# Improving Die Casting Machine Reliability through FMEA-Based Failure Analysis and Repair Optimization

**Final Project**

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**2025**

# Statement of Authenticity of Final Project

I, the undersigned, certify that the contents of part or all of my Final Project entitled: " Improving Die Casting Machine Reliability through FMEA-Based Failure Analysis and Repair Optimization" is my **own work**, **completed without the use of materials that are not permitted** , and **is not the work of other parties which I acknowledge as my own work.** All references cited or referred to have been written in full in the bibliography. If it turns out that my statement is not true, I am willing to accept sanctions in accordance with applicable regulations.

Batam,01 july 2025


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# Approval sheet

**The Final Project is structured to fulfill one of the requirements for obtaining a degree**
**Bachelor of Associate Engineer (AMd.T.)**
**in**
**Batam State Polytechnic**

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# Improving Die Casting Machine Reliability through FMEA-Based Failure Analysis and Repair Optimization


## Abstract

This project aims to conduct a comprehensive analysis of the maintenance practices of die-casting machines, which are critical to the manufacture of high precision metal components, at PT THREE CAST INDONESIA. Die-casting machines are subject to wear and tear due to the continuous operation and high pressures involved in the casting process. Effective maintenance strategies are crucial to minimize downtime, improve operational efficiency, and extend the service life of these machines. The proposed research will involve a systematic evaluation of current maintenance practices, identification of common failure modes, and assessment of their impact on production quality and efficiency. Furthermore, the research will explore predictive maintenance techniques, including the use of condition monitoring and data analysis, to optimize maintenance schedules and reduce unexpected breakdowns. By integrating theoretical insights with practical case studies, this proposal seeks to provide actionable recommendations for improving maintenance protocols in die-casting operations.

# Foreword

Praise be to God Almighty who has bestowed His grace, guidance, and gifts so that the author can complete the Proposal Seminar entitled "Improving Die Casting Machine Reliability through FMEA-Based Failure Analysis and Repair Optimization". The writing of this Proposal Seminar is one of the requirements to obtain the A.Md.T degree in the Manufactured Electronics Engineering study program, Faculty of Engineering, Batam State Polytechnic University.

During the process of preparing this Proposal Seminar, the author realizes that a lot of help, support, and guidance has been given by various parties. Therefore, on this occasion, the author would like to express his deepest gratitude to:

1. Thanks to God, for still giving me health, so that I can complete this final project well.
2. Thanks to the author's parents, Sinok B. Tambunan and Lidia Siregar, for always giving support and hope to the author.
3. Dr. Uuf Brajawidagda, ST, MT, Ph.D as the Director of Batam State Polytechnic.
4. Mr. Muhammad Arifin as the Head of the Batam State Polytechnic Manufactured Electronics Study Program who has provided encouragement and support through the socialization of the preparation of the final project.
5. Mrs. Widya, as the thesis supervisor who is always patient in guiding, taking the time and providing direction, input, and motivation to the author in the preparation of this final project.
6. Mr. Fadli Firdaus as the lecturer of the manufacturing electronics course class of 2022 who has provided a lot of advice, instructions, motivation and support to the author in the preparation of the final project.
7. The examining lecturers who have tested the author in the final project, thank you for the suggestions and constructive criticism for the perfection of this final project.
8. All Manufacturing Electronics Lecturers who have provided knowledge to the author so that the author can complete this final project well.

Batam, 08 December 2025

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# Improving Die Casting Machine Reliability Trough FMEA-Based Failure Analysis and Repair Optimization

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*Received on dd-mm-yyyy* | *Revised on dd-mm-yyyy* | *Accepted on dd-mm-yyyy*

*Abstract*— **This research focuses on enhancing the reliability of die casting machines by applying the Failure Mode and Effect Analysis (FMEA) method to detect, assess, and mitigate potential sources of failure. Through the calculation of the Risk Priority Number (RPN), the most critical failure modes can be prioritized, forming the foundation for developing more accurate and effective corrective strategies. Data for this study was gathered through field observations, discussions with maintenance technicians, and evaluation of historical machine failure records. Findings indicate that the use of FMEA successfully highlighted the three most influential failure modes affecting machine performance, and after implementing the recommended improvements, machine uptime increased significantly with a 35% reduction in breakdown occurrences. The study confirms that combining FMEA with a systematic improvement approach can strengthen machine reliability and contribute to a more consistent and efficient production flow. Die casting is utilized due to its high production speed, cost efficiency, and suitability for manufacturing aluminum automotive components with excellent dimensional precision, ultimately reducing failures and maintenance expenses.**

