OPTMIZATION OF MOLDING PARAMETER EFFECT TO WARPAGE AND SHRINKAGE OF LABORATORY GOGGLE BASED ON PLASTIC FLOW SIMULATION SOFTWARE

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BORANG PENGESAHAN STATUS TESIS

JUDUL: **OPTIMIZATION OF MOLDING PARAMETER EFFECT TO WARPAGE AND SHRINKAGE OF LABORATORY GOGGLE BASED ON PLASTIC FLOW SIMULATIUON SOFTWARE**

SESI PENGAJIAN: 2010/2011

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UNIVERSITI MALAYSIA PAHANG

FACULTY OF MECHANICAL ENGINEERING

We certify that the project entitled " *Optimization of Molding Parameter Effect to Warpage and Shrinkage of Laboratory Goggle Based On Plastic Flow Simulation Software* " is written by *Mohd 'Afif B Abd Aziz.* We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

Examiner Signature

IR AHMAD RASDAN B ISMAIL

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MOHD ‘AFIF B ABD AZIZ

Thesis submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Manufacturing Engineering

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NOVEMBER 2010

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

Signature :

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Date : 6 December 2010

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :

Name : Mohd 'Afif b Abd Aziz

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Date : 6 December 2010

Special thanks to my parents on their support and cares,

En. Abd. Aziz B Mohd Nor

Pn. Rohani Bt Abu Bakar

Also for my siblings.

Special dedications for my supervisor,

En. Mohamed Reza Zalani Bin Mohamed Suffian

On his guiding towards my project

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ABSTRACT

This thesis is about how to optimization of molding parameter effect to warpage and shrinkage. The product that will be use is laboratory goggle. The objective of this thesis is to analyze the parameters effect in injection molding to warpage and shrinkage of laboratory goggle and to determine the optimization of molding parameter effect to warpage and shrinkage of laboratory goggle during injection molding based on plastic flow simulation software. The thesis describes the moldflow software how to analyze frame and glass of laboratory goggle to identify the parameter effect to warpage and shrinkage of the product .. It need to scanning the frame and the glass of laboratory goggle and it need to use a 3D scanner machine. Then, transfer the shape and result to the solidwork software and find the dimension of the frame and glass to draw a new shape using solidwork software. Next, import the frame and glass from solidwork to the moldflow software and analyze the product. Make a optimization of the product from warpage and shrinkage. In this project, parameter in injection molding of laboratory goggle needs to define. The parameter includes mold temperature, melt temperature, injection time, and packing pressure. According to result from moldflow software, in conclusion the factor that influence the molding process it is pressure, temperature, molding temperature, molding cool must be in a correct position because it will be give a effect if the factor is not suitable.

ABSTRAK

Tesis ini adalah tentang bagaimana pengaruh cetakan mengoptimuman parameter untuk melenting dan menyusut. Produk yang akan digunakan adalah goggle makmal. Tujuan tesis ini adalah untuk menganalisis pengaruh parameter dalam cetak suntikan untuk melenting dan menyusut goggle makmal dan menentukan optimas kesan cetakan parameter untuk melenting dan menyusut goggle makmal selama injection molding didasarkan pada perisian simulasi aliran plastik. Tesis ini menjelaskan perisian moldflow bagaimana menganalisis bingkai dan kaca goggle makmal untuk mengetahui pengaruh parameter untuk melenting dan penyusutan produk .Hal ini perlu mengimbas bingkai dan kaca goggle makmal dan perlu menggunakan mesin pengimbas 3D. Kemudian, pemindahan bentuk dan hasilnya ke perisian solidwork dan mendapati dimensi dari bingkai dan kaca untuk menggambar bentuk baru menggunakan perisian solidwork. Selanjutnya, ambil sampel bingkai dan kaca dari solidwork ke perisian moldflow dan menganalisis produk. Buatlah optimalisasi produk dari melenting dan penyusutan. Dalam projek ini, parameter dalam cetakan suntikan goggle makmal perlu untuk ditakrifkan. Parameter ini meliputi suhu mold, meleleh suhu, masa suntikan, dan tekanan pembungkusan. Berdasarkan hasil dari perisian moldflow, dalam kesimpulan faktor yang mempengaruhi proses pencetakan itu tekanan, suhu, suhu molding, sejuk molding harus berada dalam kedudukan yang betul kerana akan memberikan kesan jika faktor tersebut tidak sesuai.

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INTRODUCTION

1.1 INTRODUCTION

Injection molding is a critical component fabrication technique in medical device manufacturing. Therefore, any method that can be employed to reduce costs associated with it is of much interest to device makers. This article examines how principles of lean manufacturing can be used in injection molding processes to eliminate waste and reduce costs.

In recent years, plastics have begun to show great commercial potential, especially in manufacturing micro structured parts. Injection molding is the most important process to manufacture plastic parts. While many prototype plastic micro devices are fabricated using precision engineering methods, such as laser machining, microinjection molding is currently being investigated all over the world. An important advantage is that injection molding with complex geometries becomes available in one automated production step.

Then, for part warpage, either soon after molding or at some time in-service, is a problem Frequently experienced by injection molders and, at times, also by extruders. Similar to Mold shrinkage, the causes and control of warpage are closely related to inherent Material characteristics and the laws of heat transfer. In this Technical Tip, it will explain the causes and general guidelines to minimize warpage. It should be noted that warpage, like mold shrinkage, is a very complex mechanism and many factors, other than those mentioned here, have an effect on warpage. In some cases, a specific variable may have a different effect depending on other factors present.

1.2 PROJECT BACKGROUND

Injection molding is used to create many things such as wire spools, packaging, bottle caps, automotive dashboards, pocket combs, and most other plastic products available today. Injection molding is the most common method of part manufacturing. It is ideal for producing high volumes of the same object. Some advantages of injection molding are high production rates, repeatable high tolerances, the ability to use a wide range of materials, low labour cost, minimal scrap losses, and little need to finish parts after molding. Some disadvantages of this process are expensive equipment investment, potentially high running costs, and the need to design moldable parts.

1.3 PROJECT OBJECTIVE

I) Analyze the parameters effect in injection molding to warpage and shringkage of laboratory goggle.
II) To determine the optimization of molding parameter effect to warpage and shringkage of laboratory goggle during injection molding based on plastic flow simulation software.

1.4 PROJECT SCOPE

For this project, a lot of information can be find and study about the title. Find the information from the journals, internet, books, article and other resources. And as a student needed guidance from the supervisor to make sure that project that we do is connect with our title and objective of project. The knowledge will apply in the project until it is complete.

This project needs a long time to doing step by step to get an information until the analyzes is complete in the last step. In this project, the object is to analyze a laboratory goggle. So, it will use a 3D scanner as a first step to get the accurate dimension of laboratory goggle. It is a reverse engineering to study the injection molding product in Faculty of Mechanical (FKM) Laboratory in Pekan Gambang.

For the 3D scanner from FKM lab, it can using a CIMCORE INFINITE 2.0 as a device which is can analyzes a real world object and collect as many data on the object's shape and appearance included colour.

After that, it need use software like solid work to draw the laboratory goggle with the accurate dimension and size. That's why it need to do a scanning. The advantage by using a solid work to draw the real laboratory goggle is it can get 100% dimension and size in the result.

In the last step of this project, use a Moldflow Software to make the analyze to the parameter of laboratory goggle. Moldflow Corporation's two core products are Moldflow Plastics Insight and Moldflow Plastics Advisers. One of the product will be used.

1.5 PROBLEM STATEMENT

In this project, parameter in injection molding of laboratory goggle needs to define. The parameter includes mold temperature, melt temperature, cooling time, and injection pressure. Base on research, 4 parameters was choice to make the analysis in order to make the optimization of molding parameter and minimize the warpage and shrinkage of laboratory goggle based on plastic flow simulation software. The parameters are mold temperature, melt temperature, packing pressure and injection time.

The parameter need to make analysis base on plastic flow simulation software. In this project, MoldFlow Plastic Insight was use to make the analysis on parameter chosen. The analysis includes warpage and shrinkage in laboratory goggle. From that, it's important to optimize the parameter in order to minimize warpage and shrinkage.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This project title is optimization of molding parameter effect to warpage and shrinkage of laboratory goggle based on plastic flow simulation software. Optimization definition is the procedure or procedures used to make a system or design as effective or functional as possible, especially the mathematical techniques involved. So, optimization of molding parameter is to make improvement about the molding parameter that effect to warpage in injection molding.

Injection molding is a manufacturing process for producing parts from both thermoplastic and thermosetting plastic materials. Material is fed into a heated barrel, mixed, and forced into a mold cavity where it cools and hardens to the configuration of the mold cavity. After a product is designed, usually by an industrial designer or an engineer, molds are made by a mold maker (or toolmaker) from metal, usually either steel or aluminum, and precision-machined to form the features of the desired part. Injection molding is widely used for manufacturing a variety of parts, from the smallest component to entire body of cars.

2.2 INJECTION MOLDING

Making polymers is a fantastic science. Then there is the matter of shaping the plastic into useful objects another fantastic science. One of the most common methods of shaping plastic resins is a process called injection molding. Injection molding is accomplished by large machines called injection molding machines.

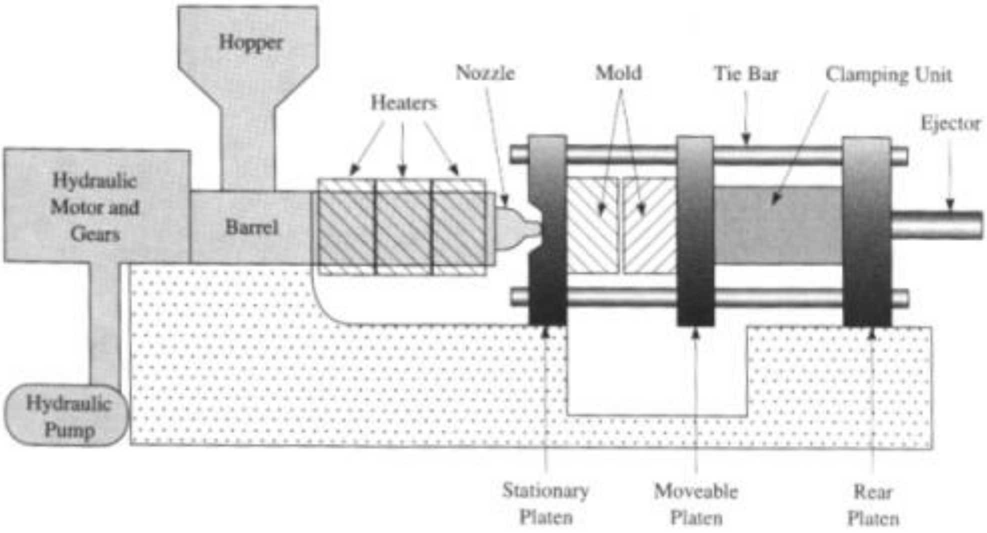

Figure 2.1: Injection molding process

Source : A. Brent Strong 2003

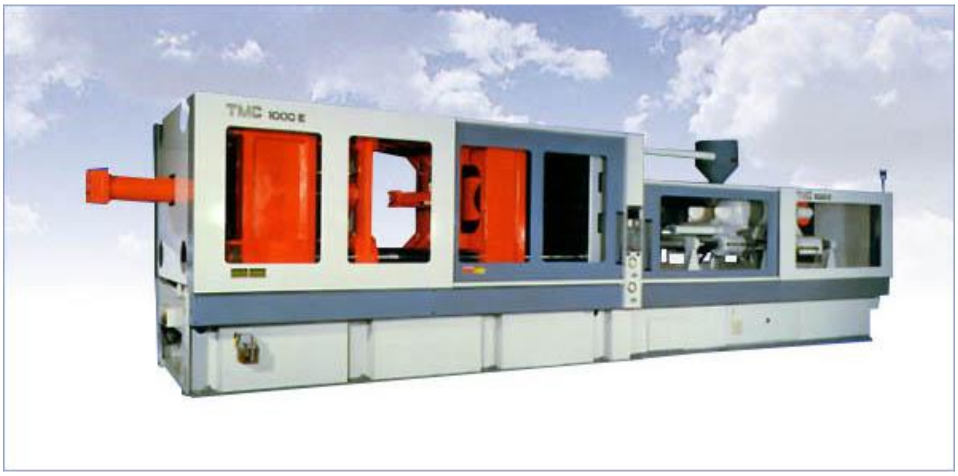

Figure 2.2: injection molding machine

Source : A. Brent Strong 2003

Resin is fed to the machine through the hopper. Colorants are usually fed to the machine directly after the hopper. The resins enter the injection barrel by gravity though the feed throat. Upon entrance into the barrel, the resin is heated to the appropriate melting temperature.

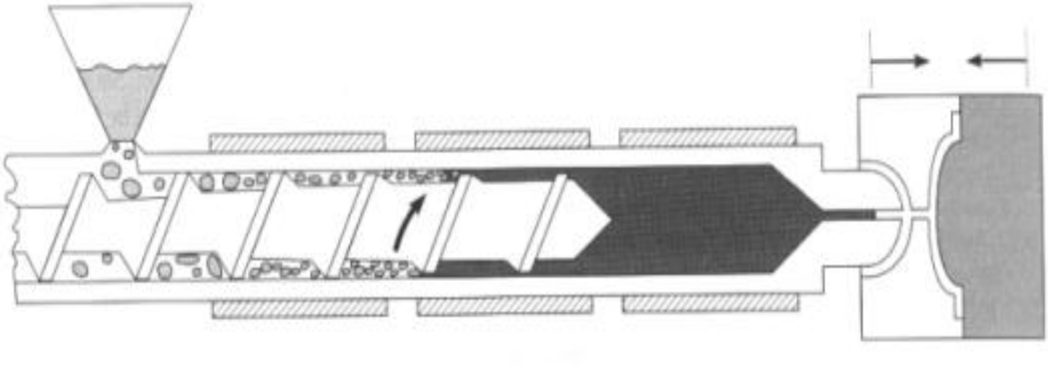

Figure 2.3: Process at hopper and heater

Source : A. Brent Strong 2003

The resin is injected into the mold by a reciprocating screw or a ram injector. The reciprocating screw apparatus is shown above. The reciprocating screw offers the advantage of being able to inject a smaller percentage of the total shot (amount of melted resin in the barrel). The ram injector must typically inject at least 20% of the total shot while a screw injector can inject as little as 5% of the total shot. Essentially, the screw injector is better suited for producing smaller parts.

The mold is the part of the machine that receives the plastic and shapes it appropriately. The mold is cooled constantly to a temperature that allows the resin to solidify and be cool to the touch. The mold plates are held together by hydraulic or mechanical force. The clamping force is defined as the injection pressure multiplied by the total cavity projected area. Typically molds are overdesigned depending on the resin to be used. Each resin has a calculated shrinkage value associated with in.

Injection molding is used to create many things such as wire spools, packaging, bottle caps, automotive dashboards, pocket combs, and most other plastic products available today. Injection molding is the most common method of part manufacturing. It is ideal for producing high volumes of the same object. Some advantages of injection molding are high production rates, repeatable high tolerances, the ability to use a wide range of materials, low labour cost, minimal scrap losses, and little need to finish parts after molding. Some disadvantages of this process are expensive equipment investment, potentially high running costs, and the need to design moldable parts.

2.3 SHRINKAGE

Shrinkage is inherent in the injection molding process. Shrinkage occurs because the density of polymer varies from the processing temperature to the ambient temperature (see Specific volume (pvT diagram)). During injection molding, the variation in shrinkage both globally and through the cross section of a part creates internal stresses. These so-called residual stresses (see Residual stress) act on a part with effects similar to externally applied stresses. If the residual stresses induced during molding are high enough to overcome the structural integrity of the part, the part will warp upon ejection from the mold or crack with external service load.

The shrinkage of molded plastic parts can be as much as 20 percent by volume, when measured at the processing temperature and the ambient temperature. Crystalline and semi-crystalline materials are particularly prone to thermal shrinkage; amorphous materials tend to shrink less. When crystalline materials are cooled below their transition temperature, the molecules arrange themselves in a more orderly way, forming crystallites. On the other hand, the microstructure of amorphous materials does not change with the phase change. This difference leads to crystalline and semi-crystalline materials having a greater difference in specific volume between their melt phase and solid (crystalline) phase. This is illustrated in Figure 1 below. We'd like to point out that the cooling rate also affects the fast-cooling pvT behavior of crystalline and semi-crystalline materials.

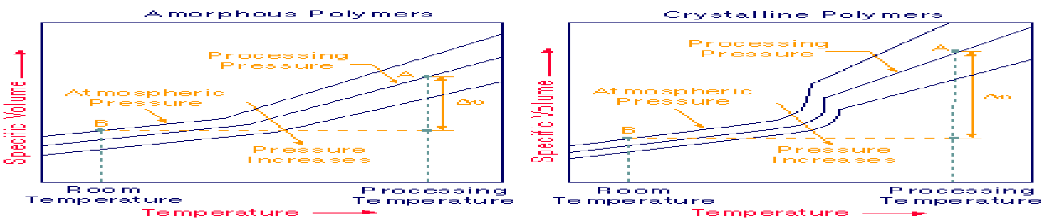

FIGURE 2.4 : The pvT curves for amorphous and crystalline polymers and the specific volume variation between the processing state (point A) and the state at room temperature and atmospheric pressure (point B). Note that the specific volume decreases as the pressure increases.

Source : Thomas L. (1995)

2.3.1 Shrinkage (accounting) – The loss of products

In financial accounting the term inventory shrinkage (sometimes truncated to shrink) is the loss of products between point of manufacture or purchase from supplier and point of sale. The term shrink relates to the difference in the amount of margin or profit a retailer can obtain. If the amount of shrink is large, then profits go down which results in increased costs to the consumer to meet the needs of the retailer. The total shrink percentage of the retail industry in the United States was 1.52% of sales in 2008 according to the University of Florida's, National Retail Security Survey. In Europe shrinkage was about 1.27% of sales and the same figure for Asia Pacific was 1.20% .

2.3.2 Shrinkage (statistics) – A technique to improve an estimator

In statistics, shrinkage has two meanings:

I) In relation to the general observation that, in regression analysis, a fitted relationship appears to perform less well on a new data set than on the data set used for fitting. In particular the value of the coefficient of determination 'shrinks'. This idea is complementary to overfitting and, separately, to the standard adjustment made in the coefficient of determination to compensate for the subjunctive effects of further sampling, like controlling for the potential of new explanatory terms improving the model by chance: that is, the adjustment formula itself provides "shrinkage." But the adjustment formula yields an artificial shrinkage, in contrast to the first definition.

II) To describe general types of estimators, or the effects of some types of estimation, whereby a naive or raw estimate is improved by combining it with other information.: see shrinkage estimator. The term relates to the notion that the improved estimate is at a reduced distance from the value supplied by the 'other information' than is the raw estimate. In this sense, shrinkage is used to regularize ill-posed inference problems.

A common idea underlying both of these meanings is the reduction in the effects of sampling variation.

2.3.3 Shrinkage (casting) – A casting defect brought about by the reduction in volume of the cast material as it cools and solidifies

In metalworking, casting involves pouring a liquid metal into a mold, which contains a hollow cavity of the desired shape, and then is allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting is most often used for making complex shapes that would be difficult or uneconomical to make by other methods.

The casting process is subdivided into two main categories: expendable and non-expendable casting. It is further broken down by the mold material, such as sand or metal, and pouring method, such as gravity, vacuum, or low pressure.

Cooling curves are important in controlling the quality of a casting. The most important part of the cooling curve is the *cooling rate* which affects the microstructure and properties. Generally speaking, an area of the casting which is cooled quickly will have a fine grain structure and an area which cools slowly will have a coarse grain structure. Below is an example cooling curve of a pure metal or eutectic alloy, with defining terminology.

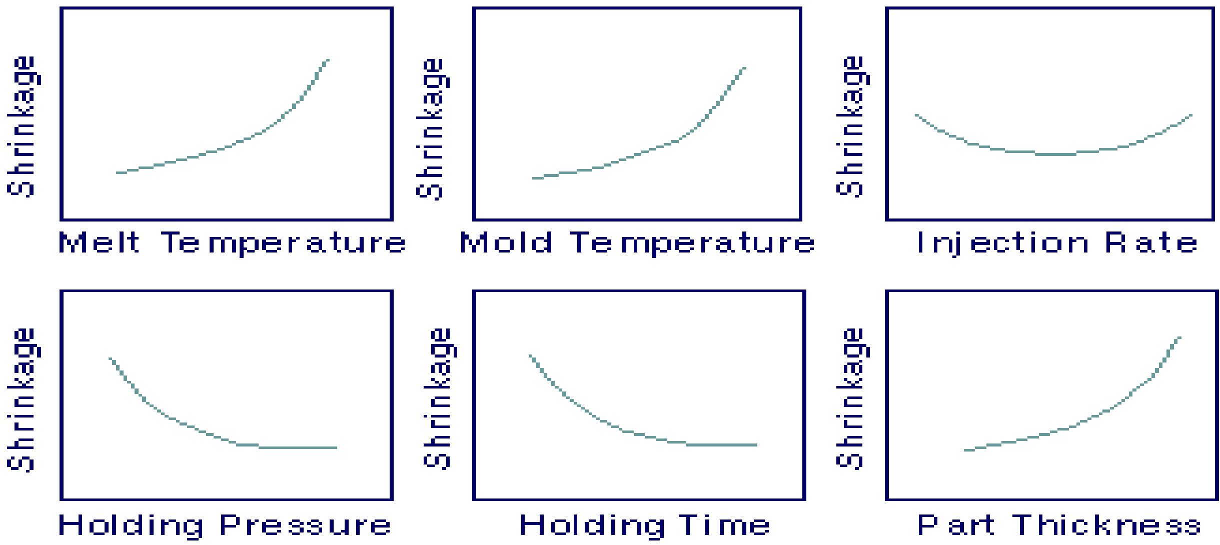

Figure 2.5: Graph of shrinkage

Source : J. Randolph 1999

Note that before the thermal arrest the material is a liquid and after it the material is a solid; during the thermal arrest the material is converting from a liquid to a solid. Also, note that the greater the superheat the more time there is for the liquid material to flow into intricate details.

The cooling rate is largely controlled by the mold material. When the liquid material is poured into the mold, the cooling begins. This happens because the heat within the molten metal flows into the relatively cooler parts of the mold. Molding materials transfer heat from the casting into the mold at different rates. For example, some molds made of plaster may transfer heat very slowly, while steel would transfer the heat quickly. Where heat should be removed quickly, the engineer will plan the mold to include special heat sinks to the mold, called chills. Fins may also be designed on a casting to extract heat, which are later removed in the cleaning (also called fettling) process. Both methods may be used at local spots in a mold where the heat will be extracted quickly. Where heat should be removed slowly, a riser or some padding may be added to a casting.

The above cooling curve depicts a basic situation with a pure alloy; however, most castings are of alloys, which have a cooling curve shaped as shown below.

