Int. J. Sci. R. Tech., 2025 2(1)
A Multidisciplinary peer-reviewed Journal
www.ijsrtjournal.com [ISSN: 2394-7063]

Original Article

The Effect of Preheating Mold Changeover on Production Efficiency and Product Quality of XYZ Company

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ABSTRACT

Production efficiency and product quality are two crucial factors in the manufacturing industry, especially in the plastic injection process. One of the challenges often faced is the long start-up time and the high level of product defects due to suboptimal mold temperatures after mold changes. This study aims to analyze the effectiveness of mold heating before replacement as a solution to improve production process efficiency and product quality. The study was conducted through field experiments by comparing two methods, namely mold changes without preheating and with preheating. The data collected included start-up time, product defect rate, material usage efficiency, mold life, and machine performance stability. Statistical analysis was used to analyze the relationship between mold heating and increased production efficiency and quality. The results showed that mold heating significantly reduced start-up time, reduced product defect rates in the early stages of production, and increased material usage efficiency by reducing waste. In addition, this practice also contributed to the extension of mold life by reducing thermal stress due to sudden temperature changes. Increased stability of the production machine was also recorded as a positive impact of this method.

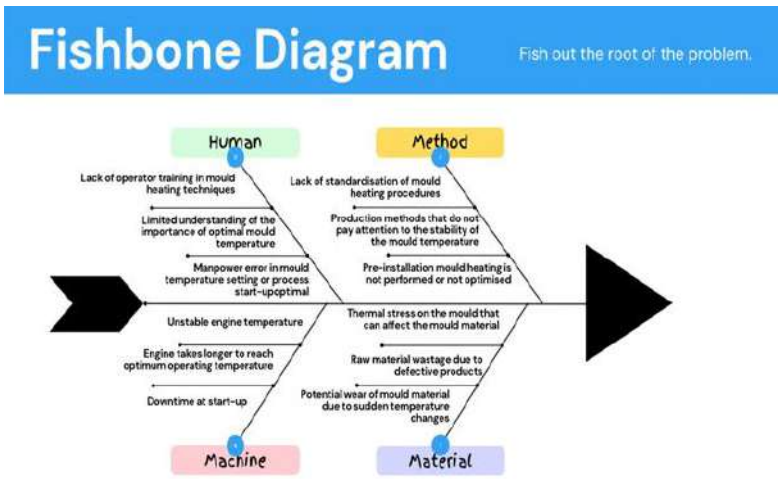
Keywords: Preheating; Molding; Plastic Injection.

INTRODUCTION

The manufacturing industry plays an important role in meeting market needs by producing quality products efficiently. In the production process, operational efficiency is the main factor that determines the competitiveness of a company. One of the challenges often faced in the manufacturing industry, especially in the plastic injection and die casting processes, is the mold change process. This process requires high time and precision, especially to ensure that the mold reaches the optimal operating temperature before starting production.Inefficient mold changeovers can cause several problems, such as longer start-up times, high defect rates in early production, material waste, and wear and tear that shortens the life of the mold. This often occurs because newly installed molds take time to reach a stable temperature, which slows down the production process and increases operating costs.One method that can be applied to overcome this problem is the mold heating technique before changing. Mold heating allows the mold to reach the optimum temperature before installation in the production machine, thus reducing start-up time, improving the quality of the mold results, and reducing waste materials. In addition, this technique is also believed to be able to extend the life of the mold by reducing thermal stress due to sudden temperature changes.This study aims to the effectiveness of mold heating before replacement in improving production efficiency and product quality. This study will provide the impact of the application of this technique on start-up time, product defect rate, material usage efficiency, mold life, and machine performance stability. Thus, the results of this study are expected to provide applicable recommendations for the manufacturing industry in optimizing the production process and increasing the company's power to say.

- **Theoretical Framework**

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



Gambar 1: Fishbone Diagram

Fishbone diagram, or fishbone diagram, is a tool used to identify, analyze, and organize the possible causes of a particular problem or effect. In the context of this study, the fishbone diagram is used to identify factors that affect production efficiency and product quality in plastic injection molding processes, especially those related to mold heating before the diagram helps to visualize the relationship between root causes and sub-causes, thus facilitating the analysis of complex problems, such as long start-up times, high defect rates, and waste materials.Based on the data, the main causes analyzed include mold temperature, heating technique, machine stability, and the quality of the mold heating material before changing, which are proven to have a significant effect on mold temperature stability, which affects the distribution of material flow and mold results. Suboptimal temperatures can cause various defects in products, such as decocting, flow marks, and lack of material. In addition, machine stability also determines production efficiency because heated molds help reduce machine downtime due to temperature adjustments.By integrating the fishbone diagram into the analysis, this study shows the complex relationship between various factors affecting the production process. The technique of warming up the mold before changing not only improves the efficiency of the start-up time, but also reduces the rate of defective materials and waste. This leads to the extension of the mold life and the improvement of the operational stability of the machine, which overall improves the power of the manufacturing industry.

