PREDICTION OF PROBLEMS IN INJECTION MOULDED PLASTIC PRODUCTS WITH COMPUTER AIDED MOULD DESIGN SOFTWARE

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ABSTRACT

Several new technologies to assist plastic injection moulding companies have been developed in the last twenty years. A number of computer software programs are now available which could revolutionise mould design. The most exciting aspect of the Computer Aided Mould Design (CAMD) software is the effect it has on reducing the lead time required to produce a working mould from a product concept.

The application of the new technology for designing moulds, however, has been slow in New Zealand. One of the main reasons for the slow progress is the perceived value of the software or consulting services. Many injection moulding companies who design and manufacture moulds do not realise the great potential of CAMD software to save many hours of mould changes and volume of polymer material, even when the program is used after the mould has been made. However, the true benefits are only seen when the mould is designed using CAMD before the mould has been manufactured. Moulds manufactured correctly the first time save a great deal of time, energy and money. The value of the software is not completely understood by injection moulding manufacturers. They perceive the immediate benefits, however, the ongoing benefits are not recognised.

A project was carried out to demonstrate the potential of CAMD software in determining moulding problems in existing injection moulded products. Four products, two of which were supplied by an injection moulding company, that had moulding problems, were simulated using Moldflow, a CAMD software package. The results of the simulation were compared with the actual moulding problems.

It was found that the Moldflow simulation results described the problems occurring in the moulds accurately. Moulding problems included warpage, air traps and weld lines in poor positions and flow marks. Warpage is a major problem in injection moulded products. Even simple products can warp if not designed correctly.

The only problems Moldflow did not identify, and does not claim to, were the flow marks caused by jetting and splashing of plastic as it entered the cavity. The designer must be aware of the problems caused by jetting and design gates to avoid it.

Moldflow, and other CAMD software, are beneficial tools for the mould designer. The advantages of CAMD include short mould development time, shorter lead times from concept to production, reduction in the amount of material used, fewer changes to machine settings and predictable, repeatable quality. These benefits are not only savings in the mould design and manufacture, they also continue on into the processing of the product since less material is used in the product and machine down time caused by moulding problems is greatly reduced.

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My life journey has given me eternal hope in Jesus Christ and I must finish by giving Him thanks for the endless grace, peace and love He gives.

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CHAPTER ONE

INTRODUCTION TO MOULD DESIGN

Mould design for the injection moulding process has changed from a technique requiring years of experience to one that incorporates experience and design simulation. This chapter gives a brief overview of the evolution of Computer Aided Mould Design software, presents a summary of the body of this thesis and introduces the hypothesis this thesis addresses.

1.1 Summary

Injection moulding is the most widely used process in the plastics industry for manufacturing plastic products. The injection moulding process requires three main components; an injection unit, a clamping device and a mould. The mould is the subject of this thesis, in particular, the design of the mould, how well Computer Aided Mould Design (CAMD) software can predict moulding problems and how useful the software is as a cost effective adjunct to the mould designer's judgment.

In the past, mould design has been an art, rather than a science. This is mainly due to the difficulties in moulding polymers into the required shapes using a high pressure process like injection moulding. The characteristics of polymer flow under high pressures and the intricacies of the injection moulding process were understood by very few designers, hence many designs required a great deal of rework before reaching production status. This continues to be a problem with mould design since the rheology of polymers under high stresses and changing temperatures is complex and difficult to solve.

The problem could not really be overcome until computers with the power to solve the complex simultaneous flow and heat equations were available. Now that these computers are available, it is possible to not only solve the equations, but also provide graphical results that give a clear picture of what occurs in the mould as the polymer flows through it, cools and freezes. These displays are available in software packages specially designed for assisting in the design of injection moulding moulds.

The software packages are aids to the designer. A good mould designer is required to analyse the output from the mould model simulation and make the necessary changes to the model to improve the design. The designer requires not only training in using the software package, he/she also requires knowledge of the properties of polymers and mould design procedures and concepts. The latter requirements may take several years to build up to a point where the mould designer is proficient at what he/she does.

A survey carried out in 1994 by Xaioping Pan discovered that 83% of the New Zealand plastics industry realised that "tool and die making had become an important part of the New Zealand Plastics Industry." Several of the comments from the industrial survey included: "In an effort to become cost competitive, die making and design is a key component." "High quality tool and die making is a key to success." "Sometimes it is the limitation of the die or tool that prevents the product being made."

The Production Technology department is eager to develop expertise in injection moulding technology. This thesis is part of the development. Moldflow, the sophisticated mould design software has been made available to the department for teaching and research purposes by Moldflow of Australia.

The introduction to this thesis will describe the project objectives in section 1.2 and the outline of the thesis in section 1.3.

1.2 Project Objectives

There are three distinct objectives this thesis addresses:

1. To determine the benefits of computer software for the analysis of injection moulds through verification techniques. This will be carried out by studying several products, analysing them using Moldflow and drawing conclusions regarding the effectiveness of the software to predict moulding problems in the mould design.

2. To increase the Production Technology Department's awareness of available technology for injection moulding.

3. To develop an understanding of the concepts behind Computer Aided Mould Design software.

Hypothesis : Computer Aided Mould Design software can accurately predict moulding problems, namely: quality, processability and in-service requirements in a product that are not met.

1.3 Outline of the report

Mould design is an important part of the moulding process. A well designed, manufactured mould will not only last, it will also be able to produce a consistent product. Mould design can be complicated, especially when small tolerances, thin sections and complex structures are required. A design that performs the task well may not necessarily mould well in the injection moulding machine. It is therefore important to use a procedure to design the best possible mould.

Computer Aided Mould Design is a major development in the mould design field. However, it has not, as yet, been widely adopted in New Zealand. More companies are beginning to see the rewards of such a product, but this has been slow. Gallagher Plastics and Fisher and Paykel are two New Zealand companies who have begun to use CAMD in the last five years. Other companies, such as Whitfield Design, Sunbeam and Coxen and Standish have utilised the services of one or more of the CAMD consulting agents in New Zealand or Australia. Mould designers may require further educating in the benefits of Computer Aided Mould Design so that they may understand and see the real benefits of such an aid. Most injection moulding companies who have used CAMD consulting in the past have considered the cost of the analysis too high and have discarded the need for it.

To gain an understanding of the great potential of Computer Aided Mould Design software, a familiarity with the injection moulding process and the rheology of polymers is required, as well as a solid grasp of mould design. This thesis includes a discussion of the mould design tools currently available. The background sections will be followed by the reasoning behind using CAMD. Chapter 4 develops the research methodology and chapter 5 presents the projects that have been carried out using one of the software packages. The aim of these projects was to determine the ability of Computer Aided Mould Design software to predict possible problems that occur in the mould. These problems may relate to warpage, poor material flow, poor design, air traps, etc which result in poor product quality, poor processability and in-service requirements that are not met.

A discussion of any further work that could be carried out in this area and an overview of the results of the projects concludes the thesis.