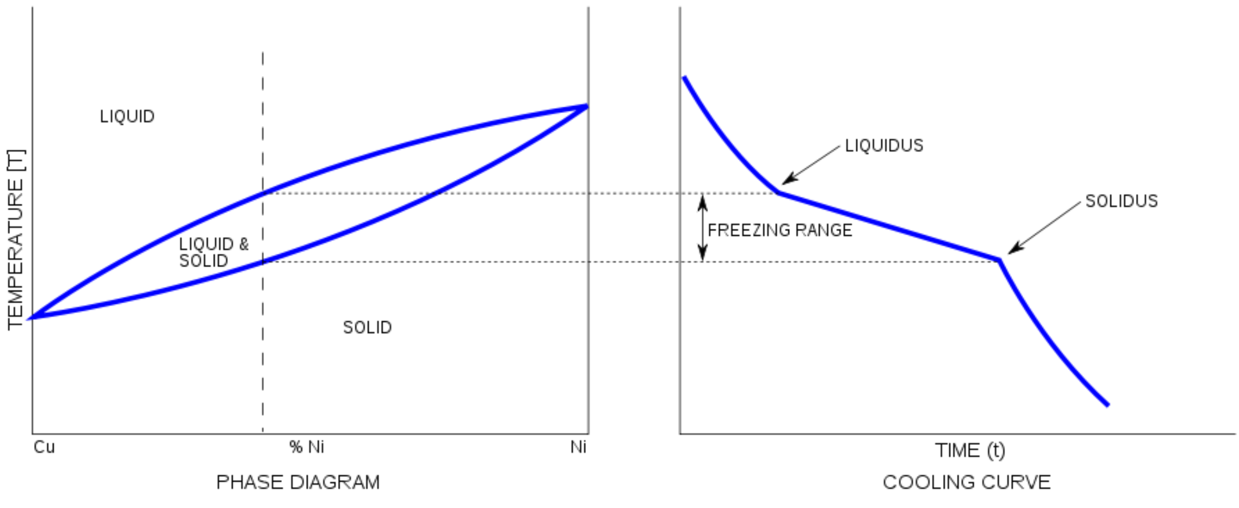

Figure 2.6: Graph of Temperature with Phase diagram and time coolong curve

Source : Meyer 1997

Note that there is no longer a thermal arrest; instead there is a freezing range. The freezing range corresponds directly to the liquidus and solidus found on the phase diagram for the specific alloy.

2.4 WARPAGE

Warpage is a distortion where the surfaces of the molded part do not follow the intended shape of the design. Part warpage results from molded-in residual stresses, which, in turn, is caused by differential shrinkage of material in the molded part. If the shrinkage throughout the part is uniform, the molding will not deform or warp, it simply becomes smaller. However, achieving low and uniform shrinkage is a complicated task due to the presence and interaction of many factors such as molecular and fiber orientations, mold cooling, part and mold designs, and process conditions.

Thick sections cool slower than thin sections. The thin section first solidifies, and the thick section is still not fully solidified. As the thick section cools, it shrinks and the material for the shrinkage comes only from the unsolidified areas, which are connected, to the already solidified thin section.

This builds stresses near the boundary of the thin section to thick section. Since the thin section does not yield because it is solid, the thick section (which is still liquid) must yield. Often this leads to warping or twisting. If this is severe enough, the part could even crack.

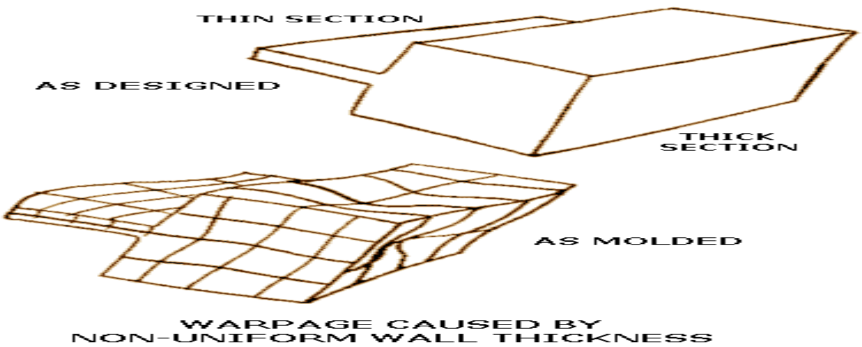

Figure 2.7: Example of warpage

Source : E. Paul 2003

Other causes:

- Warping can also be caused due to non-uniform mold temperatures or cooling rates.
- Non-uniform packing or pressure in the mold.
- Alignment of polymer molecules and fiber reinforcing strands during the mold fill results in preferential properties in the part.
- Molding process conditions--too high a injection pressure or temperature or improper temperature and cooling of the mold cavity. Generally, it is best to follow the resin manufacturer's guidelines on process conditions and only vary conditions within the limits of the guidelines.

  It is not good practice to go beyond the pressure and temperature recommendations to compensate for other defects in the mold. If runners need to be sized differently to allow for a proper fill, or gate sizes that need to be changed, then those changes need to happen.

  Otherwise the finished parts will have too much built in stresses, could crack in service or warp-leading to more severe problems such as customer returns or field service issues.

2.5 PARAMETER

In computer programming, a parameter is a special kind of variable, used in a subroutine to refer to one of the pieces of data provided as input to the subroutine. These pieces of data are called arguments. An ordered list of parameters is usually included in the definition of a subroutine, so that, each time the subroutine is called, its arguments for that call can be assigned to the corresponding parameters.

The term "argument" is often used in place of "parameter," though this is strictly incorrect. See the Parameters and arguments section for more information.

In the most common case, call-by-value, a parameter acts within the subroutine as a local (isolated) copy of the argument, but in other cases, e.g. call-by-reference, the argument supplied by the caller can be affected by actions within the called subroutine (as discussed in evaluation strategy).

The semantics for how parameters can be declared and how the arguments get passed to the parameters of subroutines are defined by the language, but the details of how this is represented in any particular computer system depends on the calling conventions of that system

2.6 3D SCANNER

A 3D scanner is a device that analyzes a real-world object or environment to collect data on its shape and possibly its appearance (i.e. color). The collected data can then be used to construct digital, three dimensional models useful for a wide variety of applications. These devices are used extensively by the entertainment industry in the production of movies and video games. Other common applications of this technology include industrial design, orthotics and prosthetics, reverse engineering and prototyping, quality control/inspection and documentation of cultural artifacts.

Many different technologies can be used to build these 3D scanning devices; each technology comes with its own limitations, advantages and costs. It should be remembered that many limitations in the kind of objects that can be digitized are still present: for example optical technologies encounter many difficulties with shiny, mirroring or transparent objects.

There are however methods for scanning shiny objects, such as covering them with a thin layer of white powder that will help more light photons to reflect back to the scanner. Laser scanners can send trillions of light photons toward an object and only receive a small percentage of those photons back via the optics that they use. The reflectivity of an object is based upon the object's color or terrestrial albedo. A white surface will reflect lots of light and a black surface will reflect only a small amount of light. Transparent objects such as glass will only refract the light and give false three dimensional information.

The purpose of a 3D scanner is usually to create a point cloud of geometric samples on the surface of the subject. These points can then be used to extrapolate the shape of the subject (a process called reconstruction). If color information is collected at each point, then the colors on the surface of the subject can also be determined.

Figure 2.8: The 3D Scanner

Source : Muhammad 2010

3D scanners are very analogous to cameras. Like cameras, they have a cone-like field of view, and like cameras, they can only collect information about surfaces that are not obscured. While a camera collects color information about surfaces within its field of view, 3D scanners collect distance information about surfaces within its field of view. The “picture” produced by a 3D scanner describes the distance to a surface at each point in the picture. If a spherical coordinate system is defined in which the scanner is the origin and the vector out from the front of the scanner is $\varphi=0$ and $\theta=0$, then each point in the picture is associated with a φ and θ. Together with distance, which corresponds to the r component, these spherical coordinates fully describe the three dimensional position of each point in the picture, in a local coordinate system relative to the scanner.

For most situations, a single scan will not produce a complete model of the subject. Multiple scans, even hundreds, from many different directions are usually required to obtain information about all sides of the subject. These scans have to be brought in a common reference system, a process that is usually called *alignment* or *registration,* and then merged to create a complete model. This whole process, going from the single range map to the whole model, is usually known as the 3D scanning pipeline.

2.7 SOLID WORK

SolidWorks is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows and was developed by Dassault Systèmes SolidWorks Corp., a subsidiary of Dassault Systèmes, S. A. (Vélizy, France). SolidWorks is currently used by over 3.4 million engineers and designers' at SolidWorks is a parasolid-based solid modeler, and utilizes a parametric feature-based approach to create models and assemblies.

Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

Design intent is how the creator of the part wants it to respond to changes and updates. For example, you would want the hole at the top of a beverage can to stay at the top surface, regardless of the height or size of the can. SolidWorks allows you to specify that the hole is a feature on the top surface, and will then honor your design intent no matter what the height you later gave to the can.

Features refer to the building blocks of the part. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, etc. This shape is then extruded or cut to add or remove material from the part. Operation-based features are not sketch-based, and include features such fillets, chamfers, shells, applying draft to the faces of a part.

2.8 MOLDFLOW

Moldflow Corporation is a wholly-owned subsidiary of Autodesk, Inc. that produces high-end plastic injection molding computer-aided engineering software. Moldflow was founded in Melbourne, Australia as Moldflow Pty. Ltd. in 1978 by Colin Austin. Moldflow Corporation is now headquartered in Framingham, Massachusetts. Moldflow Corporation's two core products are Moldflow Plastics Insight and Moldflow

Plastics Advisers. In addition, Moldflow Corporation also produces Moldflow Design Link, Moldflow CAD Doctor, Moldflow Magics STL Expert, and Moldflow Structural Alliance that serve as connectivity tools for CAD and other CAE software. They also have a free results viewer, Moldflow Communicator.

2.8.1 Moldflow plastics insight

Moldflow Plastics Insight® (MPI®) software represents the most comprehensive suite of definitive tools for simulating, analyzing,optimizing, and validating plastics part and mold designs. Powerfuland easy to use, MPI offers nineteen distinct modules that can beused to simulate nine unique molding processes.

The Benefits of Predictive Analysis :

To avoid the high costs and time delays associated with problems discovered at the start of manufacturing, it is necessary to consider the combined effects of part geometry, material selection, mold design and processing conditions on the manufacturability of a part. Using predictive analysis tools to simulate the injection molding process, companies can evaluate and optimize interactions among these variables during the design phases of a project before production begins, where the cost of change is minimal and the impact of the change is greatest.

With MPI analyses, you can simulate the filling, packing and cooling phases of thermoplastics molding processes using materials with or without fillers and fiber reinforcements, as well as predict post-molding phenomena such as part warpage. You can also simulate material flow and cure of reactive molding processes.

MPI also offers the world's largest material database of its kind with more than 7,800 thermoplastic materials characterized for use in plastics CAE analysis, as well as thermo set materials, coolants and mold materials, and injection molding machine-specific analysis capabilities.

MPI is highly acclaimed for its speed and accuracy and addresses the broadest range of design geometry types and manufacturing issues associated with plastics molding processes.

2.8.2 Moldflow plastic adviser

From the initial product launch in 1997, the Moldflow Plastics Advisers™ (MPA™) have provided part and mold designers the tools to optimize their designs and check the impact of critical design decisions on the manufacturability and quality of the product. Moldflow Plastics Advisers are integrated with the designer's CAD environment and work directly from a 3D solid model without the need of the user to create a mesh or midplane model. As molten plastic enters a mold cavity, it rapidly freezes as it comes in contact with the cool mold surface, while the central core remains molten. As additional material is injected, it flows into this central core, displacing the material already there, which forms a new flow front. This new flow front then becomes a combination of forward flow and outward flow. The outward flow contacts the cool mold wall, freezes, and forms the outermost layer or skin of the part while the forward flow forms the new molten core. When more material enters the mold, it flows along a channel, lined with these frozen walls of plastic. This means that typically the forward flow of the molten plastic is very predictable and predominantly parallel to the mold surface. The flow can be considered to be laminar.

Moldflow's patented Dual Domain™ technology has been designed to simulate injection molding by analyzing a representation of a three-dimensional part with a boundary or skin mesh on the outside surfaces of the part. This is usually obtained from the translation of a CAD model file such as STL (Stereo- Lithography) or IGES format. It allows you to analyze complex CAD solid models of thin-walled parts directly, resulting in minimal model preparation time for the part or mold designer.

Not only is this highly accurate, it is also incredibly fast.The Dual Domain™ solution is optimized for fast, reliable analysis of thin-walled plastic parts, the vast majority of plastic parts designed in practice.

2.9 MOLDING PARAMETER

The results of the investigation into the injection molding of thermoplastic mixtures based on aluminum nitride and paraffin have been discussed. The effect of the molding parameters on physico-mechanical properties of materials based on aluminum nitride with addition of yttrium oxide has been studied. A dense material having a fracture toughness of 3.0–3.1 MPa $m^{1/2}$ and bending strength of 280–320 MPa has been produced by injection molding. The level of physico-mechanical properties of AlN-based ceramics produced by the injection molding technology has been shown to depend on the relationship among basic parameters of molding (pressure, temperature, and viscosity of the thermoplastic mixture).

Processing Parameters

I) Melt Temperatures

Typical temperature profiles are based on gradually increasing temperature during the compression phase with cooling at the nozzle. More detailed information on the recommended temperature setting for each IROGRAN® TPU grade can be found on the product datasheet. For more detailed information on the modification of the profile please contact your technical service representative.

II) Injection time

A slow to moderate injection speed should be used if injection speed is too fast. The frictional heat can cause surface imperfections. Time of injection also very important to make sure the process is perfect.

III) Mold Temperature

We recommend for general molding a mold temperature between 10°C to 40°C. However for certain grades and end applications a reduction below 10°C has been found to offer advantages with cycle time. When using temperatures below 10°C care must be taken to ensure cavities will consistently fill and no condensation appears on the mold face.

IV) Packing pressure

The packing pressure in conventional injection molding comes from the molding machine and is reduced with increased filling distance within the mold cavity.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Chapter 3 will present the methodology of this research, problem faced, and how to counter the problem. Several methodology charts were included to explain the flow of research. The important of methodology to explain design experiment and analyze the data collected.

Other than that, this chapter will elaborate more about the process or step that important in order to achieve the objective. Then, in methodology, it also discusses about the flow of this project what the first thing to do until the end of the project.

3.2 METHODOLOGY FLOWCHART

Process flow chart provided to give an overview the methodology used in the research. Figure 3.1 shows the methodology proposed for investigating this research

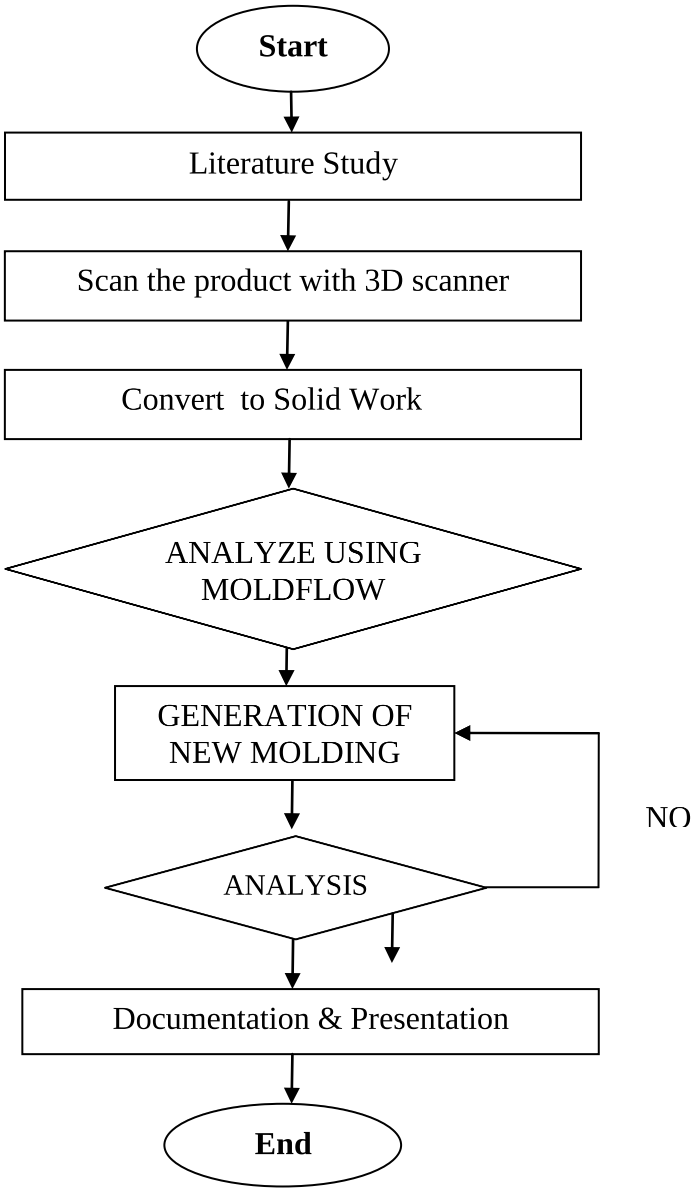

Figure 3.1: Proposed methodology flow chart

3.3 LITERATURE STUDY

To understanding the study is all about; some literatures must be studied to get overview since the student not much knowledgeable about the project. Understanding is important to plan the next step. Even though the student have confused for many fundamentals around, keep going study the literature helping to overcome the problems.

This project is to research an information about the warpage and shrinkage. Warpage and shrinkage are the main point in this project as a key to analyze and discuss. Also, in literature review gathering all the data and information about the software that use in this project such as MoldFlow and SolidWork. This is important to make student more understanding and get use to the software.

3.4 SCANNING PRODUCT

Scanning product is the first step of this project. The scanning is to collect as many data on the object’s shape and appearance included colour.

This project is using 3D scanner as reverse engineering to study the injection molding parameter. 3D scanner as known as reverse engineering and can study the injection molding parameter. The 3D scanner is can get a real object and collect the data on object’s shape and appearance include point. These points can then be used to extrapolate the shape of the subject, a process called reconstruction.

