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# **Mould Design and Manufacturing Using Computer Technology**

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## **ABSTRACT**

This thesis presents a research work carried out at the Institute of Technology and Engineering of Massey University. The overall goal of the project is to develop an integrated mould design and manufacturing system for teaching and research. The development involves establishing a computer-aided design, computer-aided manufacturing, CNC machining, and injection moulding program for Technology and Engineering undergraduate and postgraduate students. An integrated CAD/CAM/CAE and CNC system has been established through this project. Four laboratory courses together with the tutorials have been developed and established. This design and manufacturing system and the corresponding laboratory courses provide a great support for Engineering Design and Manufacturing programmes. The laboratory courses give the opportunities to the students to gain the experience from concept design, through hands-on project, to the final physical product.

The research work presented went through four stages. Before this project started, the Institute of Technology and Engineering (ITE) had a stand alone CNC milling machine, a CNC lathe, an injection moulding machine, a limited number of PCs and a few CAD licenses. The first stage was to develop an integrated CAD/CAM/CAE and CNC system based on the existing facilities in ITE and the limited funding provided by the fund of innovation and excellence in teaching. The second stage was focused on product design. It was realized that a product is needed for the development of this project. This product must have the features to demonstrate the applications of computer-aided technologies in product design, analysis and manufacturing. The product must also be a plastic component in order to smoothly integrate plastic injection moulding technologies within the programme. Stage three was to build and produce the die set of the product, which involves mould design and analysis, simulation, testing, tooling, and actual CNC machining. The final stage was to develop the laboratory courses, write the tutorials and produce a demonstration program. Four lab courses and the tutorials were developed,

which cover CAD, CAM, CNC, and injection moulding. These labs provide students with hands-on and practical experience.

The project has been successfully completed. The demonstration program is now used for ITE's open day and other occasions such as visitors from industries, high schools and other organisations. The four lab courses are now taken by 3<sup>rd</sup> and 4<sup>th</sup> year B.Eng and B.Tech students in the Institute of Technology and Engineering.

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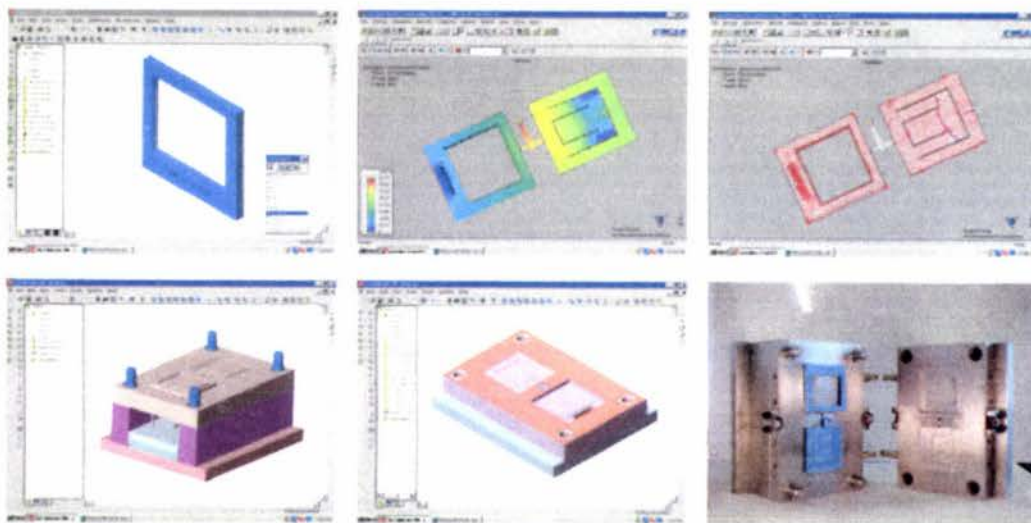
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# **1. INTRODUCTION**

The Institute of Technology and Engineering (ITE) is an industrial-oriented Institute at Massey University. It offers a number of undergraduate and postgraduate Engineering programmes. In order to meet students' requirements and challenge in the competitive market, the Institute is moving towards the direction of delivering high quality, motivated, computer-based, up-to-date educational programmes. The project presented in this thesis is supported by the Institute with the focus to develop An Integrated Mould Design and Manufacturing System for undergraduate teaching.