**Keyword:**
**FMEA, die casting,machine reability, failure analysis,repair optimization.**

## I. Introduction

In the world of modern manufacturing, the sustainability and efficiency of production processes are highly dependent on the reliability of the machinery used[1]. One of the most crucial machines in the metal casting industry is the die casting machine, which is used to produce high-precision metal components in large quantities[2]. However, due to the high frequency of operations and production pressures, these machines are prone to various technical failures that can lead to reduced productivity, increased maintenance costs, and delayed product deliveries[3]. use of fluxing, rotary degassing, holding time and injection speed settings. The author analyzed the holding time using degassing and vacuum testing.

Machine failure issues are often not only technical in nature but also related to the lack of early detection systems and a systematic approach to analyzing the root causes of damage. In this context, the Failure Mode and Effect Analysis (FMEA) method is a highly relevant tool as it can proactively identify potential failures, assess their impact on the entire system, and prioritize improvements based on risk levels (Risk Priority Number or RPN)[4].

This study aims to enhance the reliability of die casting machines by applying FMEA-based failure analysis and optimizing structured corrective actions. Through this approach, it is expected to identify more effective maintenance strategies and performance improvements for machines, thereby minimizing downtime, enhancing operational efficiency, and maintaining consistent product quality

High-pressure die casting is one of the most commonly used molding methods for magnesium and aluminum alloys. During this process, gas porosity would be formed in the produced castings mainly due to the entrapment of air in the molten metal as a consequence of the high speed injection of the molten metal into the die cavity. The presence of gas porosity in castings is harmful because the mechanical properties, weldability and pressure tightness are adversely affected. In this context, reliability refers to the ability of a die casting machine to operate stably, consistently, and without interruption for a certain period of time in accordance with the specified process parameters, without experiencing failures that cause downtime or production defects.

By designing a data-driven and risk-priority-based improvement approach, this research also contributes to strengthening a culture of continuous improvement in the manufacturing industry[5]. In this context, failure optimization refers to systematic efforts to optimize corrective actions and prevent machine failures based on risk levels that have been prioritized through the FMEA method.

This scientific approach not only provides short-term solutions to machine failure issues but also serves as a foundation for strategic decision-making regarding preventive maintenance in the future[6].

Reliability in this study relates to the ability of die casting machines to function consistently and continuously without experiencing disruptions to critical parts, such as core sensors, tie bars, oil pistons, and control panels. Reliability is measured by reducing the frequency of breakdowns, reducing machine downtime, and stabilizing the casting process parameters. Reliability emphasizes how capable the machine is of maintaining its standard performance after repairs based on FMEA.

On the other hand, repair optimization involves implementing the most efficient and targeted repair measures based on root cause analysis and risk priority number (RPN). Repair optimization not only focuses on repairing damage that has already occurred, but also seeks to prevent the same failure in the future through the selection of more suitable components, adjustment of repair methods, calibration and readjustment of machine parameters, and the preparation of inspection and preventive maintenance plans. With this approach, every repair activity is aimed at reducing the likelihood of failure, shortening machine recovery time, and improving overall operational efficiency.

In general, the focus on reliability and repair optimization in this study are interconnected, where reliability improvement is achieved through planned repair optimization, based on FMEA, and aimed at understanding the main causes of failure in die casting machines.

### 1) *Problem Statement*

- What are the main failure modes in die casting machines that cause downtime and product quality degradation?
- What is the risk level of machine failure based on FMEA (RPN) analysis?
- How effective is repair optimization on critical machine components in improving the reliability of die casting machines?

### 2) *Research Objectives*

- Identify and prioritize the main failures of die casting machines using the FMEA method.
- Optimize repair actions on critical components to reduce the RPN value.
- Improve machine reliability by reducing downtime and increasing production process stability.

## II. METHOD

This study uses a descriptive qualitative approach with a case study method. The objective is to gain an in-depth understanding of the causes of die casting machine failure and to design and implement corrective measures based on Failure Mode and Effect Analysis (FMEA) in a field context. Below, Figure 1 are the parts of the die casting machine that will be improved.