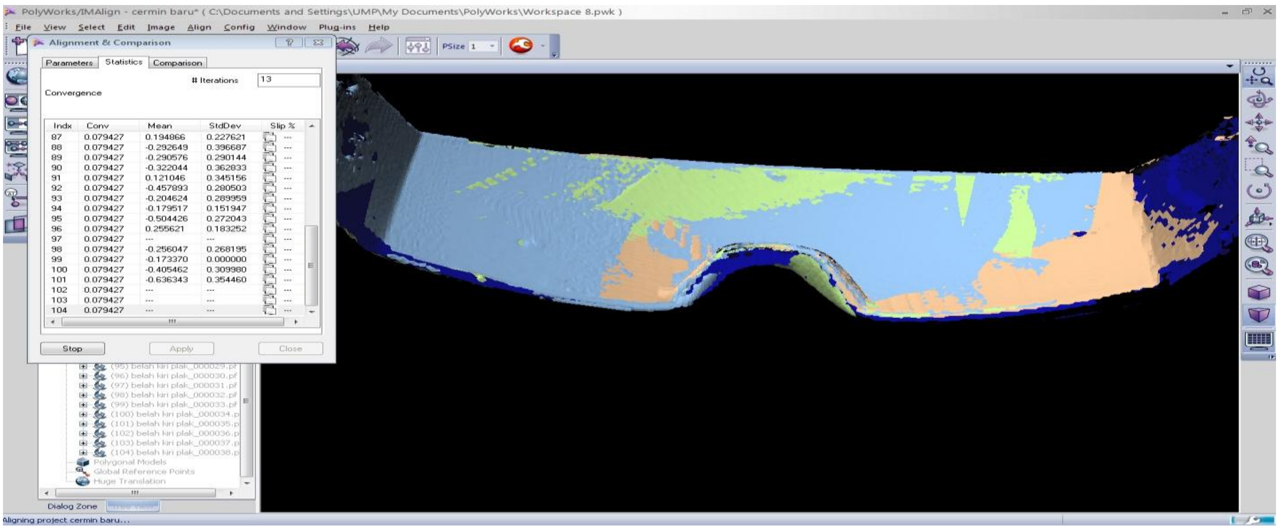

Figure 3.2: Glass data from Polywork software (3D Scanner) after iteration

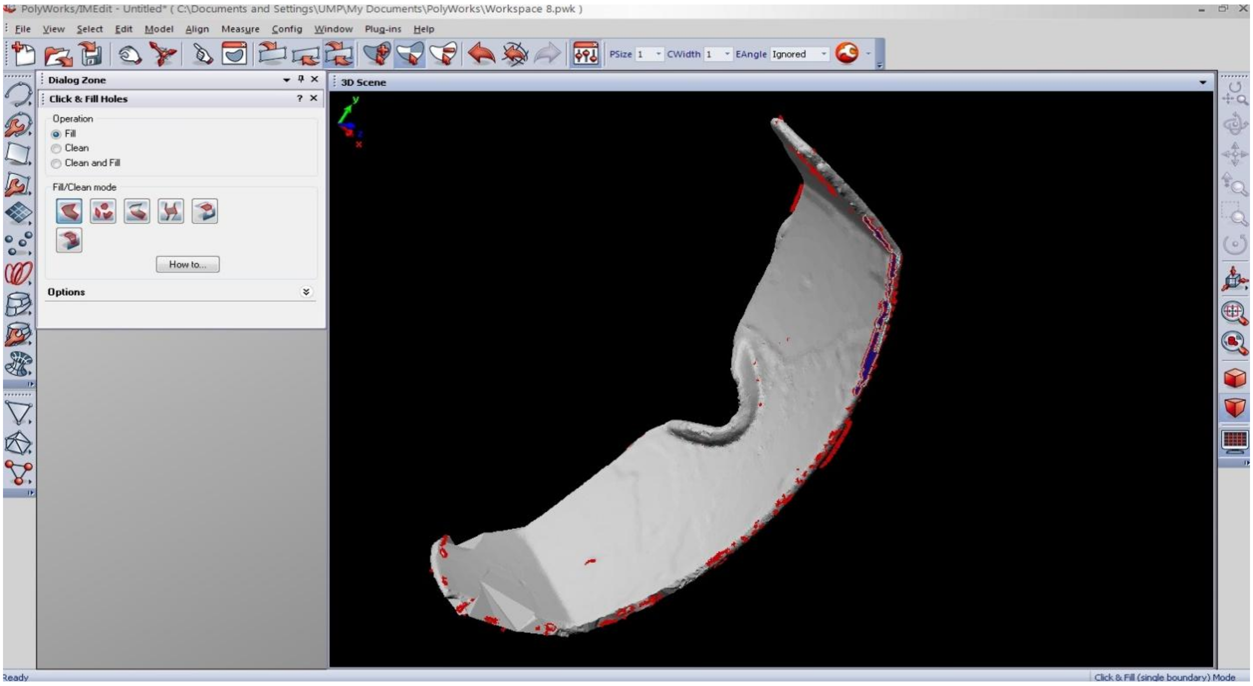

Figure 3.3: Glass was edited using IMedit

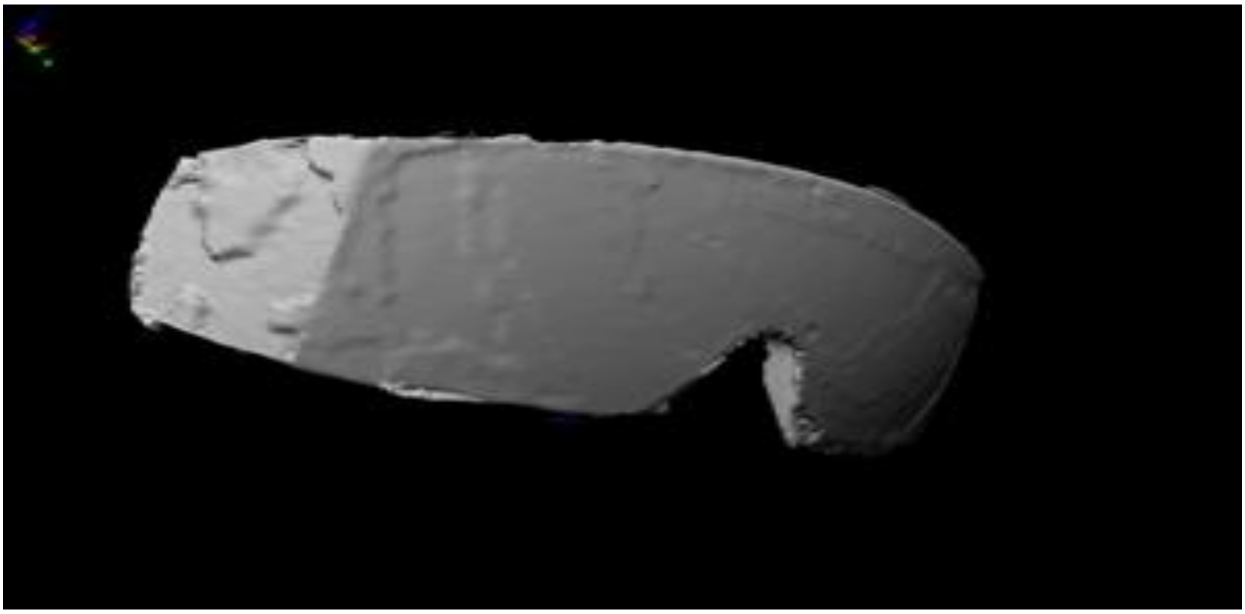

Figure 3.4 : Glass after edit using IMedit

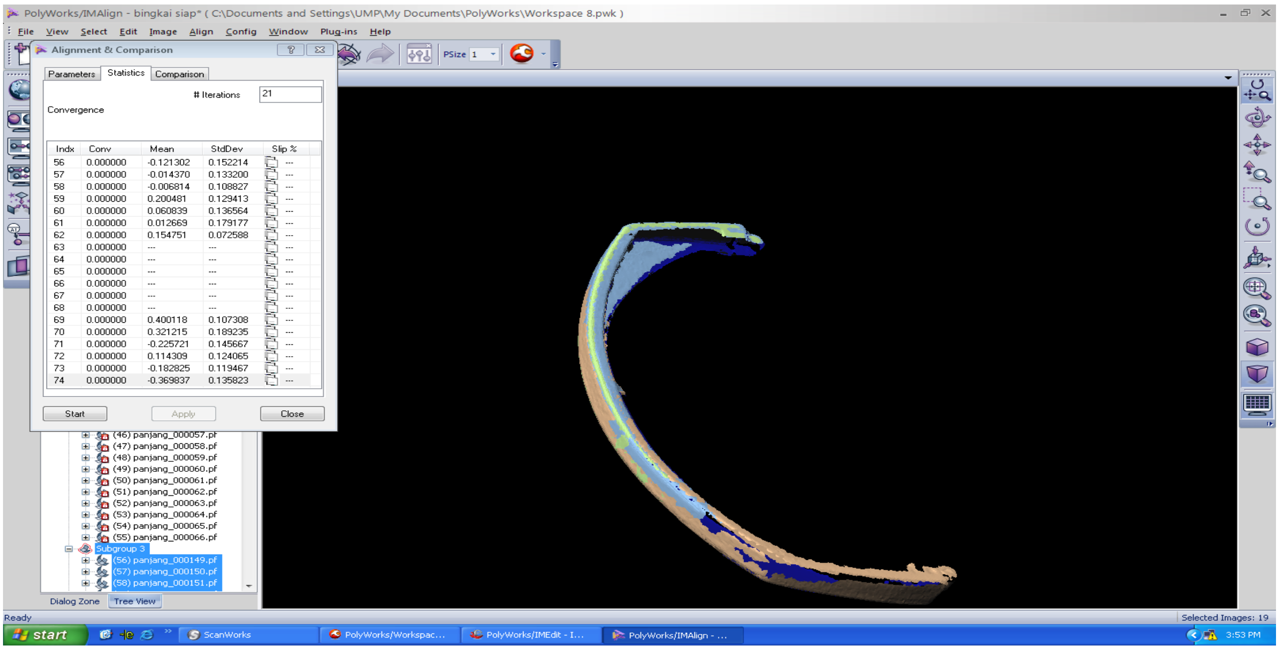

Figure 3.5: Frame data from Polywork software (3D Scanner) after iteration

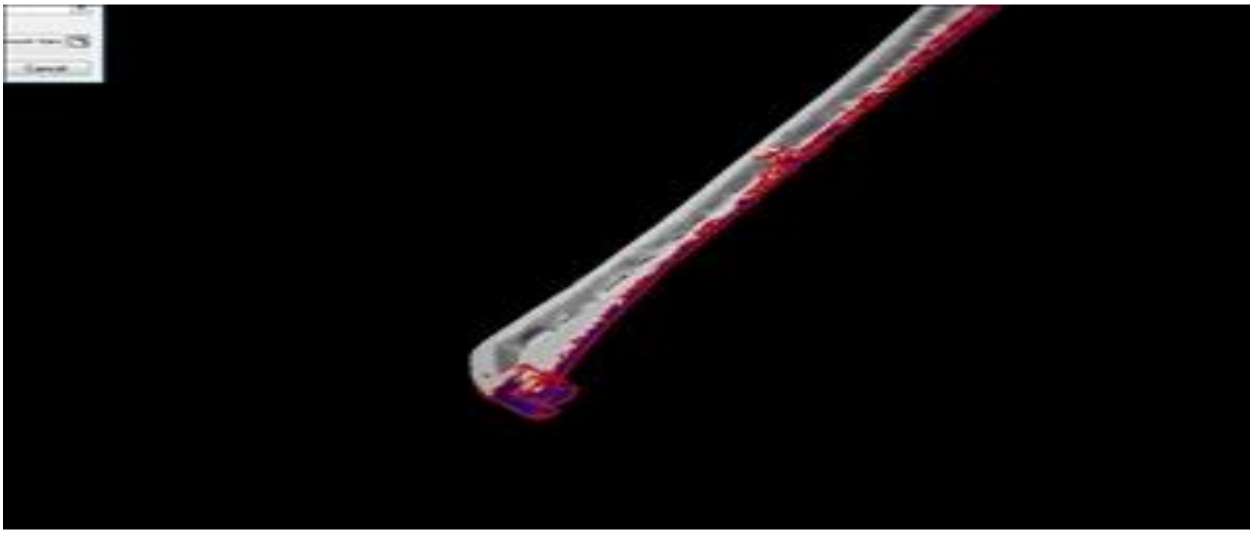

Figure 3.6: Frame was editted using IMedit

3.5 CONVERT TO SOLIDWORK

After finished scanning the product, transfer the data from the 3D scanner into SolidWork software. The data from the 3D Scanner will be transfer to the solid work by using a IGES file. Then, try to draw the laboratory goggle with the correct dimension and object shape. Result from 3D scanner is in shape appearance and still no dimension. SolidWork software is using to gather all the dimension of laboratory goggle by transfer all the data from 3D scanner to SolidWork software. Dimension is important to make the analysis and determine the change of molding parameter to optimize.

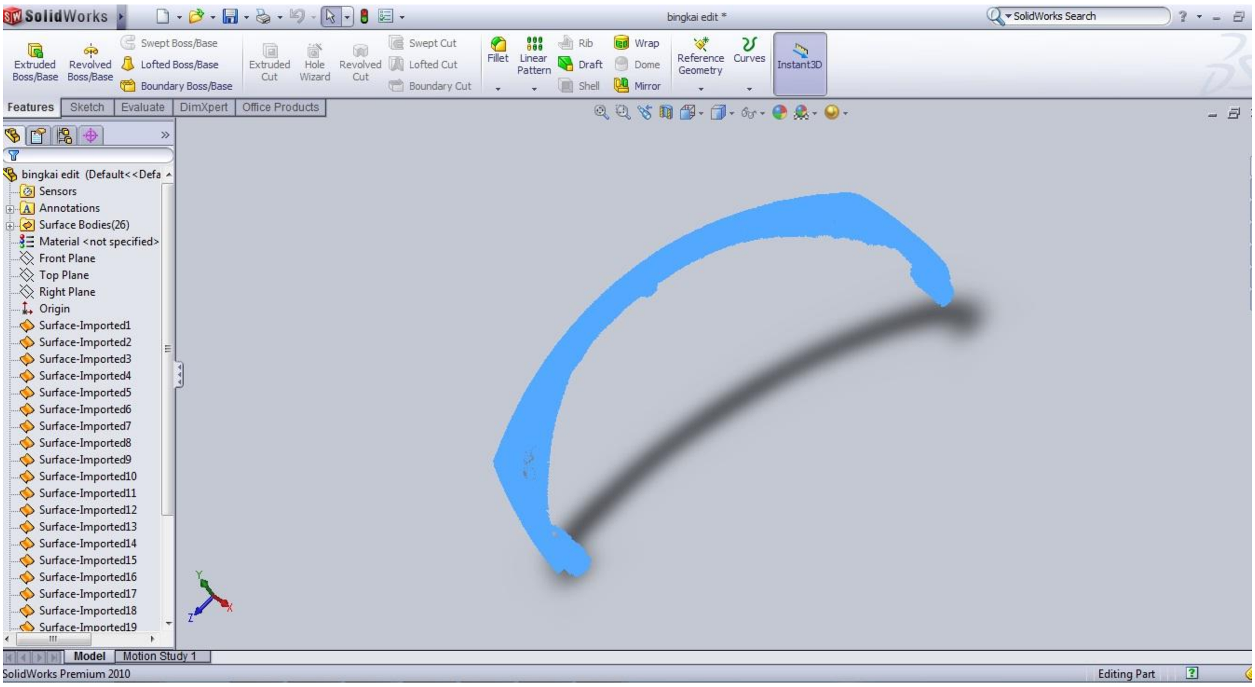

Figure 3.7: Frame in solid work software

3.6 ANALYSIS BY USING MOLDFLOW SOFTWARE

In the last step of this project, use a MoldFlow Simulation Software to analyze the parameter of laboratory goggle. MoldFlow simulation software helps to simulate the filling and packing phases of the injection molding process, so it can predict the flow behavior of plastic melts and achieve higher-quality manufacturing. Autodesk

Moldflow Insight reduces the need for physical prototypes and helps to make it possible for companies to get innovative products to market faster.

MoldFlow simulation software also are using to analyze warpage and shrinkage effect to the molding parameter. Next, MoldFlow can predicts the shrinkage and warpage of plastic parts based on process-induced stresses. It is also possible to predict the spatial deviation of an injection mold core due to non-uniform pressure distribution. Futhermore, the results help understand the causes of warpage, display where it will occur, and allow to optimize the design, material choice and processing parameters to control part deformation before the mold is built.

3.7 GENERATION OF NEW MOLDING PARAMETER

After complete analyze the product by using Moldflow software, continue to make a new molding parameter. It is to optimize the effect of warpage and shrinkage to the molding parameter including mold temperature, melt temperature, packing pressure, and injection time.

3.8 ANALYSIS

The new molding parameter will be analyzed whether the parameter has decreased the effect of warpage and shrinkage or not. For each parameter that will be analyzed, 3 parameter will be a constant value and the parameter that analyzed will be repeated for 5 times with different value. From that, the best value to decrease the effect of warpage and shrinkage will be known by compare the result. And it will do the same thing to the others parameter one by one. It will take 40 times value to be changed to get the result.

3.9 DOCUMENTATION & PRESENTATION

Lastly, documentation is very important for every project to make sure all the data and result has been document. For this project documentation is the final report and the log book. Final report is including all the information and data about the project. Actually, log book is a record about the work flow while do the project and the analysis.

For the presentation, it is more to explain about the result and the analysis of this project. It need to explain about method that was used to get the result for example from 3D scanner convert to solid work software and convert to moldflow software. This is important to make sure the validation of the result is clear.

3.10 SUMMARY

Nine steps of methodology of this research have been explained to get an overview the flow of research will be done. Next chapter will include the data collected and the analysis done to meet the objectives of the study. Several discussions on surface integrity also will be provided.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter discusses the experimental result that obtained after done the process in methodology. The results will be expressed in tables and graphs to provide the reader with a clearer view. The experimental result will then be analyzed and compared.

4.2 RESULTS

4.2.1 Frame

The frame of laboratory goggle was analyzed by the moldflow software and the result can be divided into a few part. Four parameter was used, it is a mold temperature, melt temperature, injection pressure and cooling time. For each parameter, it will repeat four times with four different values.

4.2.1.1 Mold Temperature

Analyzed the mold temperature parameter using Moldflow Software with melt temperature, injection pressure and cooling times are constant as shown in table 4.1.

Table 4.1 : Properties to analyze mold temperature parameter

Mold Temperature (C)	**Melt Temperature (C)**	**Injection Pressure (MPa)**	**Cooling Time (s)**	**Warpage (mm)**	**Shrinkage (mm)**
20	250	180	20	0.2489	0.9458
30	250	180	20	0.2810	0.8914
40	250	180	20	0.3186	0.8425
50	250	180	20	0.3462	0.7982

The analysis of shrinkage for mold temperature parameter can be compare from this result as shown in figure 4.1, 4.2, 4.3.

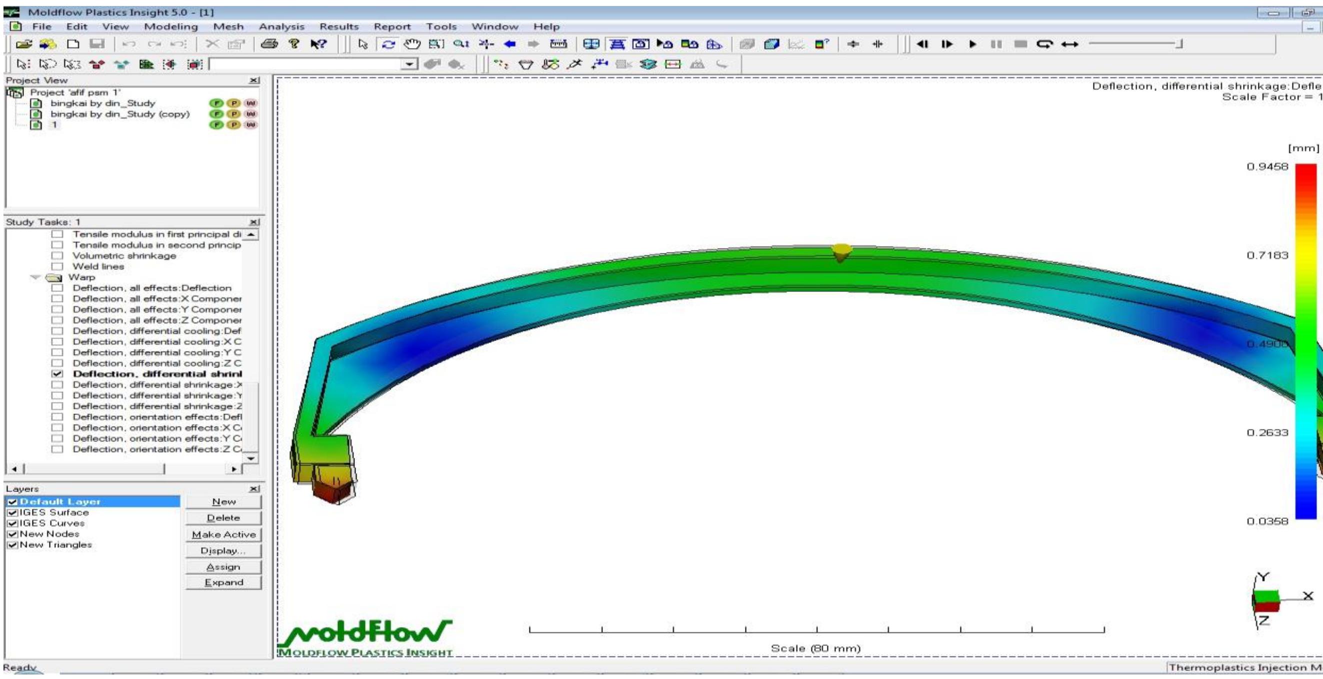

Figure 4.1: Result of volumetric shrinkage at ejection when mold temperature is 20 C

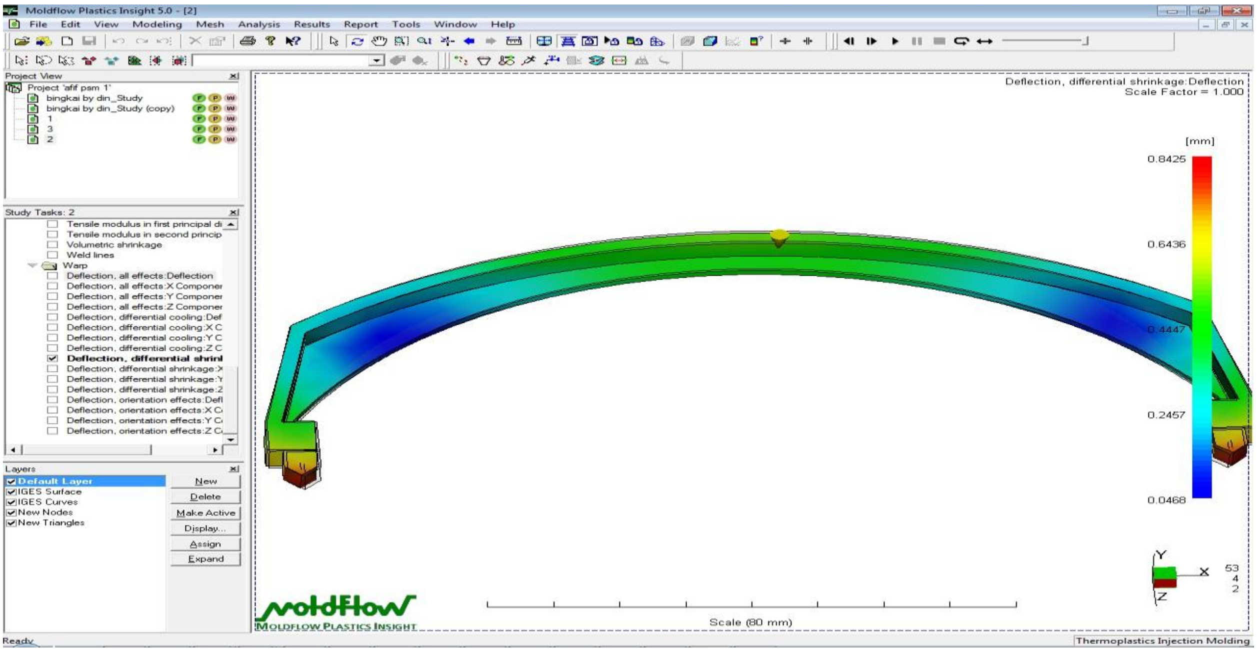

Figure 4.2: Result of volumetric shrinkage at ejection when mold temperature is 40 C

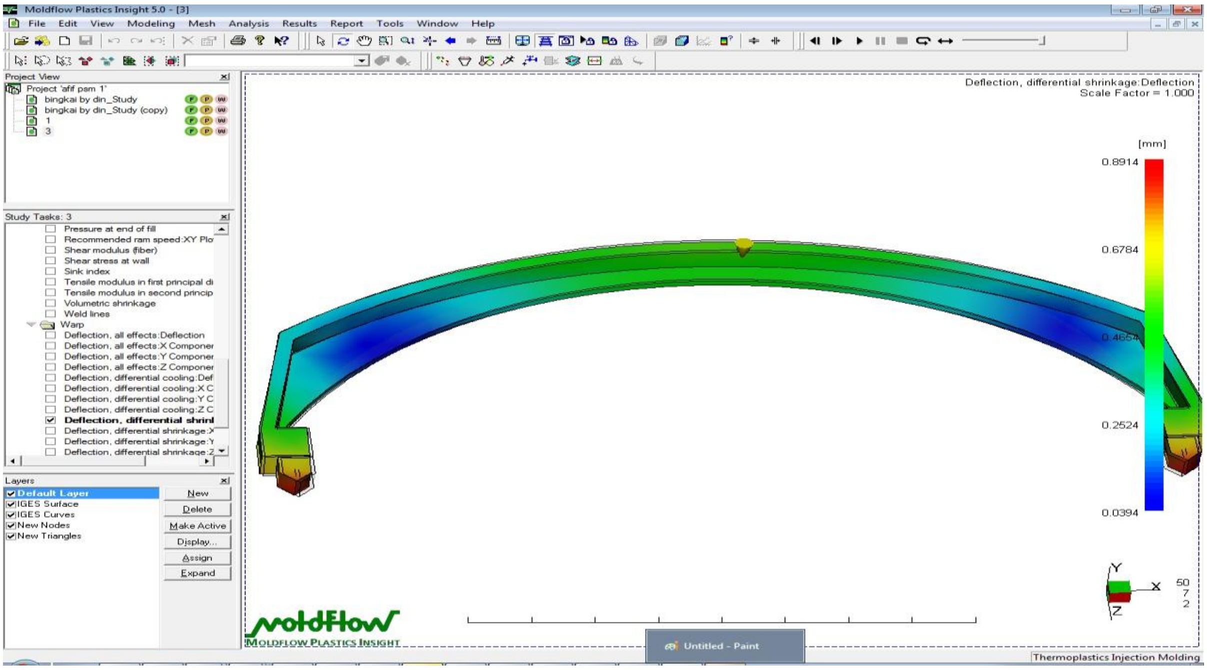

Figure 4.3: Result of volumetric shrinkage at ejection when mold temperature is 30 C

From this result as shown in figure 4.1, 4.2 and 4.3, the shrinkage of the frame will increase when the mold temperature is increase. The best mold temperature is 20 C

The analysis of warpage for mold temperature parameter can be compare from this result as shown in figure 4.4, 4.5, 4.6 .

