Automatic tool selection module for an adaptive CNC controller

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ABSTRACT – Selecting the proper cutting tool material for a specific work material is a critical activity that has a great influence on the success of machining processes. Proper selection of the cutter can provide significant advantages including enhanced machining operation efficiency, increased machining productivity, improved surface finish quality and reduced cost. However, in current practice, tool selection is done manually and always required experience-based judgement by an expert. Thus, this paper presents an automatic cutting tool selection module for an adaptive STEP-NC compliant controller. The ideas are the native planning decision is done by CNC controller itself.

1. INTRODUCTION

The modern manufacturing systems are required to have several new attributes including, to name a few, high intelligence and automation for autonomy, adaptability and flexibility for the dynamically changing environment, and interoperability for seamless information exchange system [1-2]. Despite many efforts the preparation of the machining process, it still remains bottleneck during automated manufacturing processes in CNC systems [3]. One of the reason is predefined NC commands generated in early stages is often found unsuitable for or unusable by dedicated resources, resulting in useless effort spent in advance process planning and NC code generation. With lack of intelligent capability and use of low-level information in NC code.

Selection of cutting tool is one of activity in process planning. It is time-consuming, knowledge-intensive and a real-time information-based activity, where an experience-based judgement by an expert is always needed for CNC part programming. Selection of the proper cutting tool material for a specific work material is an important prerequisite for success in metal cutting processes. By having the proper tool selection can provide substantial advantages, including enhanced machining operation efficiency, increased machining productivity, improved surface finish quality and reduced cost [4-5]. Traditionally, the process of cutting tool selection was done by manually in early stages as a part of predefined NC commands for specific CNC machine tool. Thus, when new machine tool is employed, the previous NC commands cannot be used and need to be reprogramed back from the beginning.

The aim of this paper is to propose an automatic cutting tool selection sub-module for an adaptive STEP-NC compliant controller to increase the level of autonomy and minimize the need for human intervention or manual inputs. The proposed module will be embedded inside the controller for providing decision making and control abilities.

2. METHODOLOGY

Implementing STEP-NC will allow high level and standardised information to be sustained until machine-level stage [6]. With the availability of high-level information embedded in the new breed of CNC controllers, a new possibility for adaptive control strategies can be realised. In such strategies, the native or specific planning including tool selection, machining parameter and tool paths generation can be done automatically based on available online machine resources information. In this research, generic STEP-NC program will be using as an input. In the architecture of Controller will be developed by using IEC 61499 Function Block layered architecture.

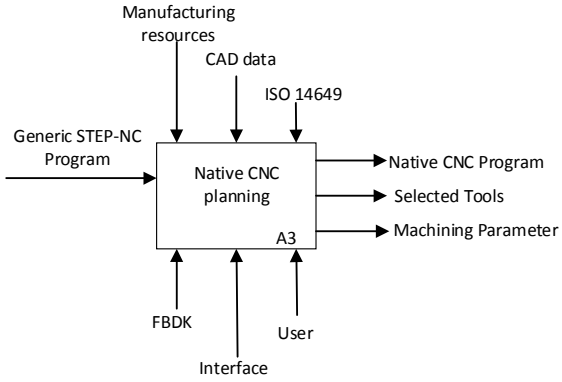

Figure 1. Native CNC planning

In this system, the input for A3 activity module is the generic STEP-NC program file that generated from previous activity module (A2). The generic STEP-NC file will maintain its generic nature until the moment when a controller system populates the process plan with native manufacturing information to generate a native CNC process plan for a specific machine tool (see Figure 1).

In this module, native or specific process planning will be carried out to generate machine tool specific information include the type of tool selection, machining parameter generation and tool-path information. Based on availability and capability of manufacturing resources, all the required native NC program is obtained. As presented in Figure 2, this activity starts with extracting workingstep and its

related information from the input generic STEP-NC file and fed into IEC 61499 controller architecture. Then, the machine tool specific information such as cutter, machining parameter and tool path is generated automatically at this activity model to populate a machine specific NC commands.

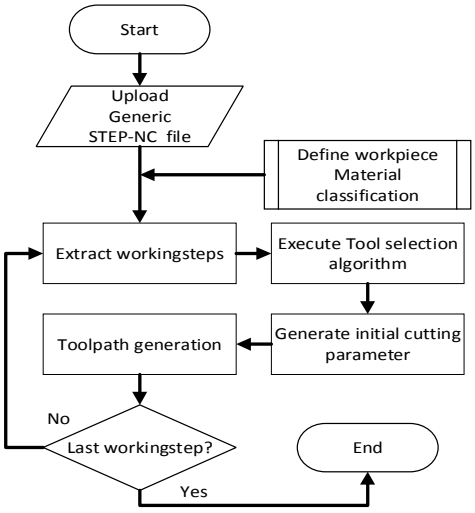

Figure 2. The process flow of native CNC planning

3. CUTTING TOOL SELECTION PROCEDURE

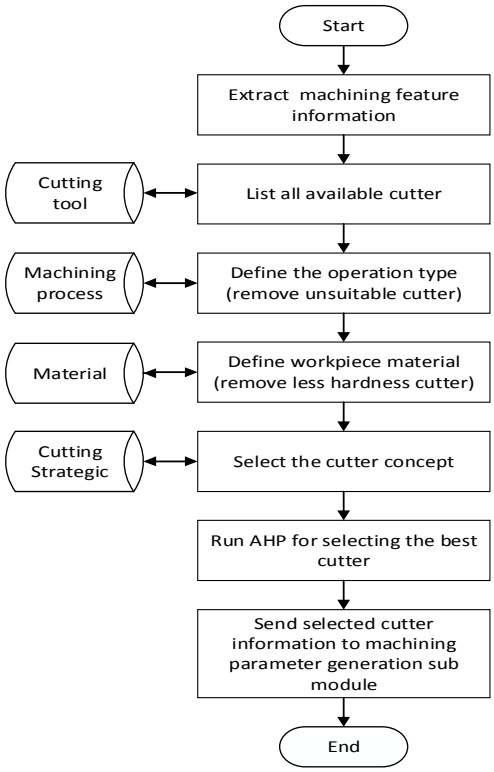

Figure 3. Cutting tool selection procedure

The selection of appropriate cutting tool for a given feature is influencing by several factors such hardness and condition of the workpiece material, type of machining operations, part geometry, available resources and machining performed. Selecting the proper cutting tool for a given feature is a crucial process. It always important to know the difference of each cutting tool material and their correct application and limitation. The main constraint is the selected cutting tool must harder than workpiece material and be able to withstand in operating temperature. The proposed procedure for selecting the most suitable tool is described in Figure 3.

Once the most suitable cutting tool has been decided, the selected cutter information will be sent to the next submodule for the determination of cutting parameter and follow by toolpath generation submodules (as presented in Figure 2). These processes will keep continuing until the last workingstep. The detail of others submodule will have discussed in detail in other papers.

4. CONCLUSION

The wrong choice of a cutting tool can lead to premature tool failure and increase the cost of production. In the traditional approach, it always required expert experience and his/her know how knowledge in selecting best cutter for each given features. A part of this research, automatic cutting tool selection sub-module for an adaptive STEP-NC compliant controller is developed with the aim to increase the level of autonomy and minimize the need for human intervention or manual inputs. IEC 61499 function blocks are uses since it capable in making decisions at the runtime and they are resource driven. So that, if environment changes (such as tool broken or machine breakdown), function blocks can adapt themselves and propose alternatives solution.

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