The development of such an integrated mould design and manufacturing system involves developing a product to integrate CAD/CAM, CNC machining and injection-moulding techniques. It is important to come up with a product that would motivate the learning spirit of the students. This led to the idea of producing a souvenir for Engineering and Technology students, which can be memorabilia to be proud of and to portray study within the Institute. The souvenir is also expected to motivate students into learning mould design and manufacturing using CAD/CAM systems, moulding process analysis and simulation, CNC machining and injection moulding techniques. Researching, brainstorming and discussions led to a few possible choices. 3D computer models of the souvenirs were first built in the CAD system. Prototypes were then successfully made. Following the prototype development, two models, one is the business card holder, the other is the picture frame, were chosen as the souvenirs to be the outcome of the mould design and manufacturing lab course. The development of the lab content to produce the die set of the souvenir was then carried out, which includes mould design, building the assembly computer models of the die set and plastic moulding analysis. Manufacturing process planning and CNC simulation were carried out using CAM systems, which then successfully generated the CNC code for the machining of the moulds. The core and

cavity plates were finally machined out using the CNC machines in the workshop. Fig. 1 presents an illustration of the design and manufacturing process from the concept design to the final product. The lab course provides the students with an opportunity to face the real problems in mould design and manufacturing and gives them a hands-on opportunity in mould design, analysis, CNC machining and injection moulding. At the end of the course, students are required to hand in the project report which includes the computer models of the product and the die set, mould analysis and simulation results, and the results of CNC simulations of the core and cavity plates for the CNC machines in the workshop.



**Figure 1-1 From concept design to final product.**

## **1.1. FACILITIES IN ITE**

The Institute of Technology and Engineering does have a CAD Lab and an Engineering Workshop. When the project started, the facilities available in the CAD Lab were a few Pentium 133 PCs and a few Solidworks 98 licenses. In the Engineering Workshop, there is an old CNC milling machine, a CNC lathe and an injection moulding machine. In

order to establish an integrated CAD/CAM/CAE and CNC environment, the Institute equipped the CAD Lab with new computers and up-to-date software such as the latest version of Solidworks, new arrival of Camworks, C-mould etc. With the new facilities arrived, an integrated system was able to be quickly established. However, as the CNC machine tool is an old model, it eliminated some of the powerful functions the new software provided. At the same time, some unwanted problems came out, such as the compatibility between the software and the hardware. A solid understanding of the facilities in the workshop and the new software was required in order to build a smooth communication between the hardware and the software.

## **1.2. MOULD DESIGN AND MANUFACTURING**

Mould design and manufacturing are important parts in manufacturing industry. So many approaches are presented to shorten the product development cycles for developing a new product such as domestic appliances and car parts. As the products become more complicated, especially in free-form shapes, thin wall thickness and the complex moulding parts, to satisfy these requirements the quality of the product is now depending on the use of new technologies and the know-how human resources. In recent years, PCs have become more and more powerful and the price has significantly dropped. It is no longer a big issue for small and medium-size companies to afford PCs. At the same time, CAD, CAM and CAE systems have become more and more popular. There are so many CAD, CAM and CAE packages on the market to select for using in mould design and manufacturing field. The application of computer technologies requires today's engineers to be familiar with computer techniques, especially in an integrated CAD/CAM/CAE environment. On the other hand, universities are facing the demanding of producing graduates with the matching knowledge and skills.

This project developed an injection moulding lab course which aimed at the application CAD/CAM/CAE technologies in mould design and manufacturing. This lab provides the information about mould design rules, prediction of the problems which may occur during the injection moulding process, such as poor unbalanced runner system, vent location, weld-lines etc. It also provides students with an opportunity to use CAD/CAM/CAE and CNC techniques such as the simulation of injection moulding process, the selection of machining parameters and the simulation of CNC machining.

### **1.3. THE OBJECTIVE OF THE PRESENT WORK**

To fulfill the main target of this project, which is to develop an integrated mould design and manufacturing system for undergraduate teaching, several objectives were set which involved developing an integrated CAD/CAM/CAE and CNC environment and the corresponding the lab courses.

#### **1. Develop a product for the lab courses**

Design a product which has features to demonstrate the techniques of CAD, CAM, CAE, CNC and injection moulding. The product is also suitable for using as an example for undergraduate teaching.

#### **2. Establish an integrated CAD/CAM/CAE and CNC system**

Based on the facilities available to build a smooth link between the hardware and the software. This requires a detail study both in the CAD lab and the workshop to totally understand the functions and the requirements of the software and the capabilities of the machine tools and the controllers.



### 3. Build the die set

According to the size and the capability of the injection moulding machine and the CNC machine tools in ITE's workshop, design and manufacture a die set to produce the product.

### 4. Make the physical product

To make the physical product requires choosing the proper material, assembling the die set, testing the injection moulding machine and fine tuning.

### 5. Develop the CAD, CAM, CAE lab courses

Develop the hands-on mould design and manufacturing lab courses including the tutorial guides.

Chapter 1 of this thesis is an introduction of the present work and Chapter 2 the product design and the requirements. Mould design and manufacturing are discussed in detail in Chapter 3. The structure of dies and the manufacturing process and the integrated mould design and manufacturing system are dealt with in Chapter 4 and 5. Chapter 6 presents the outcome of this project and the discussion and conclusions.