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NATIONAL TECHNICAL UNIVERSITY COLLEGE OF MALAYSIA

PROCESS PLANNING FOR CNC MILLING MACHINE

Thesis submitted in accordance with the requirements of the National Technical University College of Malaysia for the Degree of Bachelor of Engineering (Honours) Manufacturing (Process)

By

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FACULTY OF MANUFACTURING ENGINEERING

MAY 2006

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DECLARATION

I hereby, declare this thesis entitled

PROCESS PLANNING FOR CNC MILLING MACHINE

is the results of my own research except as cited in the reference.

Signature	:	.....
Author's Name	:	CHAN TAI TIONG
Date	:	15/05/2006

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ABSTRAK

Pembelajaran ini adalah termasuk pengaturan proses yang berkaitan dengan persediaan untuk *route sheet* bagi mengemukaan operasi yang set teratur dan tempat kerja utama supaya memenuhi pada pengeluaran produk dan komponen. Pada pengurusan komputer iaitu peralatan mesin, kaedah cara operasi dan digunakan dalam kebanyakkan cara proses untuk pembuatan yang dilukis dengan cara *solid modeling*. *Computer-Aided Process Planning* (CAPP) sistem adalah cara aplikasi yang sempurna untuk teknik *expert system* dalam pembuatan. Aplikasi CAPP sistem adalah bertujuan dalam kawasan dibawah kawalan oleh pembuatan. CAPP sistem adalah kurang mempertimbangkan status kemudahan dalam membuat keputusan. CAPP sistem adalah kritikal diantara *Computer-Aided Design* (CAD) dengan *Computer-Aided Manufacturing* (CAM) untuk melaksanakan pelan proses dengan secara automatik. Secara keseluruhannya, CAD/CAM masih tidak menyatukan dengan CAPP modul. Oleh itu, penyelidikan ini adalah bertujuan untuk membina CAPP sistem supaya menyelesaikan masalah seperti bahagian komponen prisma yang membolehkan permukaan menjadi sempadan bersama antara dua bahagian kepada CAD sistem. Progam utama yang dibina adalah oleh *Visual C++* dan bahagian dengan pangkalan data pembuatan. Meraka adalah peralatan pemotongan pangkalan data, bahan pangkalan data, dan lukisan pangkalan data. Program yang utama akan membaca data dari *DXF file* dan *TXT file* yang akan mengeksportkan dari *AutoCAD*. Contoh bahagian akan dibina oleh *AutoCAD* Apabila program dilaksanakan, operasi yang teratur akan melakukan dengan pada pilihan bahan, pemotongan dan parameter pada sesuatu produk tersebut. Pembinaan cara ini adalah disediakan pada komputer yang menggunakan bahasa C++ untuk tujuan ini dan menerangkan dengan contoh.

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ABSTRACT

This study includes process planning that concerned with the preparation of route sheets that list the sequence of operations and work centers required to produce the product and its components. On the computer controlled machine tools, operation methods and mostly used process types in manufacture are drawn with solid modeling. CAPP system application has tended to be within the machining domain in manufacturing. CAPP systems rarely consider facility status in decision making. The CAPP is a critical link between CAD/CAM in order to perform a process plan automatically. General CAD/CAM is still not integrated with CAPP module. Therefore, a skilled operator is needed to work with the CAD/CAM. This research aims to develop CAPP system to solve such problem for prismatic parts that can interface to CAD system. The main program that developed by Visual C++ and the part deals with manufacturing databases. They are cutting tools databases, material databases and drawing databases. The main program reads data from a DXF file and TXT file that is exported from AutoCAD. The sample part is created by AutoCAD. When the program is performed, the operation sequence is generated as well as material, cutting and parameter selection of the product. This developed method was prepared on PC by using C++ programming language for this purpose and is explained with a sample.

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DEDICATION

I am as ever, especially indebted to my parent, siblings and friends for their love and support throughout my life

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

CNC	Computer Numerical Control
NC	Numerical Control
B-Rep	Boundary Representation
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
CAPP	Computer-Aided Process Planning
IGES	Initial Graphics Exchange Specification
PDES	Product Data Exchange Specification
STEP	Start for the Exchange of Product Data
CSG	Constructive Solid Geometry
BOM	Bill of Material
WIP	Work In Process
GT	Group Technology
SDLC	Software Development Life Cycle

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CHAPTER I
INTRODUCTION

1.1 Overview

Nowadays, the use of computers and communication technologies in the manufacturing industries is rapidly becoming widespread in order to increase production, reduce costs and produce better quality products in design and manufacturing sectors. It is now compulsory to use CAD/CAM system to produce a qualify product with a cheaper cost for cheap and good quality products in manufacturing.