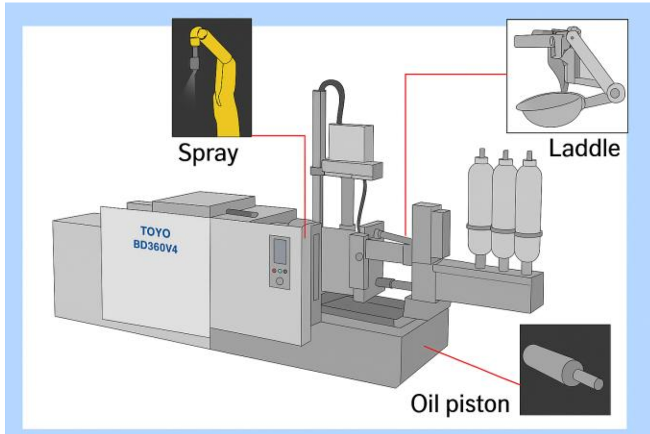


Figure 1. parts of the die casting machine

The damage found before improvement slowed down production and resulted in higher repair costs.
Each type of damage has its own cause, so the way it is handled is relatively different. The following are examples of damage to the Extractor.

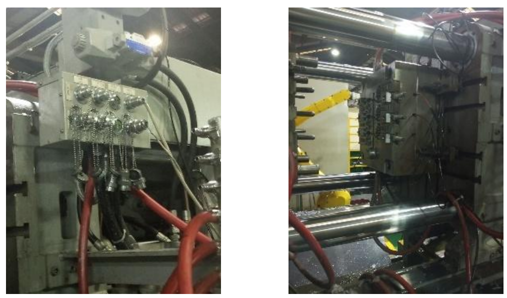

Figure 2. Extractor Failure

Figure 2 above is an example of damage to the extractor. The damage can occur for several reasons, such as: the machine is too hot, the sensor is stuck, the pressure setting is too low, damage to the sensor core, and various other causes.
The sensor core in a die casting machine has a very important function in ensuring process safety, movement precision, and product quality. Here is a complete explanation:
Functions of the Sensor Core in a Die Casting Machine
(1). Detecting the Position of the Core Pin

Without this sensor, metal could enter when the core is not ready → causing mold damage or defective products.

(2). Preventing Collisions or Mold

This sensor prevents interference between the core pin and the movement of the mold plate.If the sensor does not detect the correct position, the system will automatically stop the process to avoid mechanical damage.

(3). As a Safety Interlock

The core sensor is typically connected to the machine's interlock system, which will stop the injection process or mold opening if the core position is not correct.

(4). Automatic Core Puller Control

In die casting using a core puller mechanism, the sensor ensures that the forward or backward movement of the core pin is performed at the right time during the casting cycle.

(5). Reducing Product Defects

By ensuring the core is in the correct position, the sensor helps reduce defects such as short shots, flash, misalignment, and cracks caused by uneven distribution of molten metal pressure.

*Example Scenario*

For example, in the manufacturing process of automotive components with internal cavities:
(1) The core pin enters the mold to form the cavity.
(2) The sensor verifies that the core is fully inserted.
(3) The die casting machine begins injecting molten metal.
(4) After the metal hardens, the core is pulled out → the sensor detects the retracted position → the process continues to ejecting the product.

TABEL I
TYPE OF SENSOR

| Type of Sensor | Function |
|---|---|
| Proximity sensor (inductive/magnetic) | Detect core entry/exit position |
| Limit switch sensors | Signaling the core movement limits |
| Sensor encoder | Detects linear core position precisely |

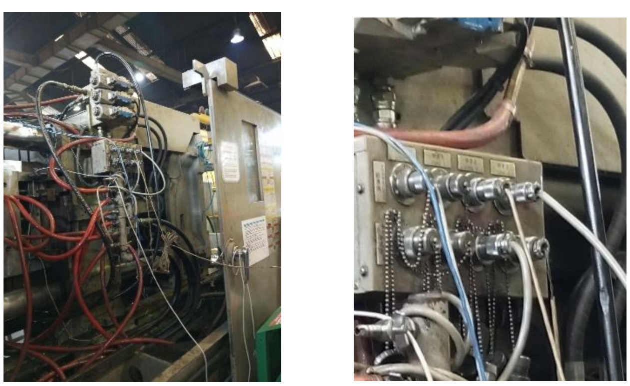

Figure 3. Demege To Core Sensors.