Research Methodology

- **Mold Preparation**The molds to be used are divided into two groups:
  - MOLD A (with heating): The mold is heated using a Hot Runner until it reaches the optimum operating temperature of 200oC before being installed in the machine.
  - MOLD B (without heating): The mold is installed directly into the machine without pre-heating treatment.
- **Production Implementation**The prints from both groups were tested in a 4-hour production cycle. Data collected included:
  - The time required to reach temperature stability (start-up time).
  - The number of defective products produced at the start of production.
  - Material consumption during the production cycle.
  - Signs of wear or damage to the mold.
- **Data collection**Data is collected systematically from several production cycles to obtain representative results. Data is taken from the following parameters:
  - Mold temperature before and after warming up.
  - Start-up time (time until the production process is stable).
  - Percentage of defective products at the start of production.
  - Efficient use of materials (no wasted materials).
  - Age of the mold based on signs of wear.
- **Data analysis** The collected data were analyzed using statistical methods to highlight significant

differences between the heating and non-heating methods. Analysis techniques include:

– Test to compare average start-up time and defect rate.
– Regression analysis to measure the relationship between mold heating and production efficiency parameters.
– Visual and quantitative evaluation to measure mold life based on wear and damage

- **Tools and materials**

– Injection machine plastic.

Figure 2:Plastic Injection Machine

– Mold with uniform specifications

Figure 3:Mold

– Hot Runner.

Figure 4:Hot Runner

– Production data recording system.

- **Research Time Frame** The study was conducted over a period of 4 weeks to cover various production cycles and ensure valid and reliable results.

DISCUSSION RESULTS

- **Start-Up Time** Preheated molds require an average of 20% less time to reach stable operating temperature than non-preheated molds. Average start-up time:

	A	B
MOLD TEMPERATURE	170-200	0-200
START-UP TIME	07.00-07.15	07.00-07.25

- **Defective Product Rate**

Defective products in the early stage of production are lower in preheated molds. Defective product rate for 4 hours with Cycle Time 0.61:

	A	B
Production Result OK	369	331
NG	20	58
OEE	93.7%	83.1%
NG Percentage	5%	15%

Defects that are visible include decoking, lack of material (short shot), flow marks, scorch marks, weld lines, silvering, and excessive burring.

- **Material Usage Efficiency**

Material usage is more efficient in preheated molds. Average material waste is reduced by 10%. Material efficiency:

	A	B
WASTE MATERIAL	2700 grams	3000

- **Age Of Mold**

The preheated molds consistently showed lower wear after several production cycles. The indication of longer mold life was even in the preheated mold group, compared to molds that were immediately installed without preheating.

- **Engine Performance Stability**

Production machines using preheated molds show less downtime. Reduced downtime by 30% and

also the stability of the machine's operating temperature is also more consistent.

- **Discussion**

  The significant reduction in start-up time on the mold with preheating indicates thatThe operating temperature of the mold plays an important role in accelerating production stability. With a preheated mold, the machine does not need to work extra hard to increase the mold temperature, thus reducing the time required to start production. HeatingMold preheating has been proven to be effective in reducing product defect rates, especially in the early stages of production. This is because the heated mold is already at the optimum temperature, so that the material flow is more even and fills the mold perfectly. In contrast, a cold mold tends to cause the material to freeze faster, resulting in defects such as underfill or repairs. Closely related to the product defect rate, material efficiency is increased due to the reduction in the amount of product that must be discarded. This reduction in material waste not only reduces production costs but also prevents operational downtime by minimizing waste. Mold preheating helps reduce thermal stress caused by sudden changes in temperature. This stress usually causes premature wear on the mold, such as cracking or repairs. With preheating, the mold experiences a smoother temperature transition, thus extending its operational life. Mold preheating helps maintain the temperature stability of the production machine, thereby reducing the risk of downtime. Machines that are operated with molds at the optimum temperature require fewer adjustments, so operations can run more smoothly and productivity increases.

- **Practical Implications**

  The results of this study indicate that the application of pre-mold heating techniques has a significant positive impact on production efficiency and product quality. This provides an opportunity for the manufacturing industry to:

– Reduce operating costs by reducing start-up time and material waste.
– Improve product quality, especially in the early stages of production.
– Extends production life, including molds and machines.

CONCLUSION

This study proves that pre-mold heating has a significant positive impact on production efficiency and product quality in the manufacturing industry. Pre-mold heating significantly reduces the time required to reach the operating temperature of 200oC, with an average start-up time reduction of 20% compared to the non-heating method. Mold heating successfully reduces the product defect rate in the early stages of production by up to 10%. This is due to better mold temperature stability, allowing the material to fill the mold perfectly. Material usage efficiency increases with reduced raw material waste. This directly contributes to reduced operating costs and improved production processes. Molds heated before installation show fewer signs of wear, allowing mold life to be extended by up to 15% compared to unheated molds. The mold heating technique helps maintain the temperature stability of the production machine, which contributes to reduced downtime by up to 30% and increased overall productivity.

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HOW TO CITE: Bambang T. A., Azka A. N., Ibnu Wiliyansyah, Kurniawan Adi Prasetyo*, M. Ibnu Fakih, Yudi Prastyo, The Effect of Preheating Mold Changeover on Production Efficiency and Product Quality of XYZ Company, Int. J. Sci. R. Tech., 2025, 2 (1), 162-166. https://doi.org/10.5281/zenodo.14637344