Although, it seems that CAD and CAM are independent modules, in fact they are directly integrated with computer-aided process planning (CAPP). As it is, the starting point and first station of CAD/CAM integration, design is the main feature of computer integrated manufacturing (CIM). With the help of CAD activities, a model can be designed and presented to the production line with a minimum time and effort.

Process planning is a plan that decides how to manufacture a work part according to its design properties and find the parameters and necessary production methods in order to transform raw material into a product. The development software has huge databases including knowledge, which is based on expertise.

In the CAPP particles, determination of sequence of operation and operation type, selection of cutting tool and the module for cutting parameter are directly related to each other. Data are formed by the computer recognizing the process part by determining the operation type and sequence and cutting parameters data files are

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used for determining cutting parameters together with the selection of cutting tool and holder.

In order to achieve operation type and sequence of operation, operation type and sequence operation data, tool holder selection and cutting parameter data files are used, respectively. However, CNC part program generation and simulation of operations are performed by using constructed data files which are derived from part program generation and simulation modules which use these databases, respectively. If one of these modules is absent or functions insufficiently, it will be prepared by hand. In this case the main aim of the CAD/CAM integration will have collapsed. For full integration of CAD/CAM all modules should be determined automatically by the aid of a computer.

The CAPP is a critical link between CAD/CAM in order to perform a process plan automatically. General CAD/CAM is still not integrated with CAPP module. Therefore, a skilled operator is needed to work with the CAD/CAM. This research aims to develop CAPP system to solve such problem for prismatic parts that can interface to CAD system. The main program that developed by Visual C++ and the part deals with manufacturing databases.

1.2 Problem Statement

The CAPP project is purposely developing to help the process planner project system's user, to overcome the manufacturing and process plan problem that faced by the most manufacturing field since established until today.

The most significant problem that exist in the most manufacturing field is lack of computerize system to aid the process planning on the product. The following statement simply clarifies the result from the observation.

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a) Excessive Clerical Content

The paperwork generated by manual process planning is excessive and is an inefficient use of engineering staff. It is also very labour intensive due to the excessive paperwork.

b) Lack of Consistency Planning

There are many ways to manufacture even the simplest of components. The plan developed for any given component will reflect the process planner's knowledge and experience, and different planners might manufacture the same part completely differently. This leads to a lack of consistency in the process planning for similar parts if carried out by different process planners.

1.3 Objectives

a) Reduce time spent on process planning

- Process planner working with a CAPP system can provide route sheets in a shorter time compared to manual preparation. Route sheets can be prepared more quickly compared to traditional handwritten routing sheets.

b) Improve productivity

- The systematic approach and the available of standard process plans in the data files permit more work to be accomplished by the process planners.

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c) Process rationalization and standardization

- Automated process planning leads to more logical and consistent process plans than when process planning is done completely manually. Standard plans tend to result in lower manufacturing costs and higher product quality. Besides, it is also improve accuracy and consistency of process plans.

d) Retrieved new product

- Process plan can be prepared for having similar shapes and features, and they can be retrieved easily to produce new parts.

1.4 Scope Project

a) Step by step process planning

The system will prompt and enable user to input some required data and process those data to generate all the manufacture process steps logically. The process steps are display sequentially and each step provides all the processes calculation such as spindle speed, depth of cut, cutting power and etc.

b) Machining process calculation

Each of the process steps contains the machine tool, power machine, work piece material, tool type, operation type, tool diameter, tool material, depth of cut, deep of cutter, cutting speed, spindle speed, feed rate, cutting force, power, torque and efficiency.