Figure 3 above shows an example of damage to the sensor core. This damage can occur due to several causes, such as the sensor cable being broken, loose, or peeled due to heat or vibration, or the sensor being damaged due to overheating of the mold. This has an impact on machine performance, such as the machine automatically stopping (safety interlock is active), and the cycle cannot continue to the injection stage.

FISHBONE DIAGRAM

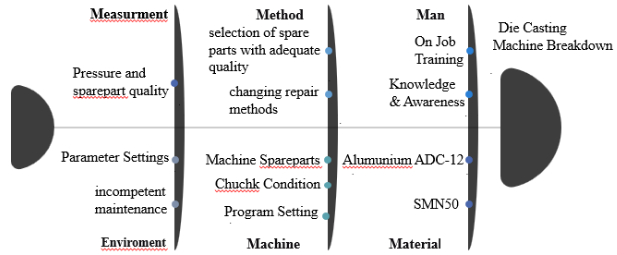


Figure 4. Fishbone Diagram

The Fishbone Diagram is used in this research as an analytical tool to identify and map the root causes of each failure in the die casting machine. In the context of improving machine performance through the FMEA method, the Fishbone Diagram plays a very important role in ensuring that failure analysis does not only focus on the symptoms, but truly identifies the underlying contributing factors. In this study, fishbone diagrams were used to systematically identify, group, and map the main factors causing breakdowns in die casting machines before conducting FMEA analysis and corrective actions.

The fishbone diagram in this study serves as a tool for analyzing the main causes in order to identify and group the main factors that cause damage to die casting machines. This diagram organizes the sources of problems based on human, machine, method, material, measurement, and environment aspects, so that the causes of damage are not only analyzed from a technical perspective of the machine, but also from the perspective of process parameter settings, quality and condition of spare parts, operator capabilities, and material and working environment conditions. The results obtained from identification through the fishbone diagram are then used as a basis for compiling FMEA, so that the failure mode analysis and proposed corrective measures really focus on the core of the problem. Therefore, the fishbone diagram plays a crucial role in ensuring that the improvements made are on target, reducing the risk of failure recurrence, and supporting the improvement of die casting machine reliability.

TABEL II
ELEBRATION OF THE FISHBONE

| Caused Category | Sub Category | S | O | D | RPN |
|---|---|---|---|---|---|
| Man | On Job Training | 2 | 2 | 2 | 8 |
| | Knowledge & awareness | 2 | 2 | 3 | 12 |
| Machine | Machine Spareparts | 1 | 2 | 2 | 4 |
| | Chuchk Condition | 5 | 3 | 4 | 60 |
| | Program Setting | 2 | 1 | 2 | 4 |
| Method | | 3 | 2 | 3 | 18 |

| | | | | | |
|---|---|---|---|---|---|
| | Selection of spareparts with | | | | |
| | Adequate quality | | | | |
| | Changing Repair Method | 2 | 3 | 3 | 18 |
| Measurement | Pressure and Sparepart Quality | 4 | 5 | 4 | 80 |
| Enviroment | Incompetent | 2 | 3 | 3 | 18 |
| | Maintenance Parameter Settings | 4 | 4 | 4 | 64 |

Fishbone diagrams are used to identify factors that may be causing problems, and then find the root cause. Here, it is concluded that the root cause focuses on machinery and methods. The severity and frequency of occurrence are rated on a scale of 1 to 10.

The Severity (S), Occurrence (O), and Detection (D) scores that appear in the FMEA table are obtained from direct observation, historical data related to damage, and analysis of the system's ability to identify failures, then compiled into an FMEA assessment scale. To determine the Severity (S) value, an assessment is made based on the extent of the impact of the failure on the production process; failures that cause the machine to stop completely, potential for major damage, or a significant decline in product quality receive a high score, while failures that have a minor impact on operations receive a lower score. Meanwhile, the Occurrence (O) value is based on how often the failure occurs, referring to maintenance data and damage incidents, where failures that occur frequently within a certain period will have a higher O value than failures that occur infrequently. On the other hand, the Detection (D) value is determined by how well the system, operator, or inspection procedure can detect failures before they impact the machine or product, where failures that are difficult to recognize early on and are only detected after damage or product defects occur are given a high D value. The combination of these three parameters produces a Risk Priority Number (RPN) that is useful in setting repair priorities, so that components or factors with the highest RPN become the main focus in repair optimization and improving the reliability of die casting machines.

