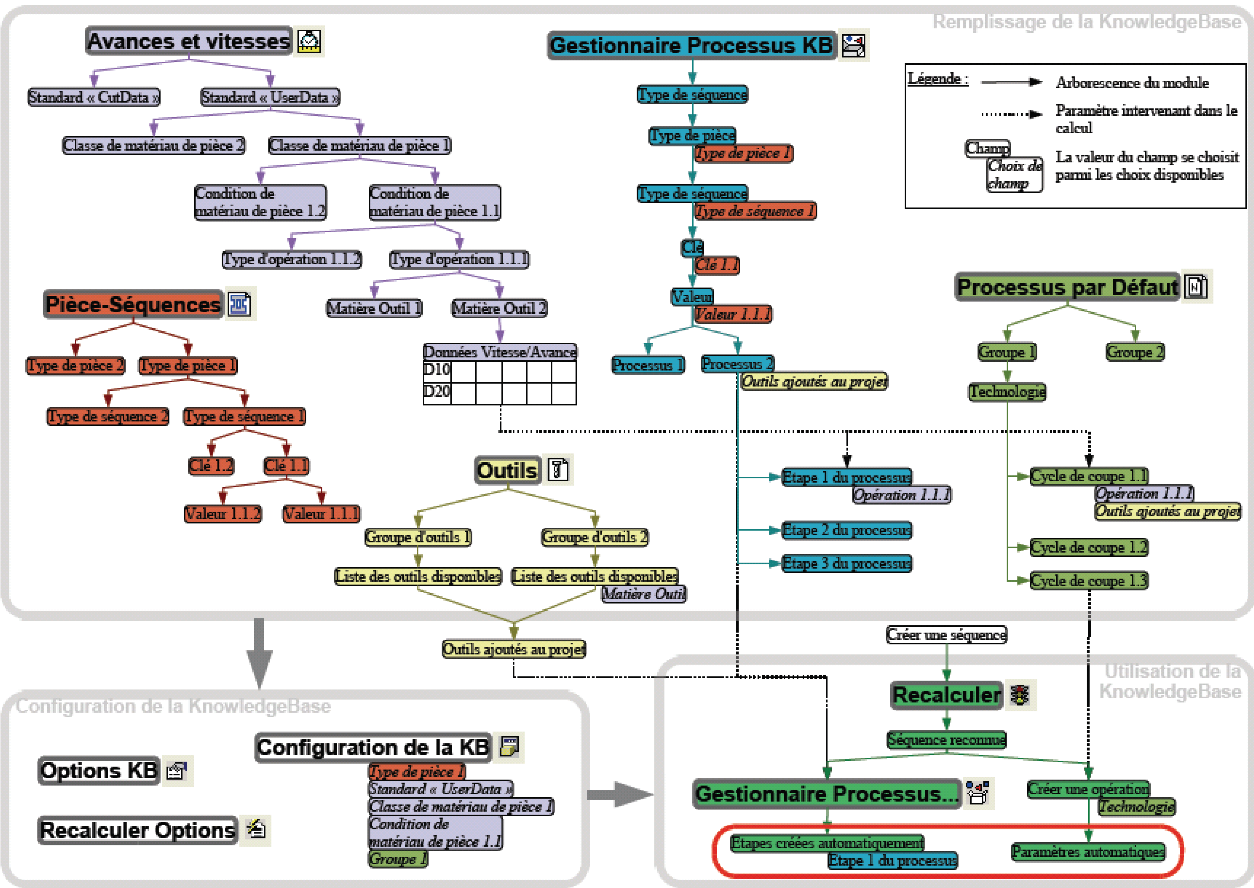

Fig. 3. General outline of the ESPRIT KBM.

hand (Fig. 3), and machining 5 axes HSM on the other hand, will be certainly slower to put in work. It is planned in the 2 years to come.

3. PROSPECTS

3.1. KBM (Knowledge Based Manufacturing)

Currently, we filled the user data bases illustrated by Fig. 3 with some working material characteristics, tools definition and cutting conditions [8] to program the machining of aeronautical parts like that of Fig. 4.