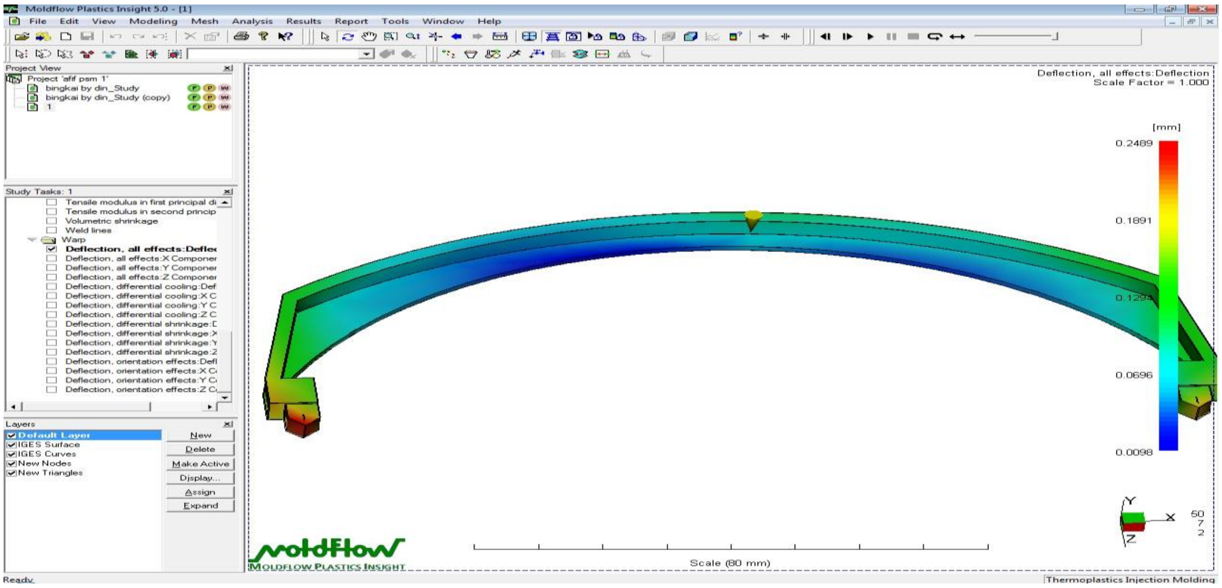

Figure 4.4: Result of warpage when mold temperature is 20 C

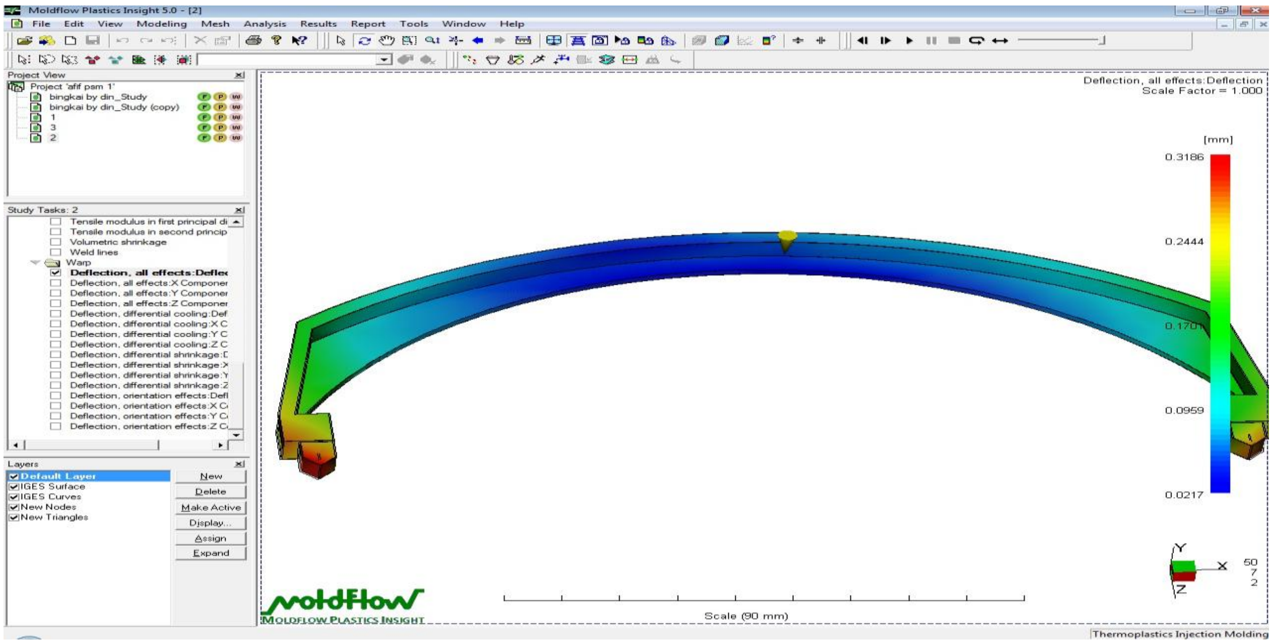

Figure 4.5: Result of warpage when mold temperature is 40 C

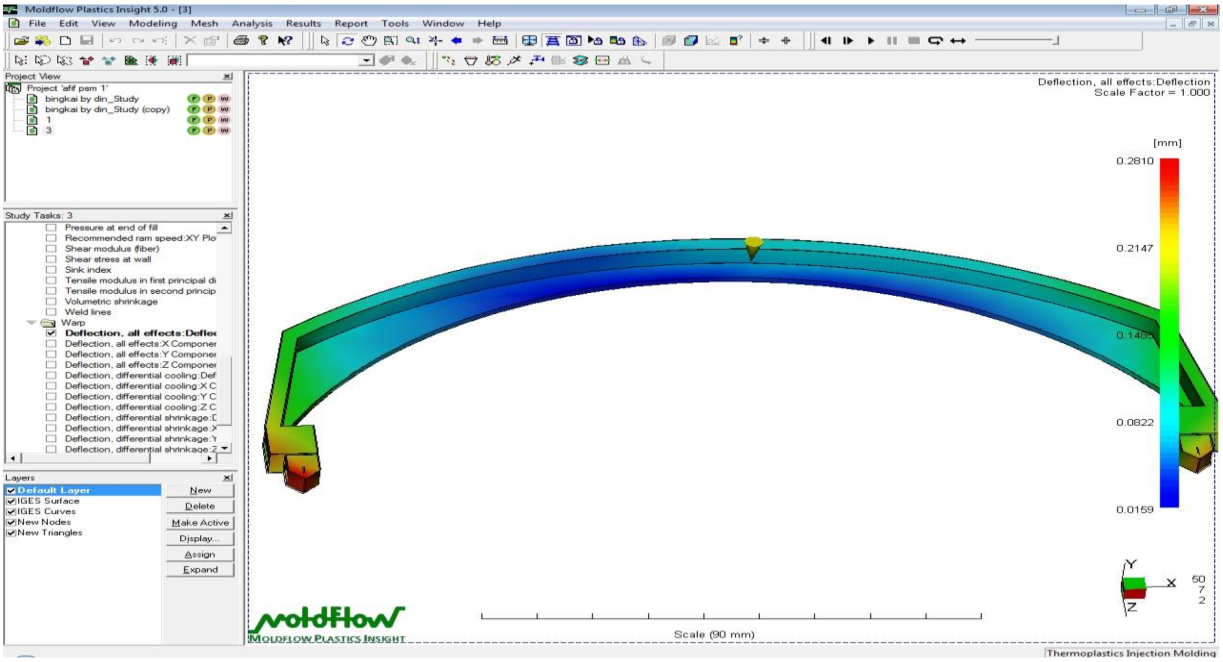

Figure 4.6: Result of warpage when mold temperature is 30 C

From this result as shown in Figure 4.4, 4.5, 4.6, the warpage of the frame is decrease when the mold temperature is increase. The best mold temperature is 50 C

4.2.1.2 Melt Temperature

Analyzed the melt temperature parameter using Moldflow Software with mold temperature, injection pressure and cooling times are constant as shown in table 4.2.

Table 4.2 : Properties to analyze melt temperature parameter

Mold Temperature (C)	**Melt Temperature (C)**	**Injection Pressure (MPa)**	**Cooling Time (s)**	**Warpage (mm)**	**Shrinkage (mm)**
30	230	180	20	0.3225	0.8283
30	240	180	20	0.2914	0.8569
30	250	180	20	0.2610	0.8914
30	260	180	20	0.2718	0.9290

The analysis of shrinkage for melt temperature parameter can be compare from this result as shown in figure 4.7, 4.8 .

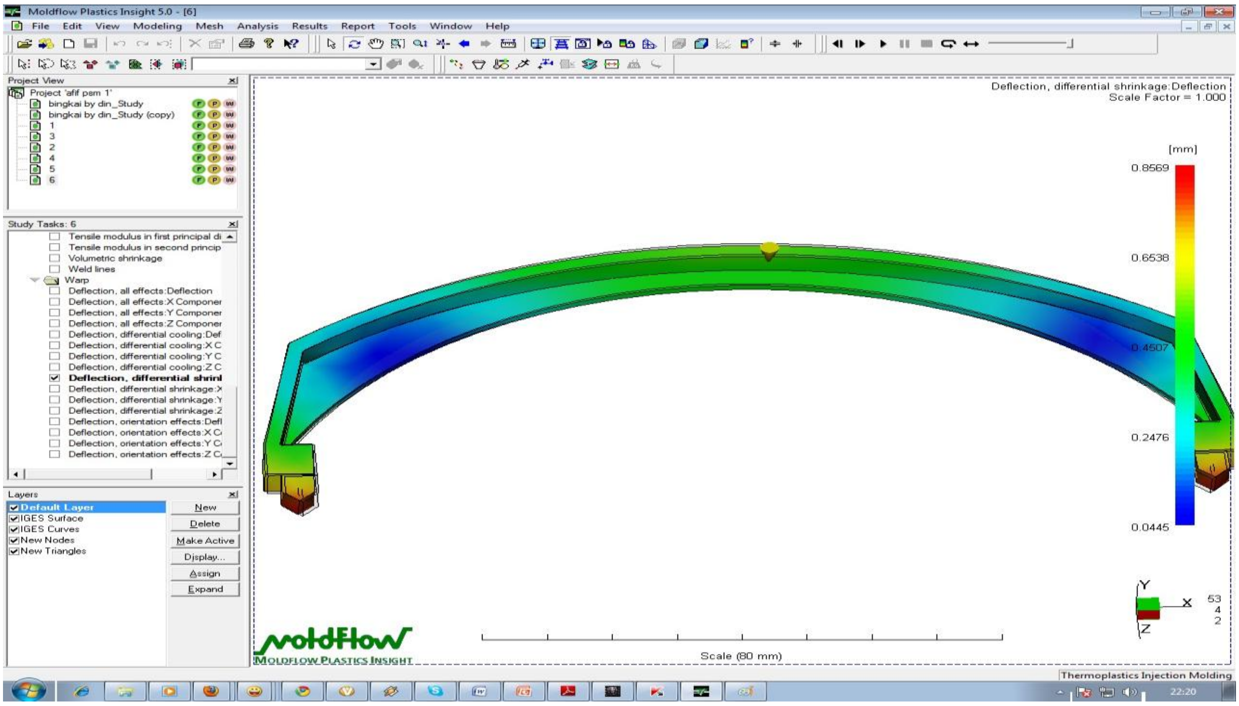

Figure 4.7: Result of volumetric shrinkage at ejection when melt temperature is 240 C

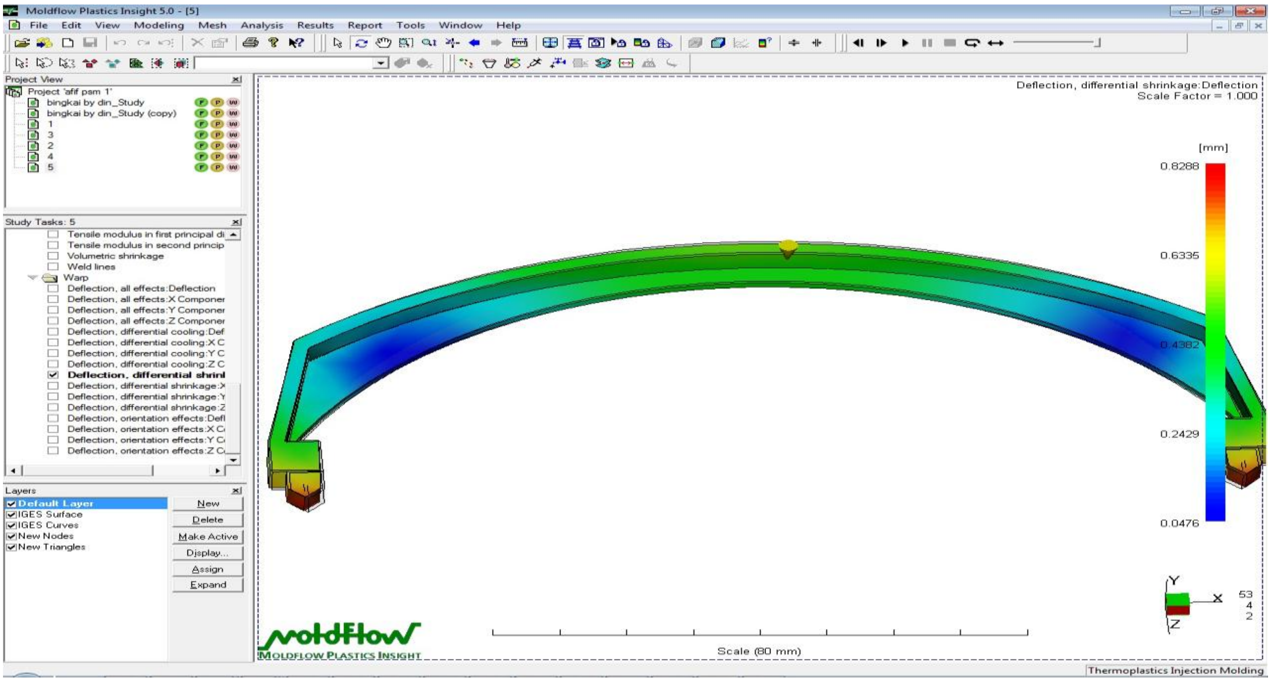

Figure 4.8: Result of volumetric shrinkage at ejection when melt temperature is 230 C

From this result as shown in figure 4.7, 4.8, the shrinkage of the frame is increase when the melt temperature also increase. The best melt temperature is 230 C

The analysis of warpage for melt temperature parameter can be compare from this result as shown in figure 4.9, 4.10 .

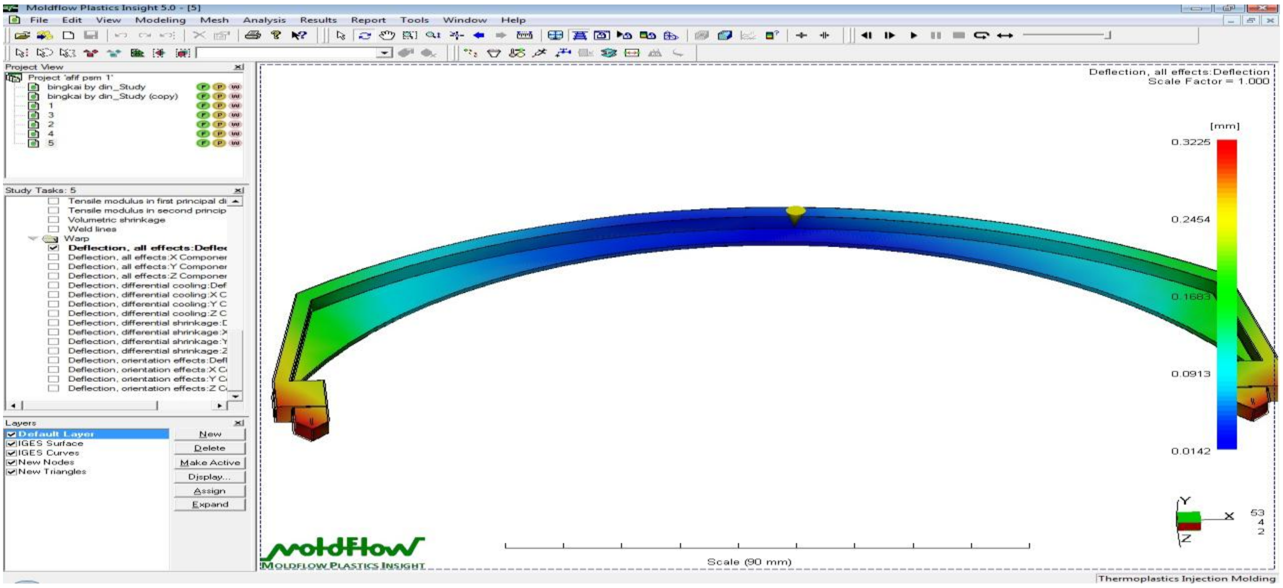

Figure 4.9: Result of warpage when melt temperature is 230 C

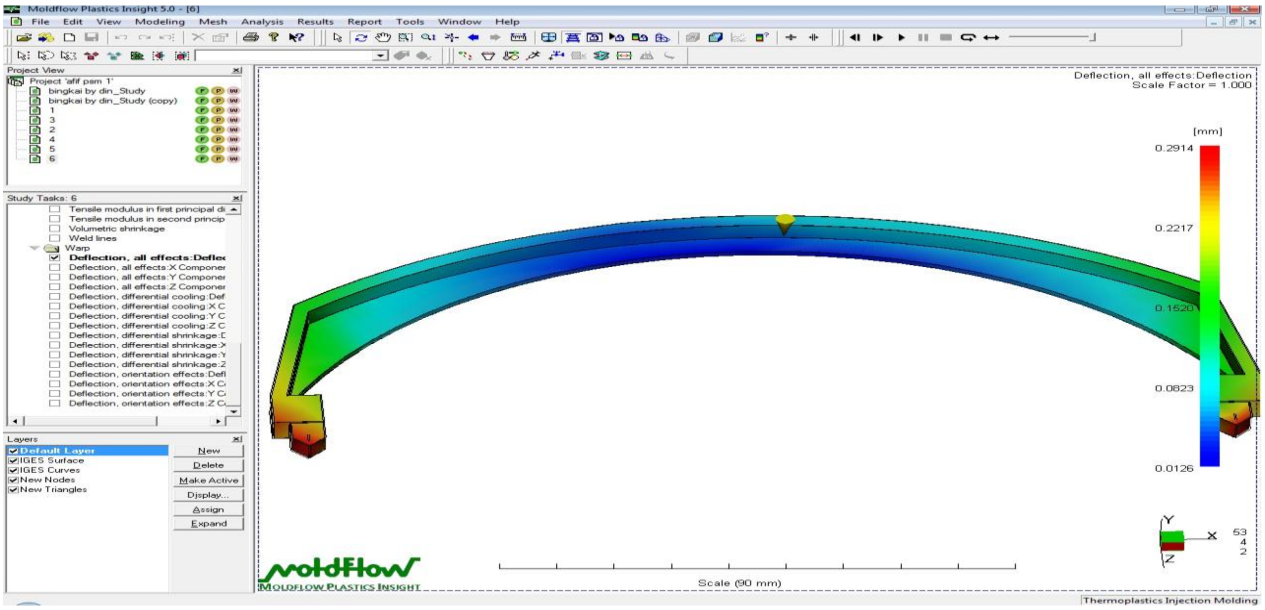

Figure 4.10: Result of warpage when melt temperature is 240 C

From this result as shown in figure 4.9, 4.10, the warpage of the frame is decrease when the melt temperature is increase. The best melt temperature is 250 C.

4.2.1.3 Injection Pressure

Analyzed the injection pressure parameter using Moldflow Software with mold temperature, melt temperature and cooling times are constant as shown in table 4.3 .

Table 4.3 : Properties to analyze injection pressure parameter

Mold Temperature (C)	Melt Temperature (C)	Injection Pressure (MPa)	Cooling Time (s)	Warpage (mm)	Shrinkage (mm)
30	250	100	20	0.2610	0.8914
30	250	200	20	0.2257	0.8902
30	250	300	20	0.2610	0.8914
30	250	400	20	0.2257	0.8902

The analysis of shrinkage for injection pressure parameter can be compare from this result as shown in figure 4.11, 4.12, 4.13.