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c) Selection on 3 types of material input

The system allow user to select the raw material type from the menu, the selection includes mild steel, brass and aluminium. The machining process calculation may vary based on different types of raw material input that select by user.

d) Direct interprets DXF file content and generate the process steps flow

Simplest way to make a process planning by input the file path of the finish part DXF file. User will be prompt to enter the DXF file path of the CAD drawing and system will direct interprets the file content to generate the process steps flow.

e) 5 types of cutting type (face mill, end mill, center drill, drill bit, counter bore)

The system is able to determine the cutting type of each process steps. There are 5 types of cutting which are face mill, end mill, center drill, drill bit and counter bore.

f) Calculation of roughing and finishing operation

For face milling and end milling, the process steps will indicate that it was roughing cutting or finishing cutting. Besides that, the number of roughing and finishing operation needed for each step will also be shown in bracket.

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g) Determine the depth of cut on work piece and deep of cutter

The system will determine the depth of cut on work piece for each step and the deep of cutter use for it.

h) Input raw material dimension parameter for calculation (length, width, thickness)

Besides the DXF file path, the user also will be required to provided the value of raw material dimension, therefore the system can process the calculation and steps. The dimension will be the work piece length, width and thickness.

i) Instruction menu and message prompting when inappropriate input value

Once the system is running, the system will display the instruction for user. In order to make user more understand on how to enter the valid input, there is example of input show for user to refer. Notes section ensure user know how to start over the system or quit from system by enter appropriate character, for example, enter "s" to start over the system and enter "q" to quit the program. If user enters inappropriate value, error message will be shown and the valid input will display for user.

j) Rerun system or exit from system anytime when system running

System user was able to rerun and exit from the system whenever they want. For example, enter "s" to start over the system and enter "q" to quit the program. This option can be done during each input prompting for raw material dimension.

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CHAPTER II
LITERATURE REVIEW

2.1 Introduction

Literature review can be defined as a background study about the knowledge and information needed to develop a project. In order to develop a complete and really functional project in the reality, a literature review is necessary to go through before start to analysis and design the project.

Literature review for the Process Planning project is starting on the beginning of the project planning phase. Information and knowledge that gather from the industrial training, internet (online discussion or newsgroup) and related reference books for Process Planning had eased the process of the literature review.

Literature review can be done by refer to the theories and concepts that published and declared by expertise or celebrity that in the related fields. Besides, case study on the existing similar projects is one of the effective methods for literature reviews too.

The advantages and significant of the literature review are that it helps to determine the project scopes and features that are necessary in the intended develop project. Further more, case study are helpful to avoid the system weakness that may found in the similar review's projects. On the other hand, enhancement of the similar projects can be done to overcome the existed weakness.

The importance of the case study on the existing projects that are similar with the Process Planning is obvious because it helps to determine the intended develop

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Process Planning features and how it should look like. By doing the literature review before start to analyze of the project would result in success development and implementation of the Process Planning.

2.2 Definition of Process Planning

A simple job shop, with only a few machines, can do process planning using experience and intuition. But, as the size of the factory grows, and the permutations and combinations of options grows, so does the complexity. This creates a need for specialists called Process Planners who use their experience and detailed knowledge to select the method of production. According to Requicha and Vandenbrande in 1988 that describe the task of process planning as:

"A process planner and a set-up planner (often the same person) examine a part's blueprint and consult various files and handbooks to produce a process plan. A plan contains process specifications and information on fixtures and clamping devices to be used, and on set-up of the work-piece on a machine tool. Set-up specifications are typically conveyed through annotated sketches or engineering drawings."

Besides, they also describe the process planning operation as a two step process, as shown in Figure 2.1.

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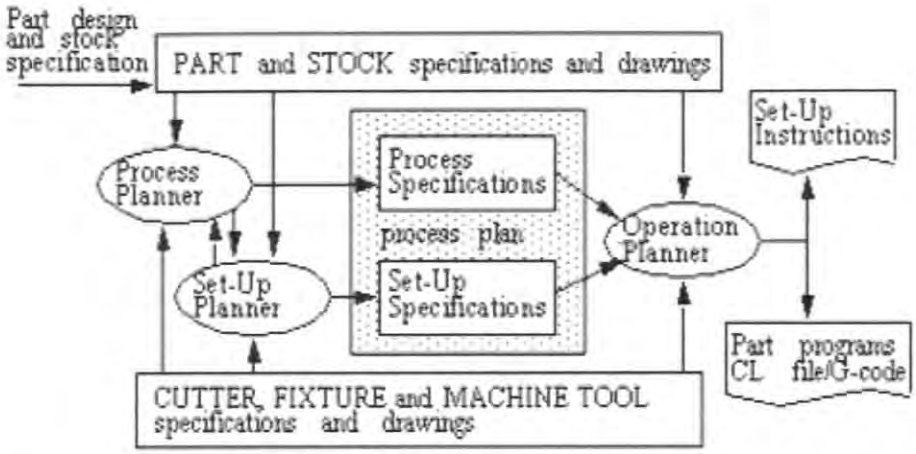