We also use the internal cutting data base. The unit is rather easy to realize for the selected range (forged gross out of alloy of titanium, 2 settings, 5 operations including 3 surface machining, 5 drillings, 1 boring, 1 cavity of pocket).

The changes of matter or order of the operations are rather easy but we do not have yet retreat for the exploitation for the machining of the parts of the same family. Work is in hand.

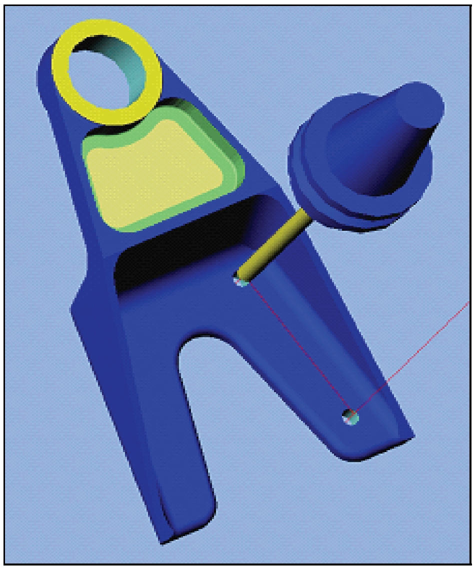

Fig. 4. Machining a fitting for ATR aircraft.

3.2. The virtual machining and the e-Manufacturing

The software is envisaged to be integrated in a unit made up of a 5 axes HSM centre, a lathe and a wire Electrical Discharge Machine (EDM), organized for mixed educational systems, e-learning and face-to-face (courses and trainings). The objective is to control the manufacturing of free form surfaces, more and more used in aeronautic and automotive industry [9, 10]. On the basis of experience gained with ESPRIT, this device should be put in work completely within 3 years on the Rhone-Alps area and with its assistance within the framework of the centres of resources and exchanges between the universities, the centre [11, 12] AIP-PRIMECA of the Western Rhone-Alps (Lyon, Saint-Etienne, Roanne) and the centre AIP-PRIMECA Dauphiné Savoy (Grenoble, Chambéry). This situation will be then extended into the rest of France and abroad with the support of academic and industrial collaborations.

4. CONCLUSION

The exploitation of the CAM software such as ESPRIT was developed by the INSA-Lyon within an academic framework to train engineers. This development has important and rich information for industry also. Two important points are to be noted:

- the numerical model of the machine tool and,
- the KBM.

The numerical model integrates the tool, the tool holder, the system of setting and blocking with the complete kinematics of the machine (bed, table, assembly of the spindle...). With this software, this model can also integrate the changer of tool (turret revolver in turning or loading arm and magazine in milling). The teaching exploitation of this model is interesting because it allows a setting in very realistic situation of the students in formation. From an industrial point of view this function of the software makes it possible to make reliable the numerical chain of the CAM software to the numerical control unit. It makes possible of many simulations to develop the final machining program and limit thus the machining of prototypes. This function makes it possible to consider a real situation of e-manufacturing where the sites of preparation and execution of manufacture are geographically at distance. Moreover this function which makes it possible to very quickly simulate machining in realistic situation is an essential auxiliary for the development of simultaneous engineering in co-operating design where one wishes to very quickly quantify the initial choices of design.

The KBM makes it possible to organize in a very rigorous way the manufacturing process planning. This faculty represents the first interest in training of the engineers. From an industrial point of view this function KBM obliges with a rigorous management of the resources (tools, equipments, machines...) and machined materials, but also it makes it possible to capitalize the uses and the know-how of a real workshop. In this case the organization and the digitalization of information allow an effective preparatory work which can be carried out whatever the geographical distance. The KBM is thus a function which takes part in the development of the virtual machining and the e-manufacturing.

In the current state of the developments at the INSA - Lyon the experiment is geographically limited, but our objective is to extend it by concentric circles the zones of e-manufacturing in France and abroad (Romania, Tunisia, Maroco, ...) to be conclusive for the industrial development.

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