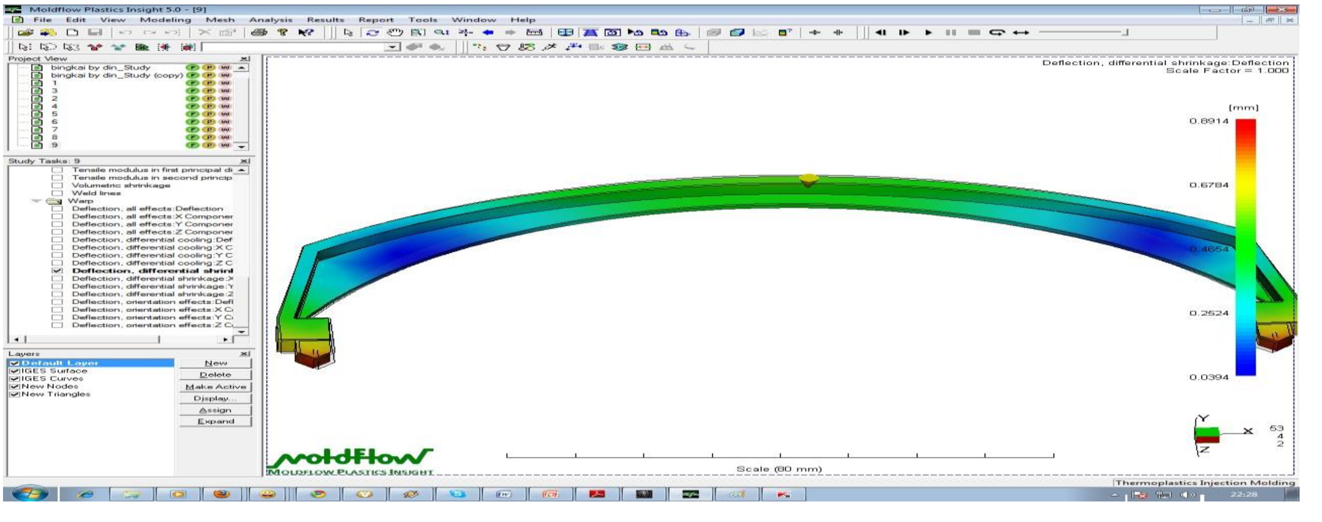

Figure 4.11: Result of volumetric shrinkage at ejection when injection pressure is 100 MPa

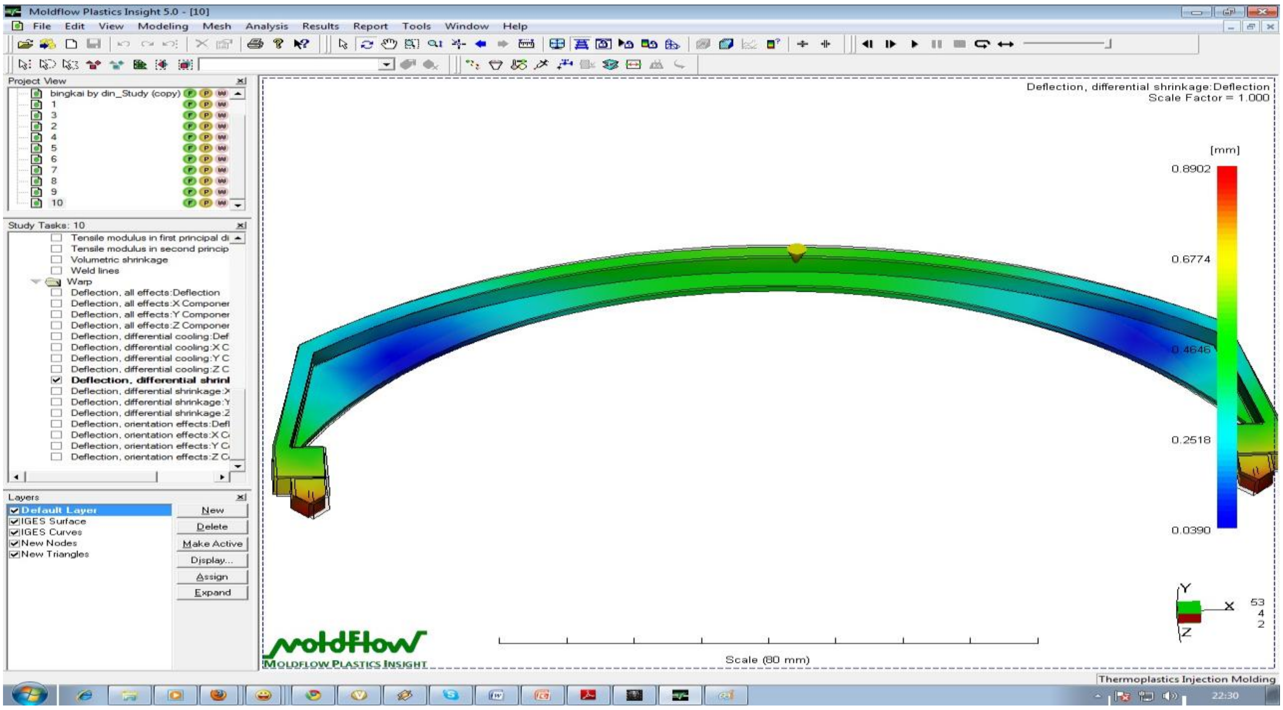

Figure 4.12: Result of volumetric shrinkage at ejection when injection pressure is 200 MPa

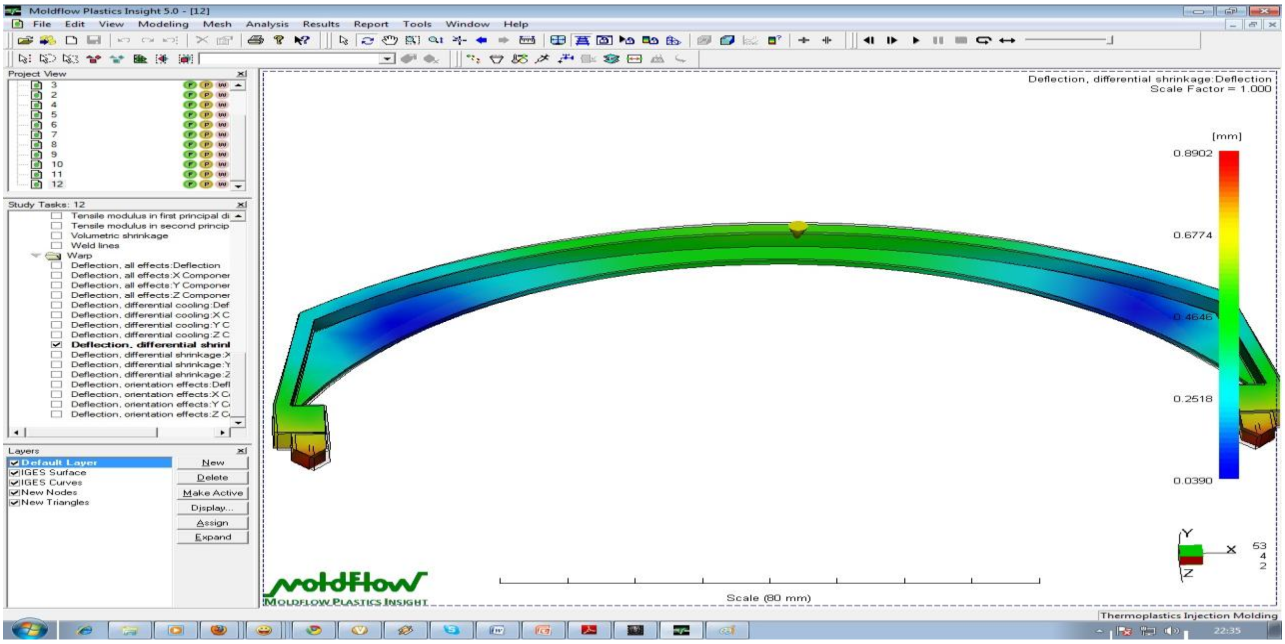

Figure 4.13: Result of volumetric shrinkage at ejection when injection pressure is 400 MPa

From this result as shown in figure 4.11, 4.12, 4.13., the shrinkage of the frame is decrease when the injection pressure is increase. The best injection pressure is 300 MPa.

The analysis of warpage for injection pressure parameter can be compare from this result as shown in figure 4.14, 4.15, 4.16 .

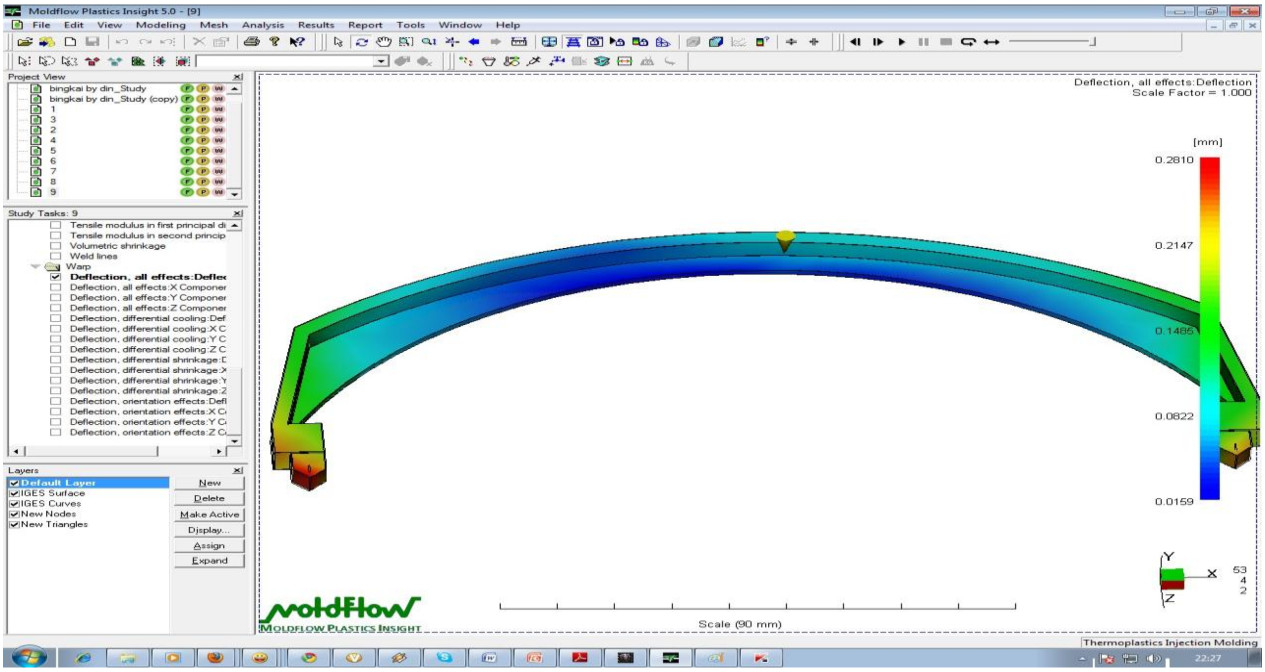

Figure 4.14: Result of warpage when injection pressure is 100 MPa

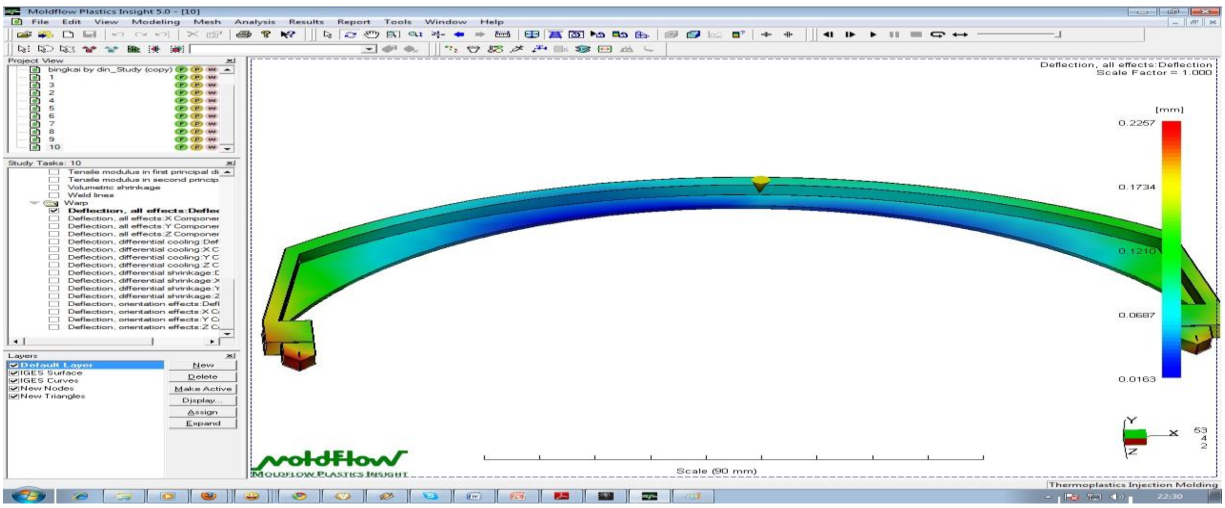

Figure 4.15: Result of warpage when injection pressure is 200 MPa

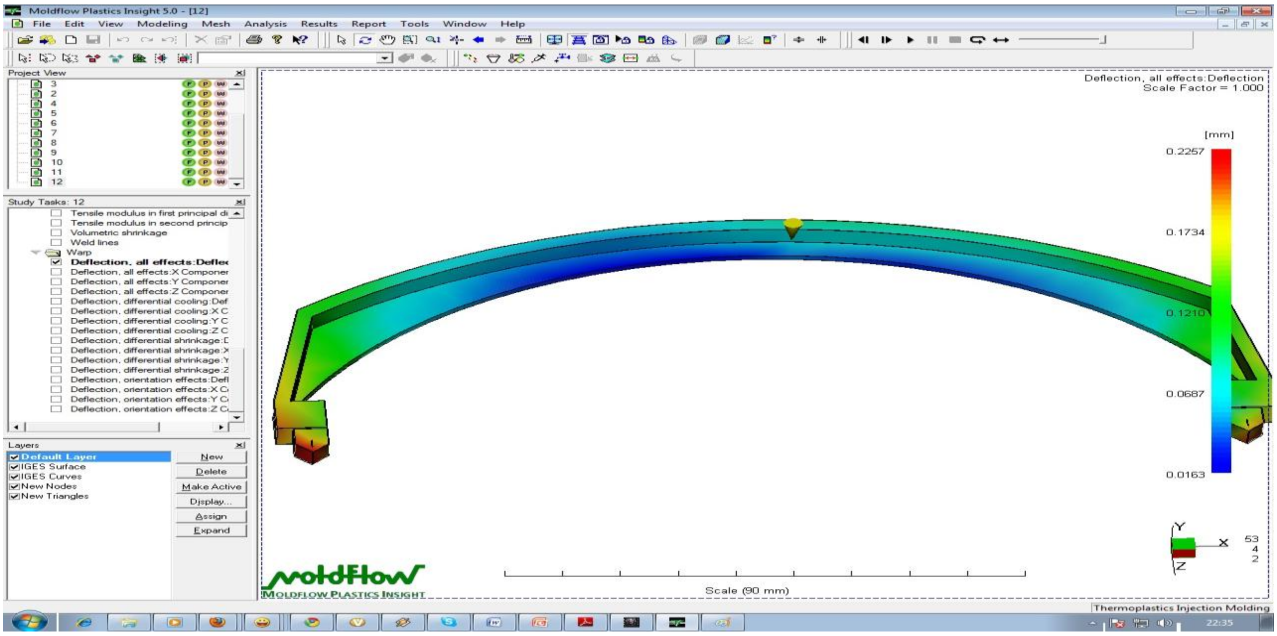

Figure 4.16: Result of warpage when injection pressure is 400 MPa

From this result as shown in figure 4.14, 4.15, 4.16, the warpage of the frame is increase when the injection pressure also increase. At 400 MPa, the warpage become constant (maximum). The best injection pressure is 100 MPa.

4.2.1.4 Cooling Time

Analyzed the injection time parameter using Moldflow Software with mold temperature, melt temperature and injection pressure are constant as shown in table 4.4 .

Table 4.4 : Properties to analyze cooling time parameter

Mold Temperature (C)	Melt Temperature (C)	Injection Pressure (MPa)	Cooling Time (s)	Warpage (mm)	Shrinkage (mm)
30	250	180	10	24.17	18.90
30	250	180	20	24.17	18.90
30	250	180	30	24.17	18.90
30	250	180	40	24.17	18.90

The analysis of shrinkage for injection time parameter can be compare from this result as shown in figure 4.17, 4.18.

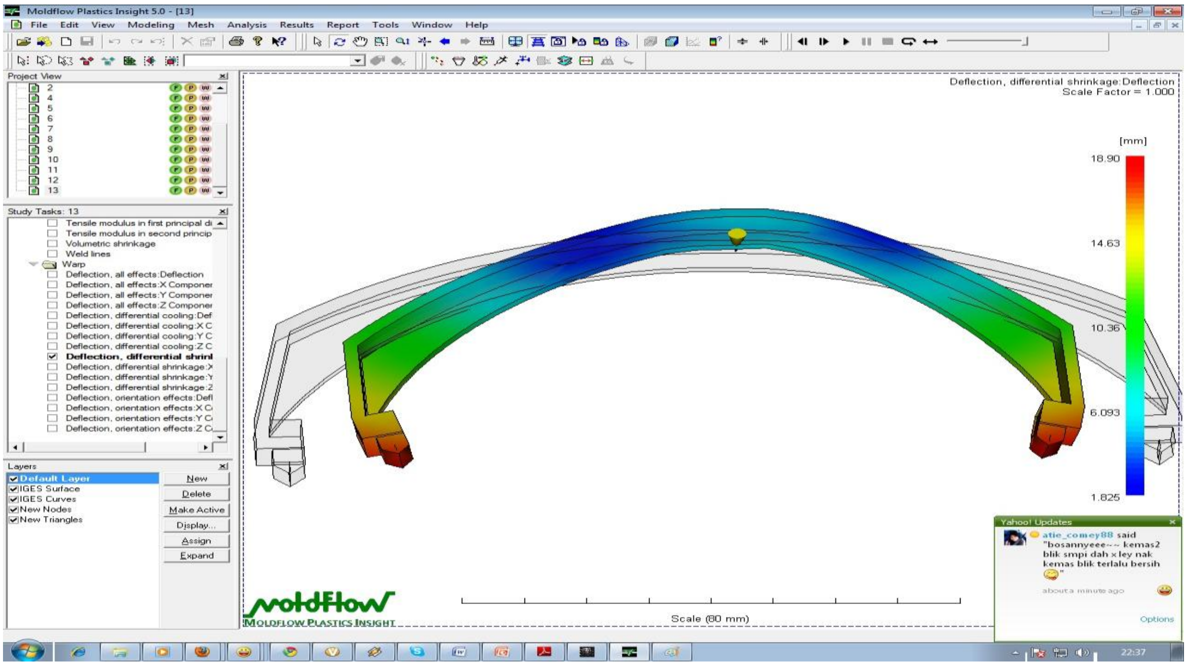

Figure 4.17: Result of volumetric shrinkage at ejection when cooling time is 10 s

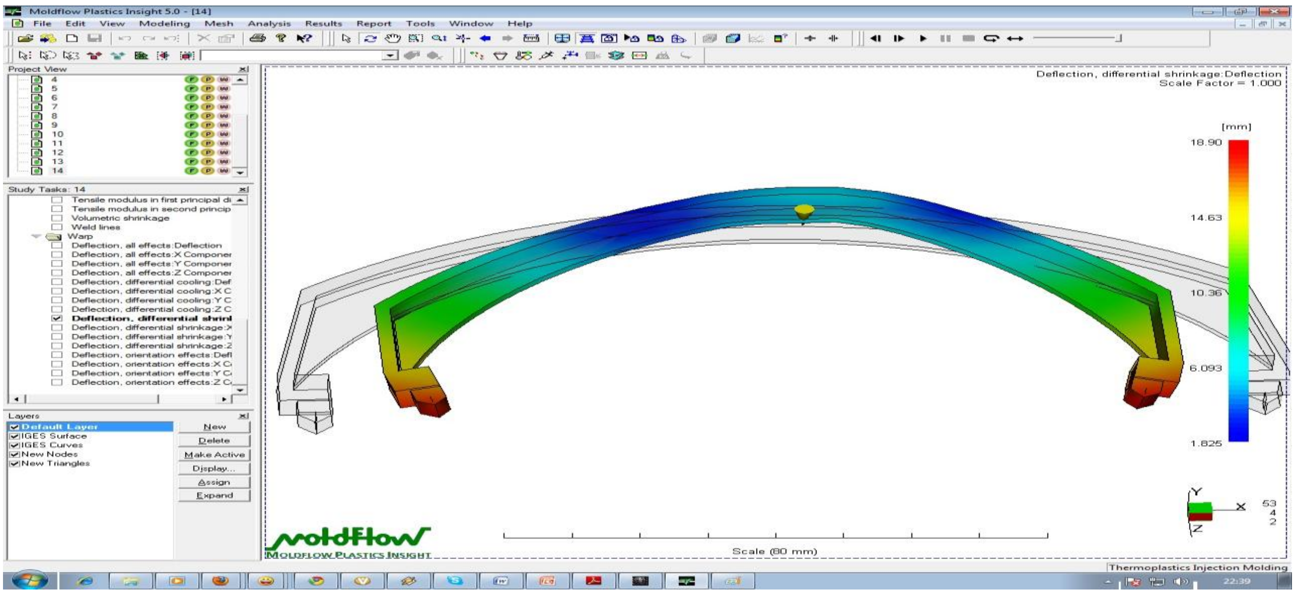

Figure 4.18: Result of volumetric shrinkage at ejection when cooling time is 20 s

From this result as shown in figure 4.17, 4.18, the shrinkage of the frame is decrease when the cooling time is increase. The shrinkage is also constant at 30 s, and 40 s. The best cooling time is 30 s.

The analysis of warpage for injection time parameter can be compare from this result as shown in figure 4.19, 4.20 .

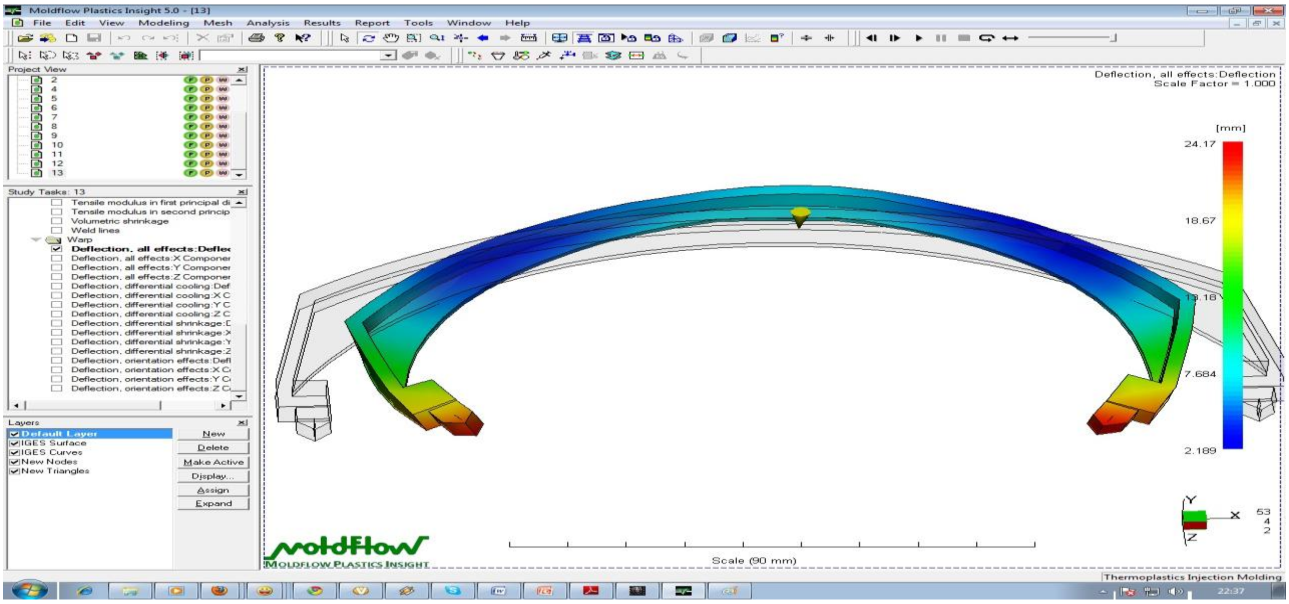

Figure 4.19: Result of warpage when injection time is 10 s

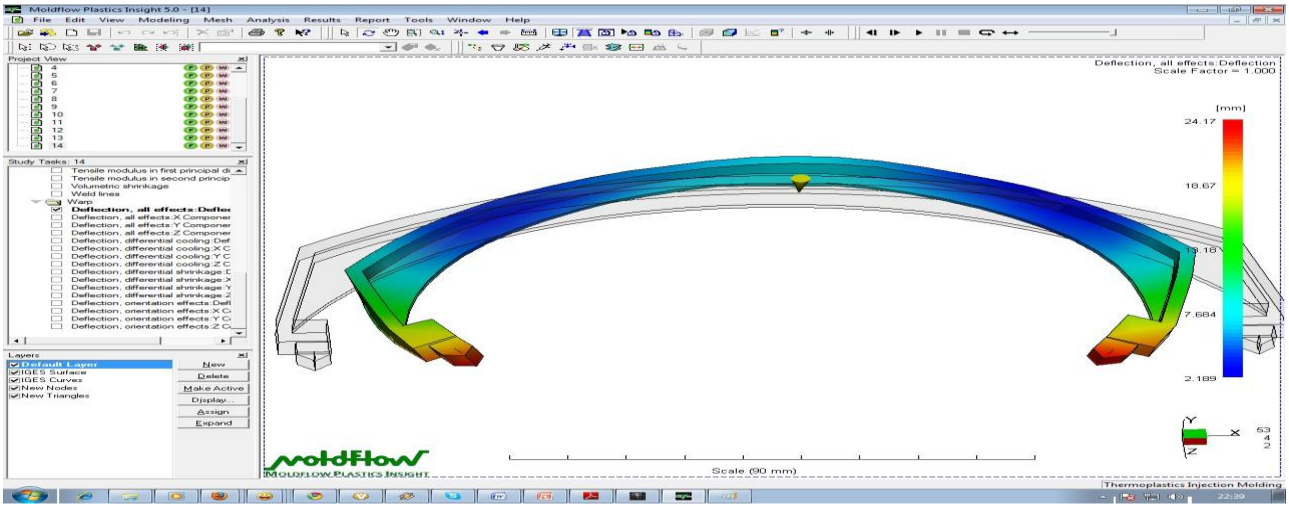

Figure 4.20: Result of warpage when injection time is 20 s

From this result as shown in figure 4.19, 4.20, the warpage of the frame is increase when the cooling time is increase. The warpage is constant at 30s and 40 s. The best cooling time is 10 s.