Figure 2-1: Traditional Two-Stage Approach To Process Planning

(Adapted from Requicha & Vandenbrande, 1988, pp.302)

The first step involves the abstract phases of Process Planning and Set-up Planning. In the second stage, Operation Planning is used to assign details to the operations in the process plan. The final result of process planning can be as shown in Figure 2.2. This sheet emphasizes the ad-hoc nature of data identification, and plan completeness. Many details are cryptic, or must be completed at the machine by the operator.

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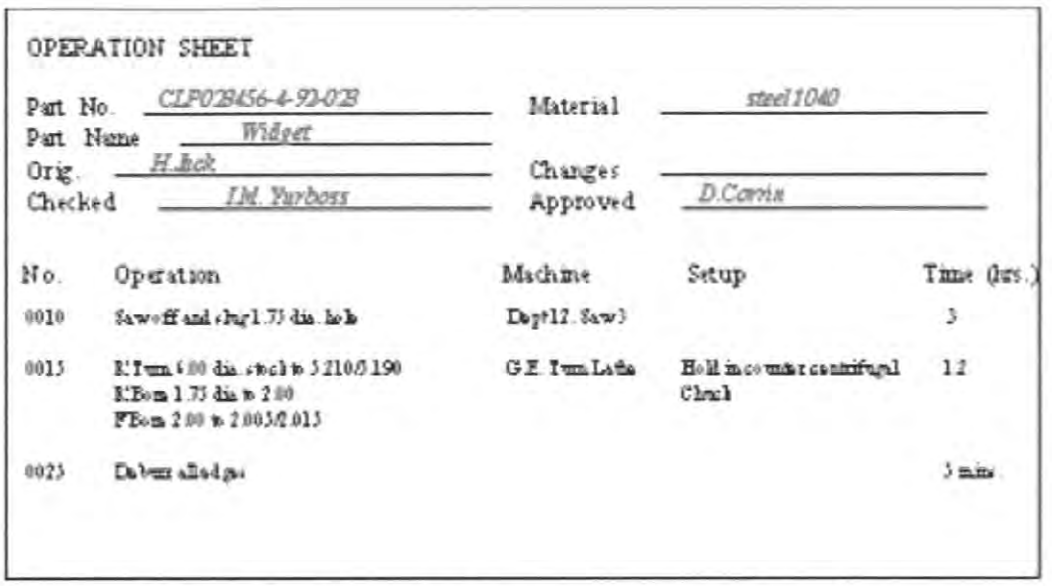

OPERATION SHEET

Part No. CLP023456-4-92-023 Material steel 1040

Part Name Widget

Orig. H.Jack Changes

Checked I.M. Yurboss Approved D.Corrin

No.	Operation	Machine	Setup	Time (hrs.)
0010	Saw off and chg 1.75 dia. bar	Dept 12 Saw 3		3
0015	R Turn 4.00 dia. stock to 3.210/3.190 R Bore 1.75 dia to 2.00 F Bore 2.00 to 2.005/2.015	G.E. Turn Lathe	Hold in conventional centrifugal Chuck	1.2
0025	Deburr all edges			5 min.

Figure 2-2: A Sample of a Process Plan Found in Industry

The details in a process plan can have a profound impact on the cost of a product and this makes many manufacturers justifiably cautious about change. Employees that do process planning are often long-term employees with a great deal of experience. Companies recognize that it is difficult to capture the knowledge of these individuals. One of the first types of Computer Aided Process Planning (CAPP) systems is generally classified as Variant. According to Nolan 1989, these systems `look-up' plans created previously and allow them to be edited to suit new parts. These systems have not replaced the process planner, but they have increased productivity, decreased costs, and reduced mistakes. To date these have been the most successful planners used in industry.

2.3 Definition of Computer-Aided Process Planning (CAPP)

Manufacturers have been pursuing an evolutionary path to improve and computerize process planning in the following five stages:

Stage I - Manual classification; standardized process plans

Stage II - Computer maintained process plans

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