4.2.2 Glass

The glass of laboratory goggle was analyzed by the moldflow software and the result can be divided into a few part. Four parameter was used, it is a mold temperature, melt temperature, injection pressure and cooling time. For each parameter, it will repeat four times with four different values.

4.2.2.1 Mold Temperature

Analyzed the mold temperature parameter using Moldflow Software with melt temperature, injection pressure and cooling times are constant as shown in table 4.5.

Table 4.5 : Properties to analyze mold temperature parameter

Mold Temperature (C)	**Melt Temperature (C)**	**Injection Pressure (MPa)**	**Cooling Time (s)**	**Warpage (mm)**	**Shrinkage (mm)**
20	250	180	20	0.9459	0.5068
30	250	180	20	0.9735	0.5193
40	250	180	20	1.012	0.5344
50	250	180	20	1.034	0.5404

The analysis of shrinkage for mold temperature parameter can be compare from this result as shown in figure 4.21, 4.22, 4.23 .

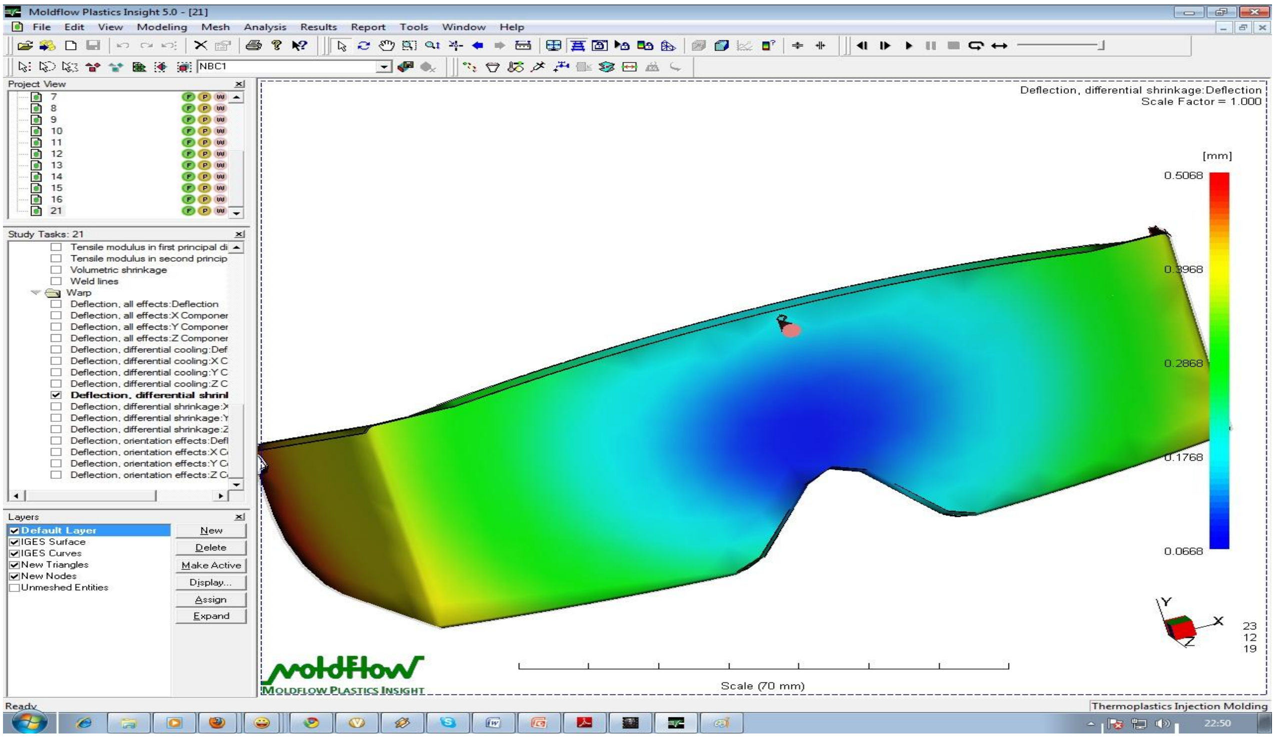

Figure 4.21: Result of volumetric shrinkage at ejection when mold temperature is 20 C

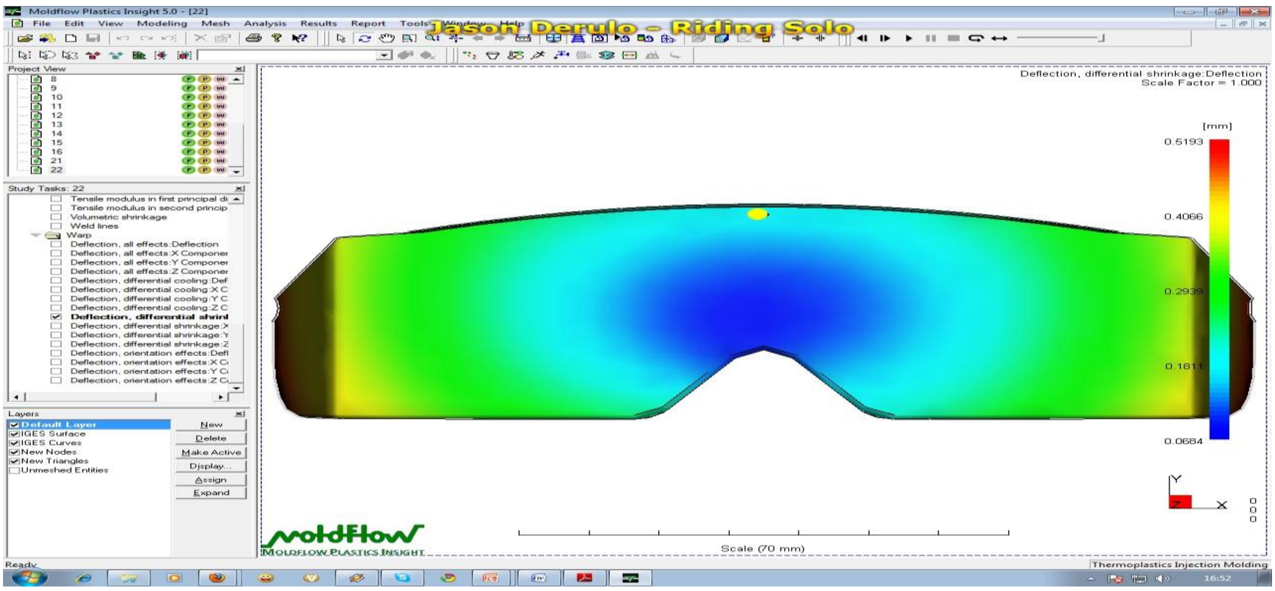

Figure 4.22: Result of volumetric shrinkage at ejection when mold temperature is 30 C

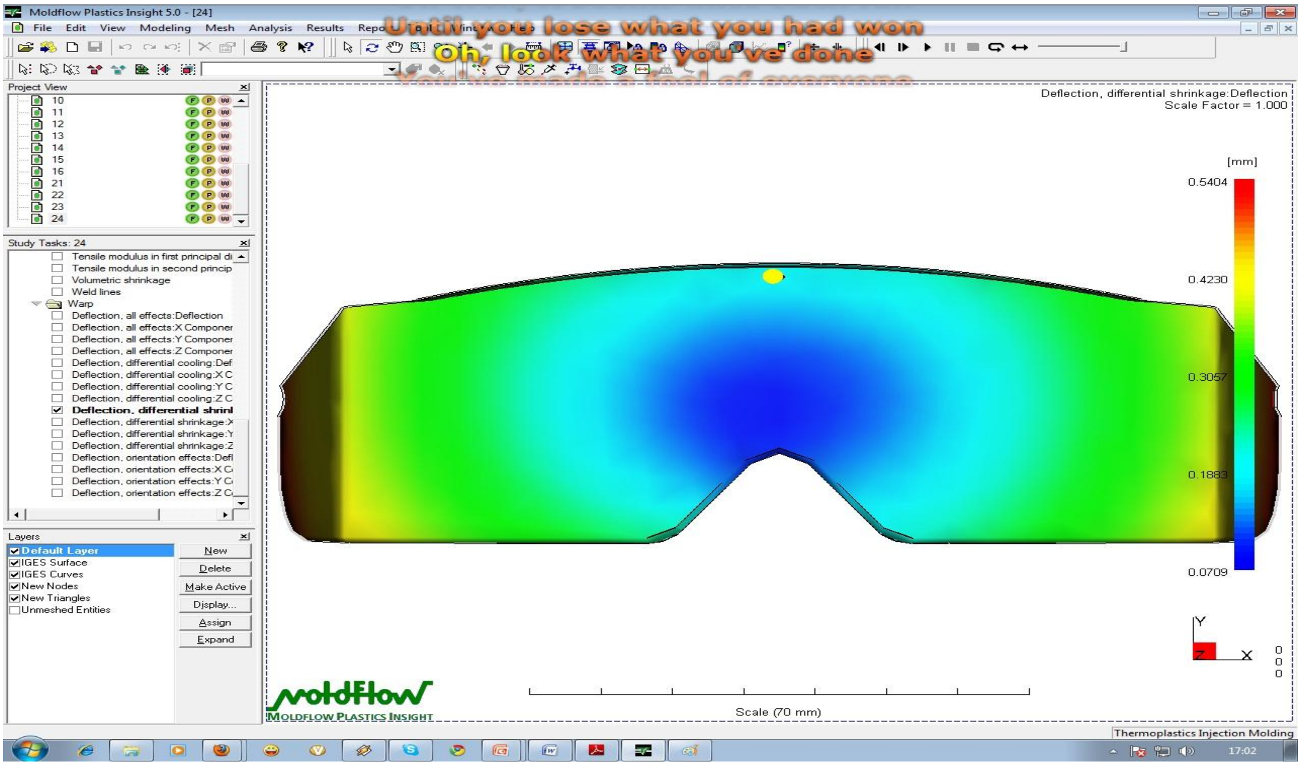

Figure 4.23: Result of volumetric shrinkage at ejection when mold temperature is 50 C

From this result as shown in figure 4.21, 4.22, 4.23, the shrinkage of the glass will increase when the mold temperature is increase. The best mold temperature is 20 C

The analysis of warpage for mold temperature parameter can be compare from this result as shown in figure 4.24, 4.25 .

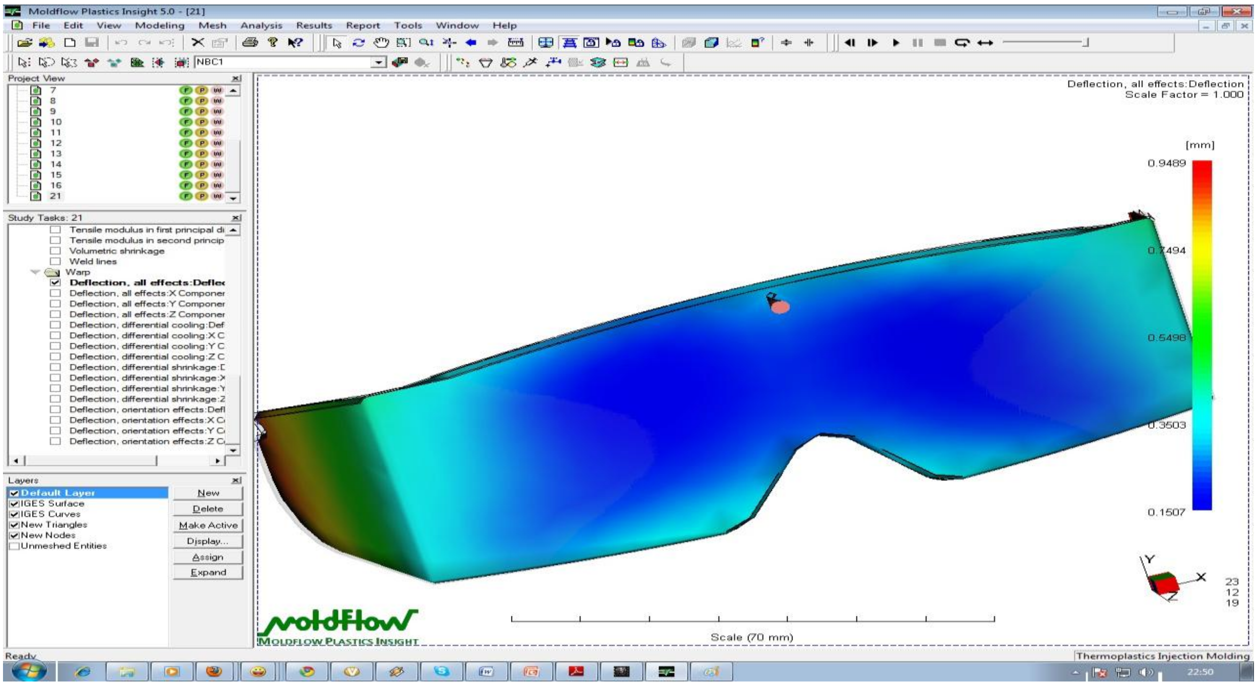

Figure 4.24: Result of warpage when mold temperature is 20 C

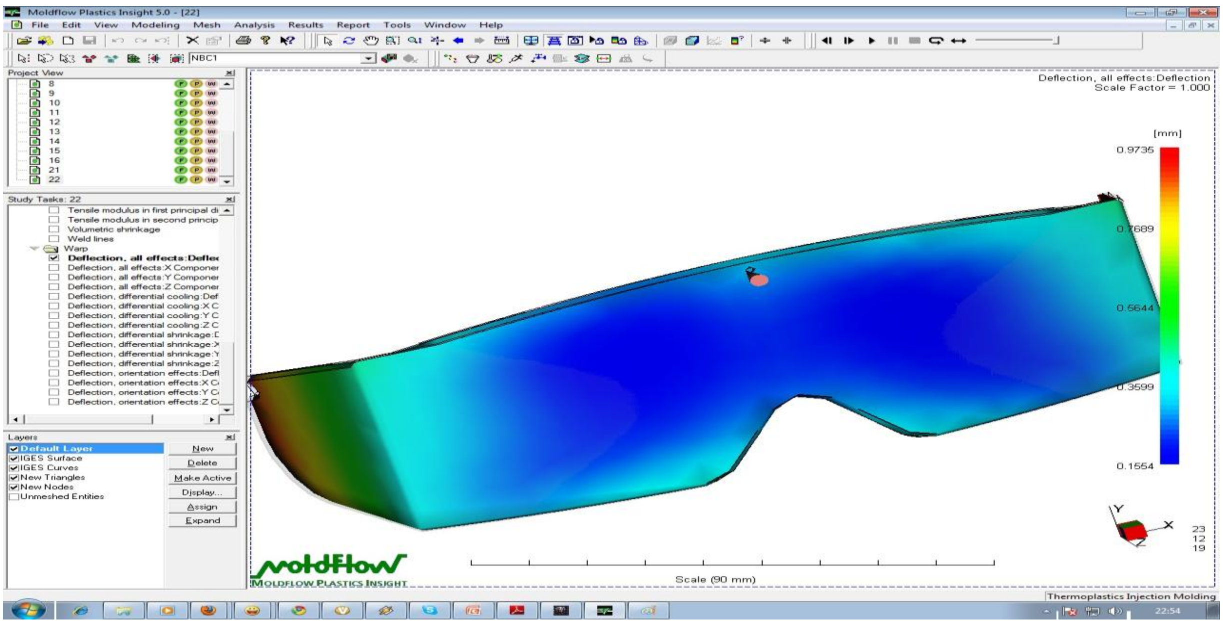

Figure 4.25: Result of warpage when mold temperature is 30 C

From this result as shown in figure 4.24, 4.25 the warpage of the glass is decrease when the mold temperature is increase. The best mold temperature is 50 C.

4.2.2.2 Melt Temperature

Analyzed the melt temperature parameter using Moldflow Software with mold temperature, injection pressure and cooling times are constant as shown in table 4.6.

Table 4.6 : Properties to analyze melt temperature parameter

Mold Temperature (C)	Melt Temperature (C)	Injection Pressure (MPa)	Cooling Time (s)	Warpage (mm)	Shrinkage (mm)
30	230	180	20	0.9946	0.5314
30	240	180	20	0.9910	0.5296
30	250	180	20	0.9735	0.5193
30	260	180	20	0.9502	0.5060

The analysis of shrinkage for melt temperature parameter can be compare from this result as shown in figure 4.26, 4.27, 4.28 .

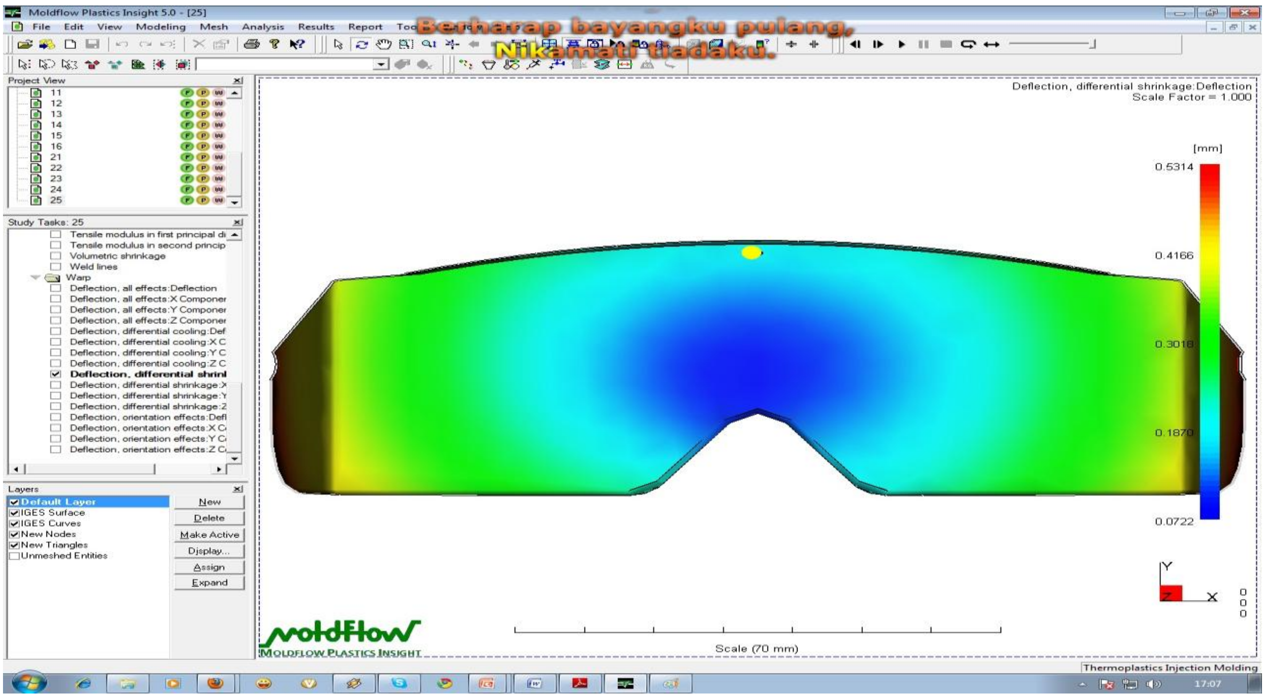

Figure 4.26: Result of volumetric shrinkage at ejection when melt temperature is 230 C

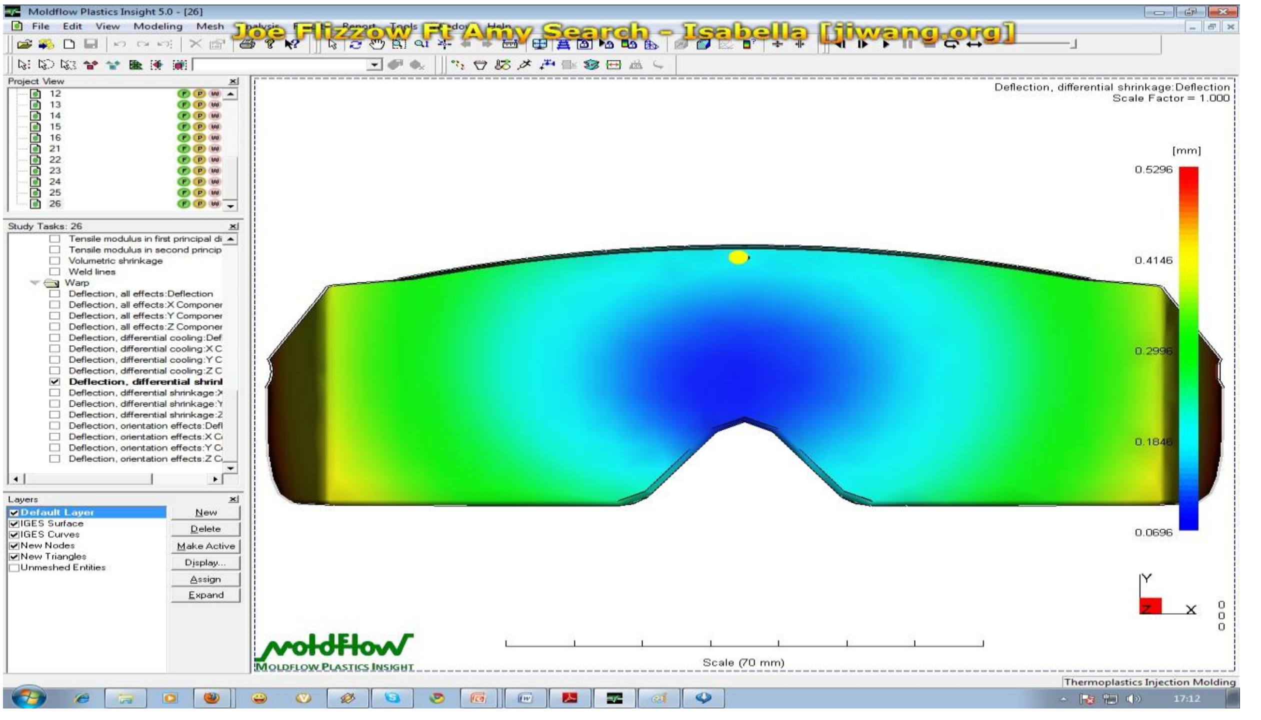

Figure 4.27: Result of volumetric shrinkage at ejection when melt temperature is 240 C

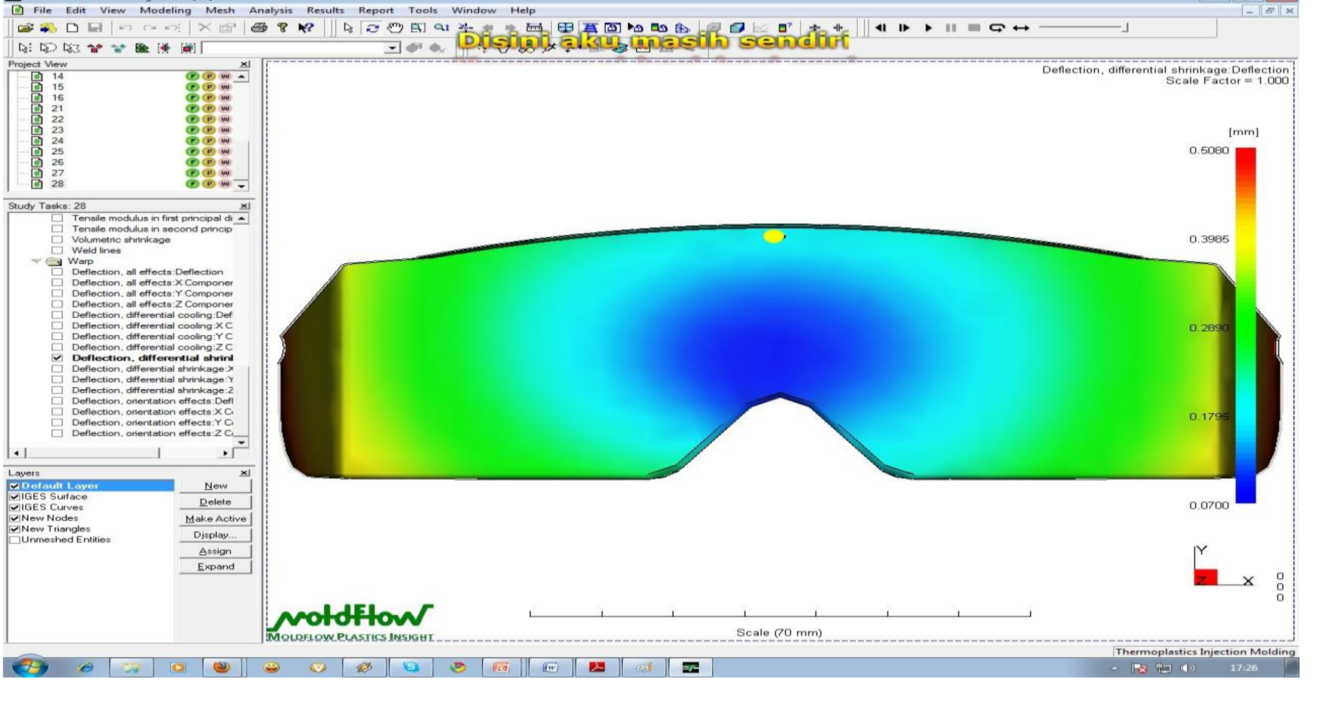

Figure 4.28: Result of volumetric shrinkage at ejection when melt temperature is 270 C

From this result as shown in figure 4.26, 4.27, 4.28, the shrinkage of the glass is decrease when the melt temperature increase. The best melt temperature is 260 C.
The analysis of warpage for melt temperature parameter can be compare from this result as shown in figure 4.29, 4.30, 4.31.

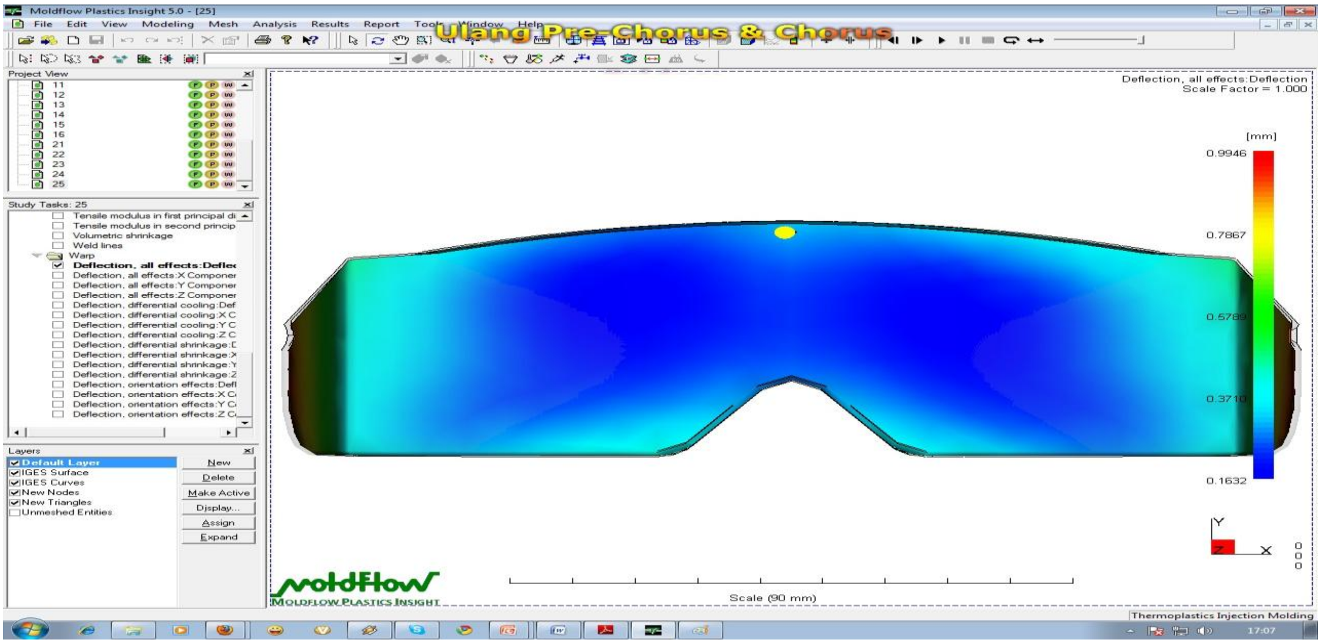

Figure 4.29: Result of warpage when melt temperature is 230 C

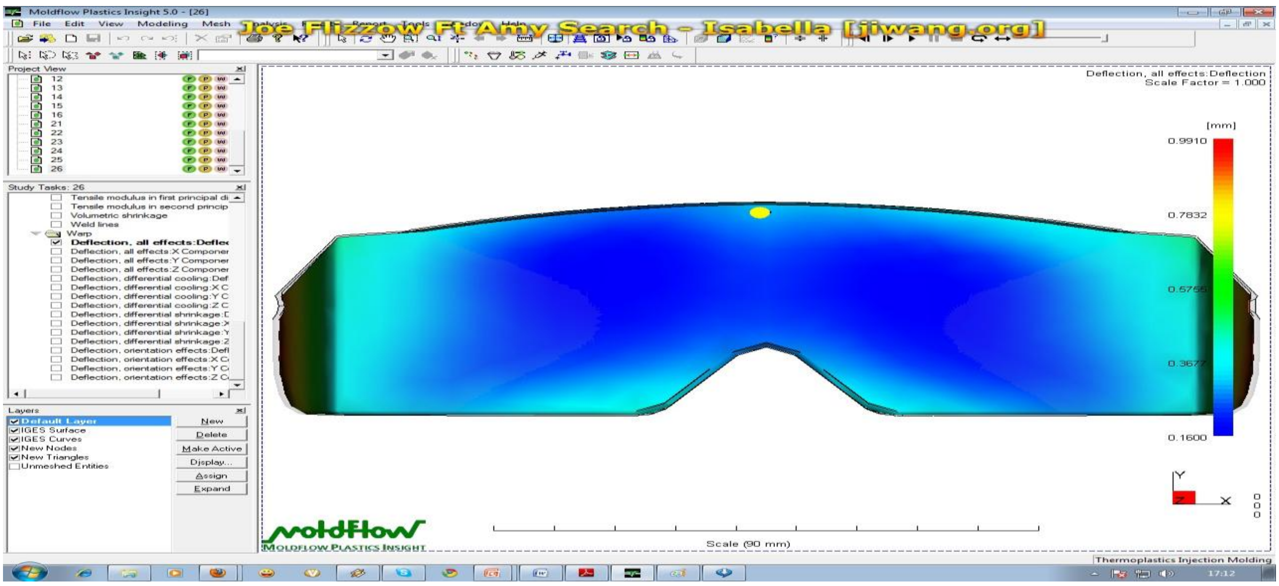

Figure 4.30: Result of warpage when melt temperature is 240 C

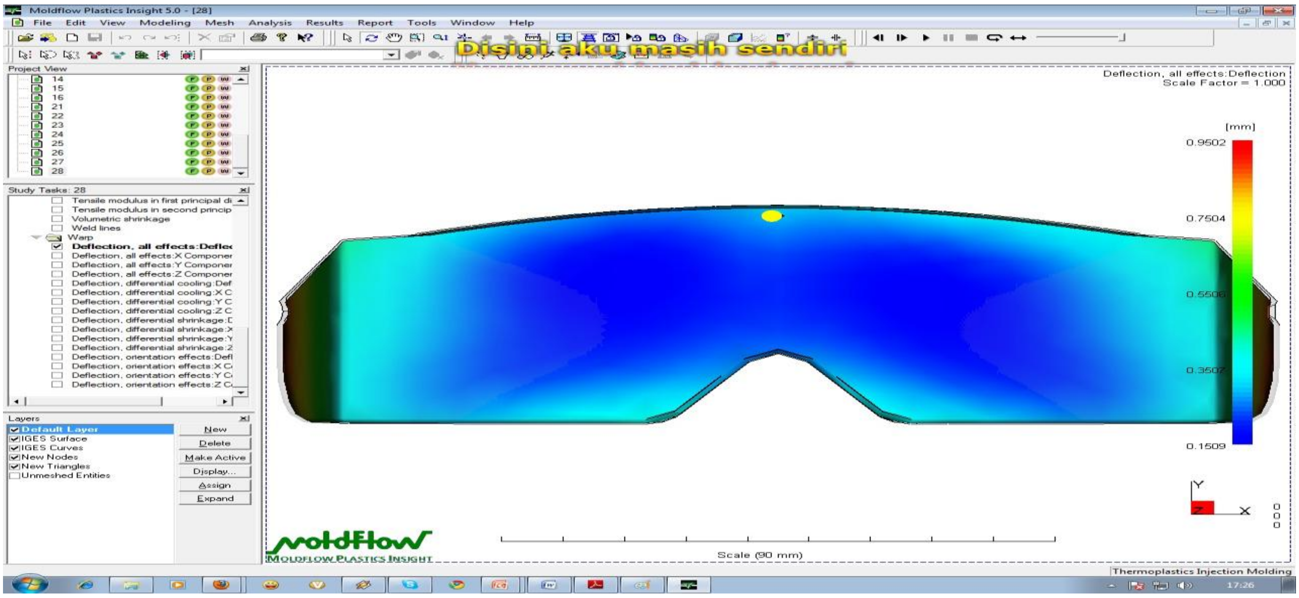

Figure 4.31: Result of warpage when melt temperature is 260 C

From this result as shown in figure 4.29, 4.30, 4.31, the warpage of the glass is decrease when the melt temperature is increase. The best melt temperature is 260 C

4.2.2.3 Injection Pressure

Analyzed the injection pressure parameter using Moldflow Software with mold temperature, melt temperature and cooling times are constant as shown in table 4.7 .

Table 4.7 : Properties to analyze injection pressure parameter

Mold Temperature (C)	**Melt Temperature (C)**	**Injection Pressure (MPa)**	**Cooling Time (s)**	**Warpage (mm)**	**Shrinkage (mm)**
30	250	100	20	0.9735	0.5193
30	250	200	20	24.41	10.38
30	250	300	20	24.41	10.38
30	250	400	20	24.41	10.38

The analysis of shrinkage for injection pressure parameter can be compare from this result as shown in figure 4.32, 4.33, 4.34 .

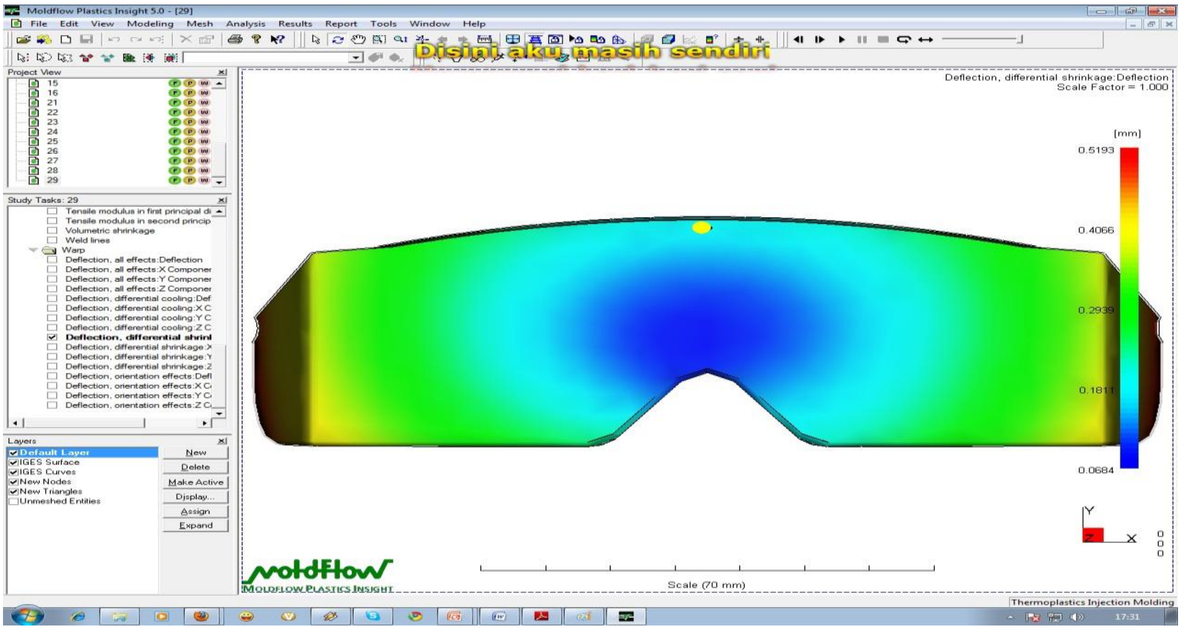

Figure 4.32: Result of volumetric shrinkage at ejection when injection pressure is 100 MPa

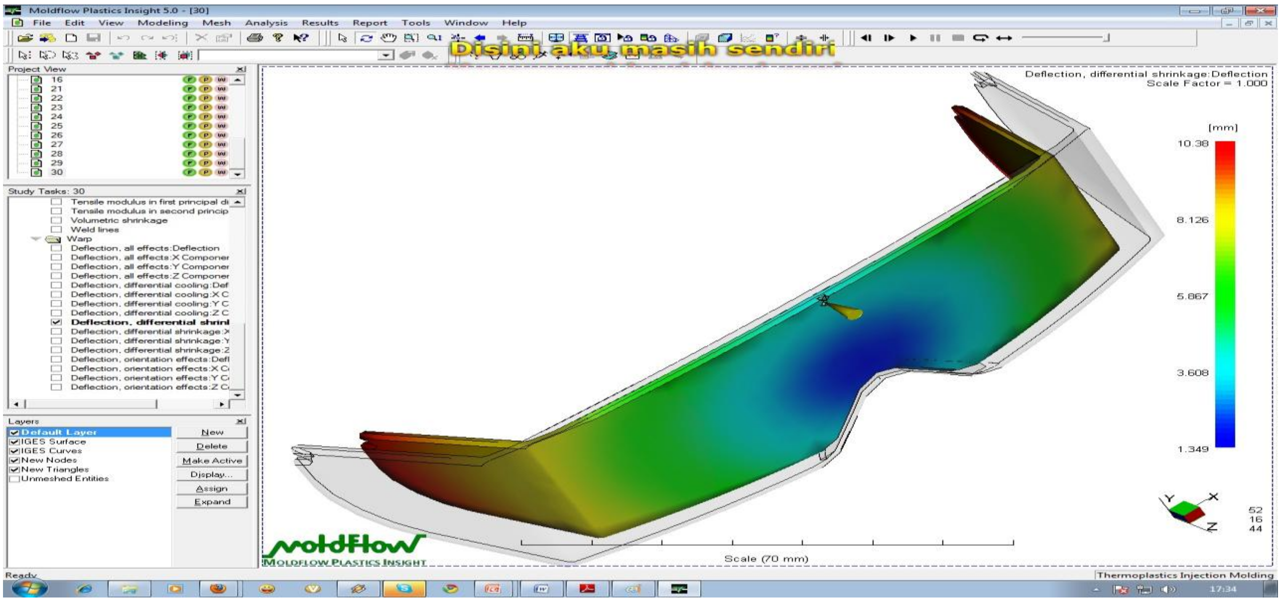

Figure 4.33: Result of volumetric shrinkage at ejection when injection pressure is 200 MPa

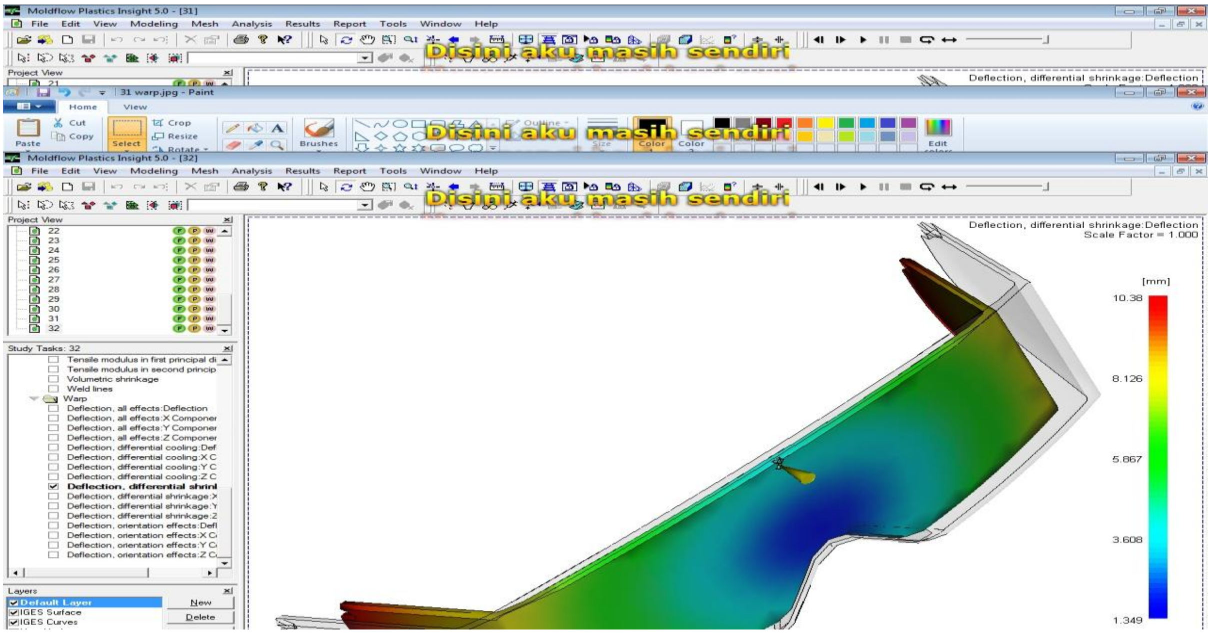

Figure 4.34: Result of volumetric shrinkage at ejection when injection pressure is 400 MPa

From this result as shown in figure 4.32, 4.33, 4.34, the shrinkage of the glass is decrease when the injection pressure is increase. The best injection pressure is 400 MPa.

The analysis of warpage for injection pressure parameter can be compare from this result as shown in figure 4.35, 4.36 .

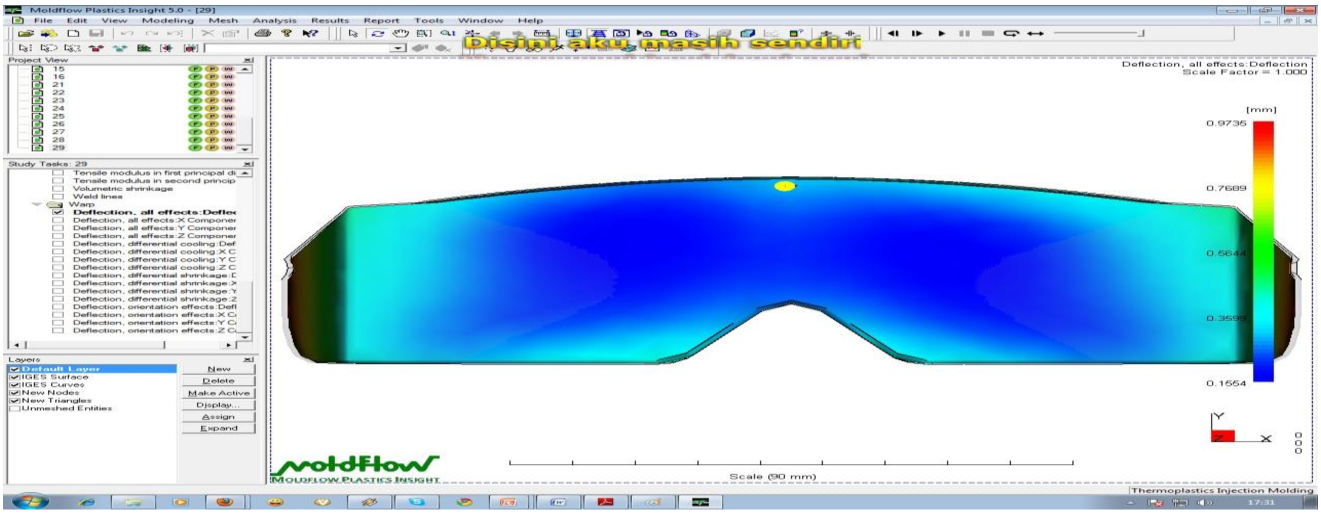

Figure 4.35: Result of warpage when injection pressure is 100 MPa

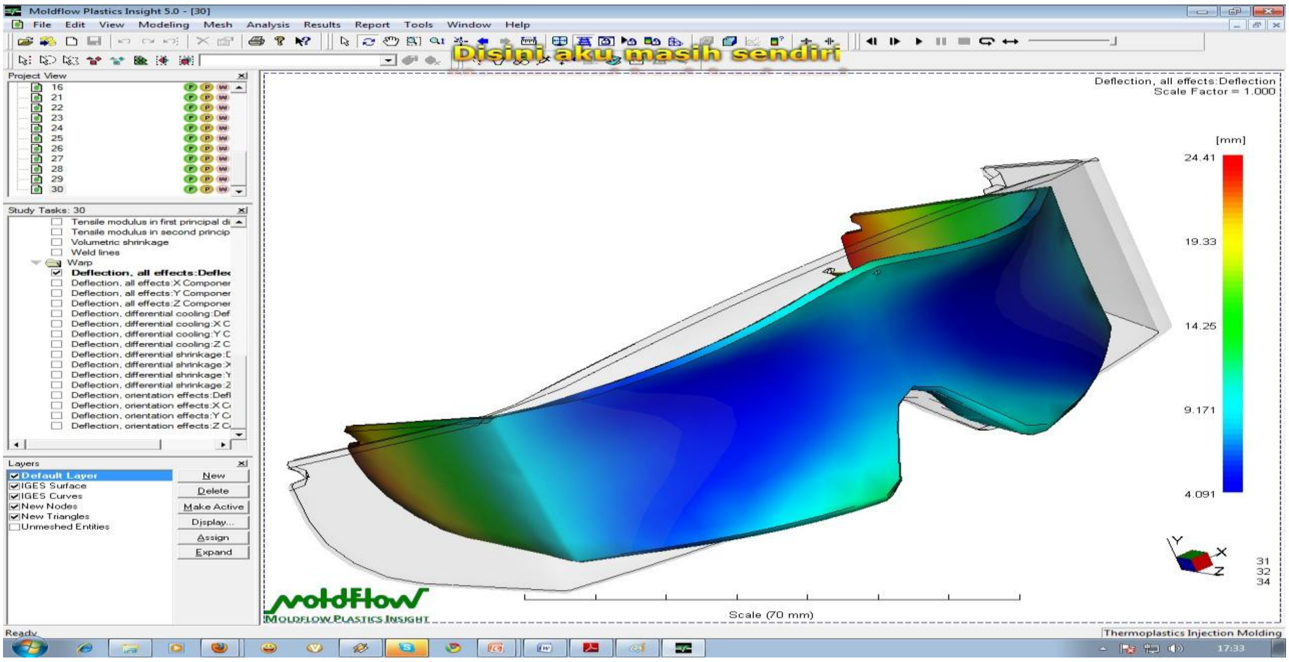

Figure 4.36: Result of warpage when injection pressure is 200 MPa

From this result as shown in figure 4.35, 4.36, the warpage of the glass is increase when the injection pressure also increase. The best injection pressure is 100 MPa.

4.2.2.3 Cooling Time

Analyzed the injection time parameter using Moldflow Software with mold temperature, melt temperature and injection pressure are constant as shown in table 4.8.

Table 4.8 : Properties to analyze cooling time parameter

Mold Temperature (C)	Melt Temperature (C)	Injection Pressure (MPa)	Cooling Time (s)	Warpage (mm)	Shrinkage (mm)
30	250	180	10	0.9735	0.5193
30	250	180	20	24.41	10.38
30	250	180	30	24.41	10.38
30	250	180	40	24.41	10.38

The analysis of shrinkage for injection time parameter can be compare from this result as shown in figure 4.37, 4.38, 4.39 .

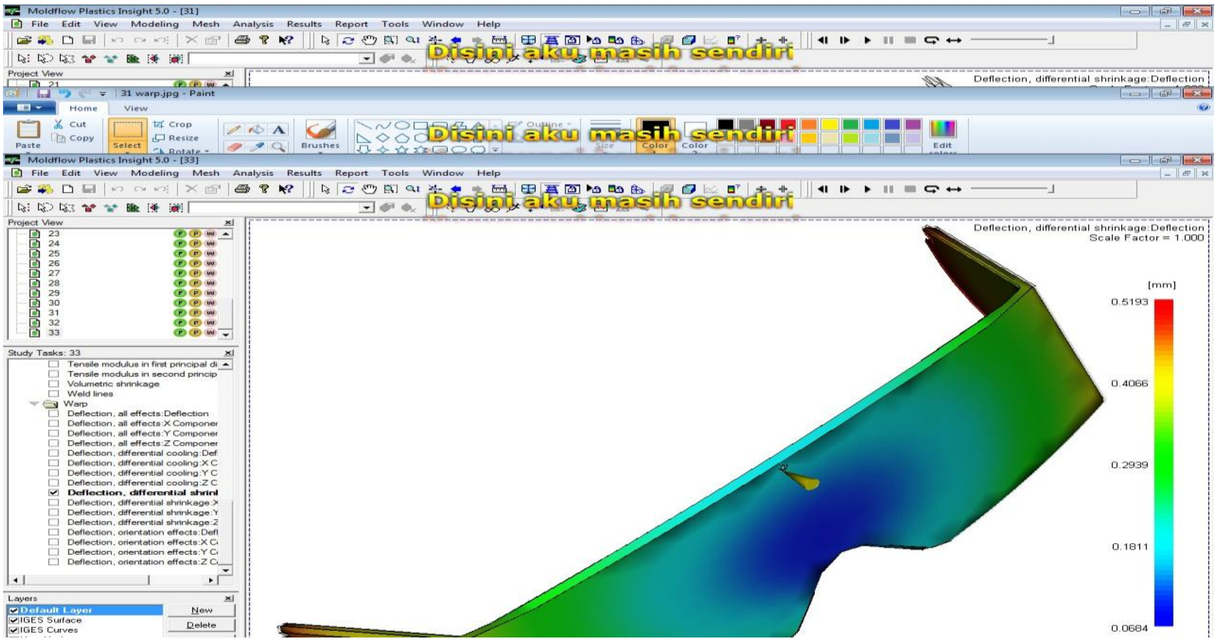

Figure 4.37: Result of volumetric shrinkage at ejection when cooling time is 10 s

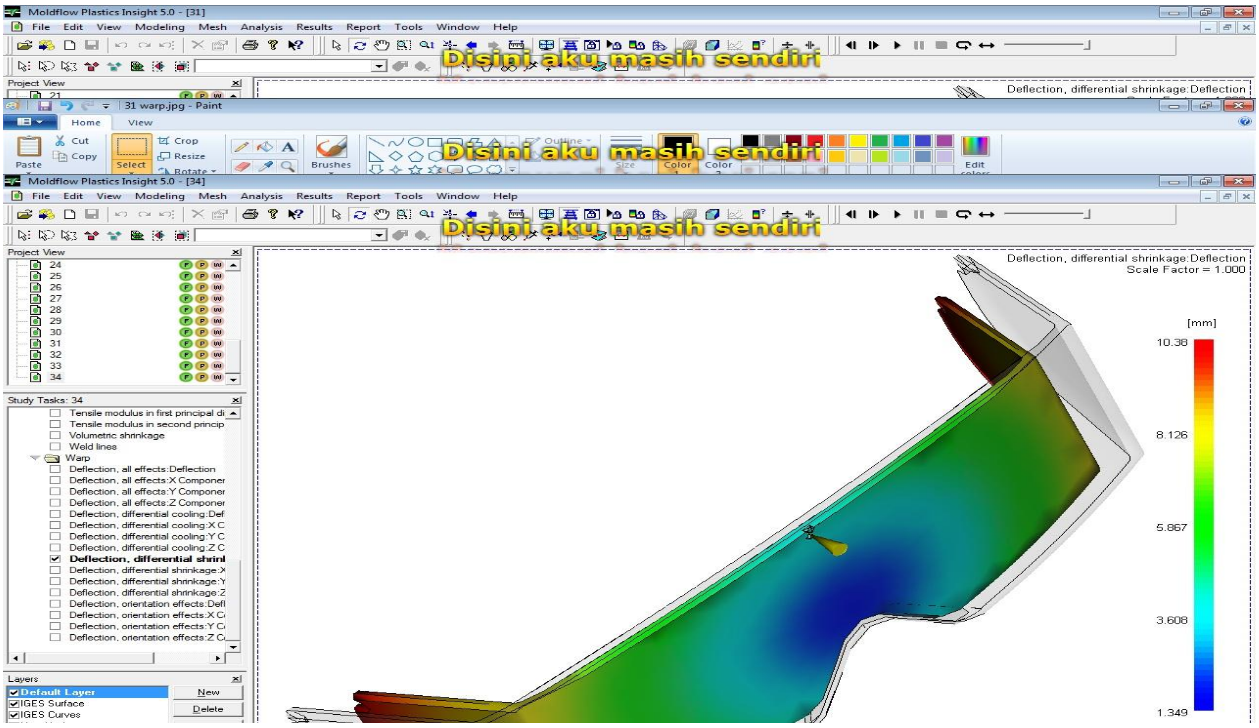

Figure 4.38: Result of volumetric shrinkage at ejection when cooling time is 20 s

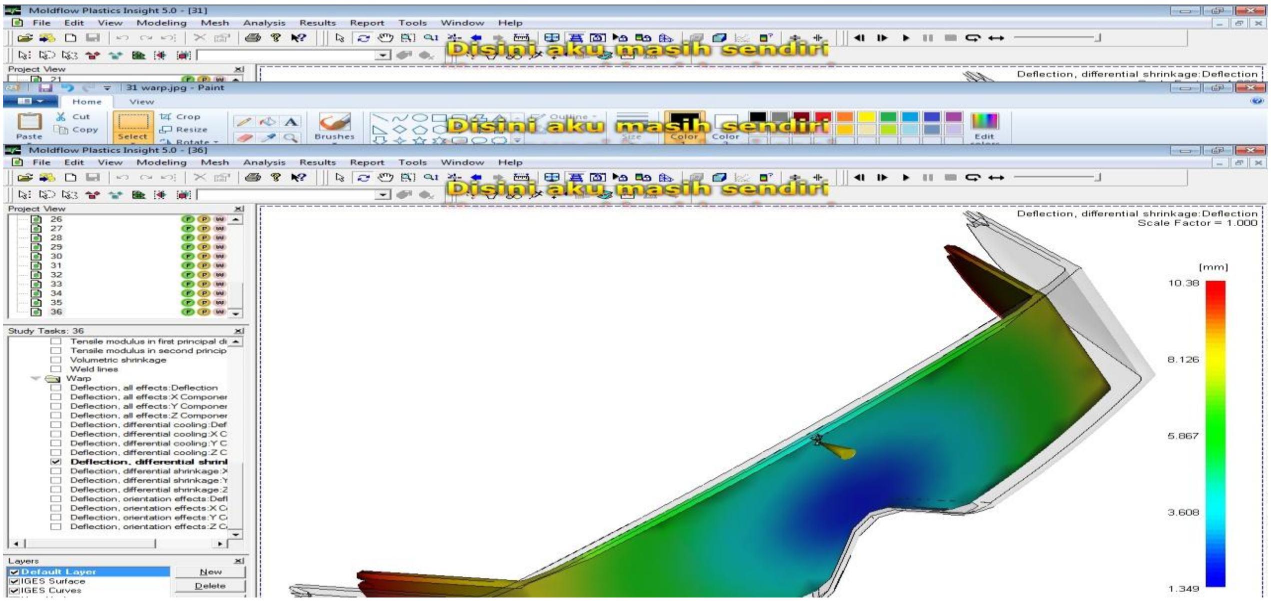

Figure 4.39: Result of volumetric shrinkage at ejection when cooling time is 40 s

From this result as shown in figure 4.37, 4.38, 4.39, the shrinkage of the glass is decrease when the cooling time is increase. The shrinkage is also constant at 30 s, and 40 s. The best cooling time is 30 s.

The analysis of warpage for injection time parameter can be compare from this result as shown in figure 4.40, 4.41 .

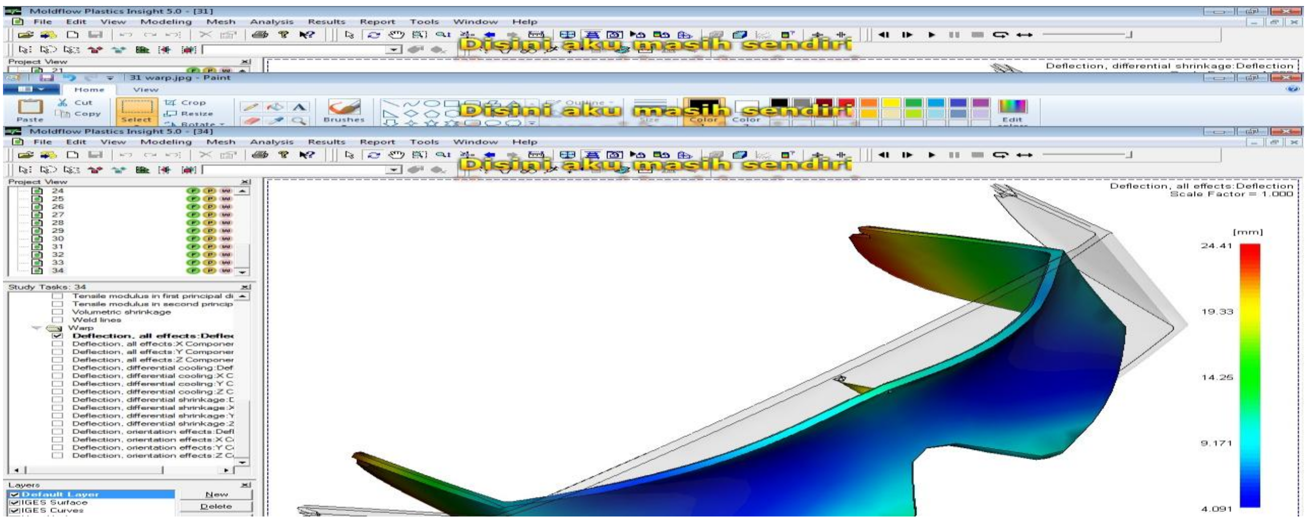

Figure 4.40: Result of warpage when cooling time is 20 s

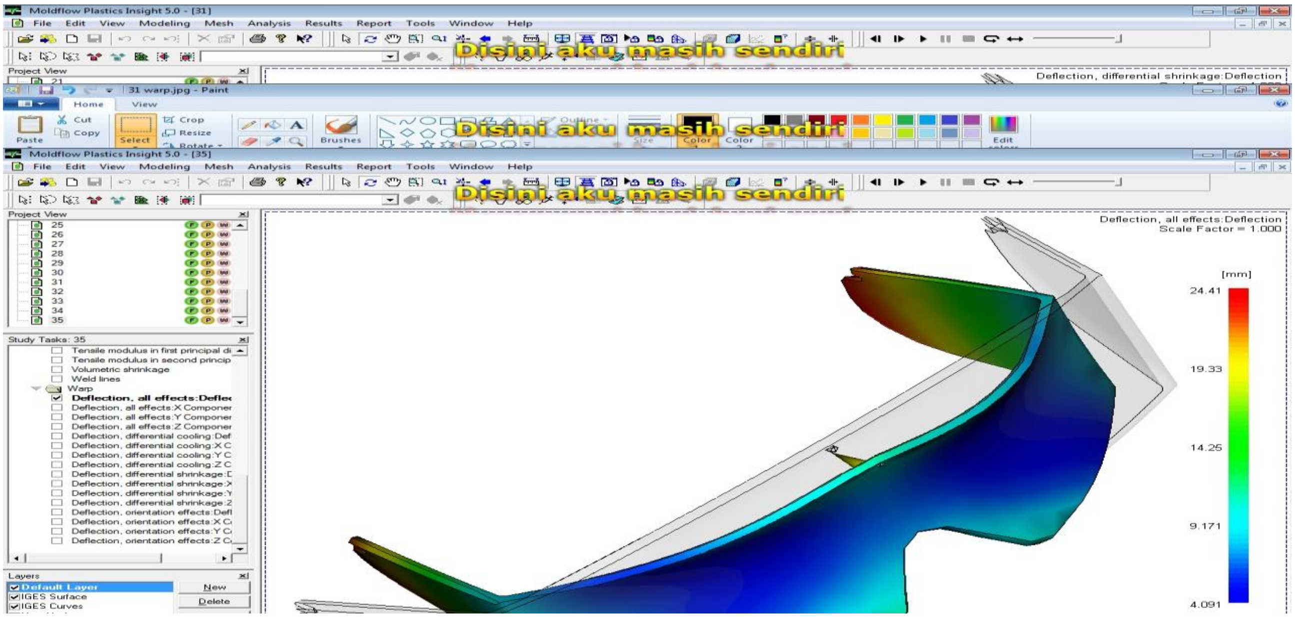

Figure 4.41: Result of warpage when cooling time is 30s

From this result as shown in figure 4.40, 4.41, the warpage of the glass is increase when the cooling time is increase. The warpage is constant at 30s and 40 s. The best cooling time is 10 s.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter is the summary of what this whole research is about. The conclusion of overall about this study either this experiment achieve their objectives or not. The conclusion is makes based on the results. Recommendations will also be given to improve this study next time.

5.2 CONCLUSION

According to result from moldflow software, in conclusion the factor that influence the molding process it is pressure, temperature, molding temperature, molding cool must be in a correct position because it will be give a effect if the factor is not suitable. The use of computer simulation software, Moldflow Plastic Insight has enabled the current study to identify the effects of warpage and shrinkage by using four parameter , it is a mold temperature, melt temperature, injection pressure and injection time. Mold temperature, melt temperature, injection pressure and cooling time are considered as process parameters. Findings in this study also indicate that warpage is inversely proportional with mold temperature, and melt temperature but directly proportional with cooling time and injection pressure at least for the problem of interest.

5.3 RECOMMENDATIONS

For every studies and researches that has been done, there is always room for further improvements. So is this research. There are some suggestion and method that can be taken into account when running this research in the future. The recommendations to improve this study are:

- For validation of this project, the student must have an insert and inject the product to validate the result.

- Student also must make a collaboration with laboratory goggle company to make this project have a validation.

- Also the student must make a comparison the result from moldflow software with other software.

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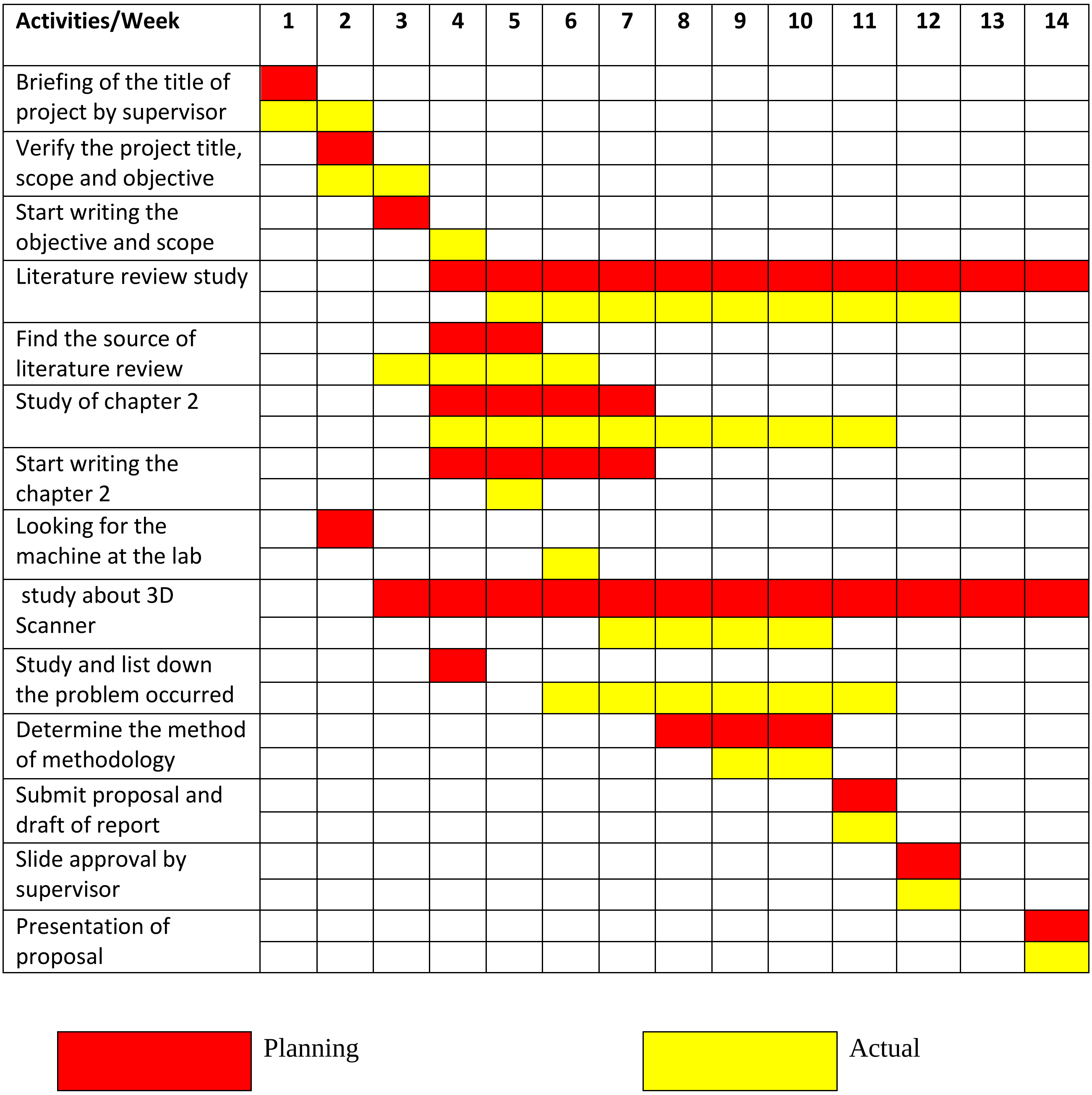
APPENDIX A
GANT CHART

A1. Gant Chart for FYP 1



A2. Gant Chart for FYP 2

Activities/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
Discuss with supervisor about the project																
Start scanning from 3D Scanner																
Literature review study																
Edit the product after scan																
Transfer to solidwork software																
Redrawing using Solidwork																
Use Moldflow Software																
Analysis the data																
Start writing chapter 4 & 5																
Repair chapter 1 - chapter 3																
Finish chapter 1- chapter 5																
Check format & grammer																
Submit draft 1 and log book																
Presentation																