Machine factors include the condition of key components such as: Chuck condition, sensor core, hydraulic system, and mold alignment,all of which directly impact metal injection performance in the die casting process. Therefore, improvements are focused on machine aspects through:replacing components with quality spare parts,calibrating pressure systems and sensors.and enhancing preventive maintenance programs.

In addition to engine factors, repair methods and spare part selection also play an important role. This approach ensures that every repair action is carried out with the correct and measurable method, not just a temporary fix. such as: Developing more appropriate repair procedure standards (SOP), Establishing inspection procedures and component replacement based on FMEA analysis, Optimizing maintenance schedules according to reliability data (reliability trends). Damaged sensor cores are part of machine spare parts. While stuck extractors, damaged tie bars, damaged laddles, and stuck oil pistons are focused on the engine, the control panel focuses on program settings. This is the core of the problem, so improvements are focused on the engine and repair methods.

TABLE III
AMOUNT OF DAMAGE BEFORE IMRPOVING

| Type Of Demege | Failure Frequensi of Damage in February | Failure Frequensi Of Damage in march | Total |
|---|---|---|---|
| Demaged Sensor Core | 5 | 5 | 10 |
| Stuck Extractor | 5 | 4 | 9 |
| Demaged Tie Bar | 7 | 6 | 13 |
| Demaged Laddle | 3 | 4 | 7 |
| Oil Piston Stuck | 4 | 5 | 9 |
| Control Panel Error | 3 | 4 | 7 |

The table above shows the level of damage experienced by the machine before improvements were made. In one month, the machine can produce 13,000 products if there are no problems. However, damage can result in a decrease in production rate and even product defects, which are certainly detrimental to the company.

TABEL IV
PRODUCTION AND PRODUCT DAMAGE BEFORE IMPROVEMENT

| Normal Production Volume | production volume in February | Defect Product in Feb | production volume in March | Defect Product in March | Week |
|---|---|---|---|---|---|
| | 3200 | 127 | 3150 | 83 | 1 |
| 13.000 | 2850 | 114 | 3100 | 107 | 2 |
| | 3170 | 96 | 3250 | 116 | 3 |
| | 3480 | 109 | 2500 | 72 | 4 |
| Total | 12700 | 446 | 12000 | 378 | |

Product damage caused by machine malfunction significantly affects production stability, which can be detrimental to the company and increase employee workload. This is a major issue that reduces production, and a solution is needed to stabilize production rates.

TABLE V
ROOT CAUSE OF DEMEGE

| Type of Demage | Cause of Damage | Resulting from Damage |
|---|---|---|
| Demaged sensor core | The sensor does not read the core position | Sensor dead, cable broken, or disrupted |
| Stuck Extractor | The ectractor position sensor is faulty. | deformation or breakage during clamping |
| Demaged tie bar | Wear on the toggle or hydraulic system. | metal escaping from the mold |
| demaged laddle | cooling system not working | Stuck movement |
| Oil piston stuck | Air enters the hydraulic system. | porosity and short shots occur. |
| Control panel eror | Sensor signal interference, faulty relay, or power drop. | The machine stopped suddenly. |

The table above explains the most common problems that occur, along with their causes and effects. These problems greatly affect production rates and hinder operator working hours. They also require handling costs for related materials and spare parts. After analysis, the most effective handling method will be determined, which will reduce the level of damage and provide greater benefits.

## III. RESULT AND DISCUSSION

Action planning is carried out to facilitate maintenance and extend the life of die casting machines. This aims to reduce all types of damage that will affect the product and also the production rate. There are several actions that must be implemented before carrying out repairs, including:

1). *Analyzing the damage and its causes*. This is to facilitate the next steps.

2). *Selecting spare parts of guaranteed quality*. This is one of the fundamental steps in repairing die casting machines.

3). *Conducting regular machine inspections*. This is to ensure the functionality and condition of the machine, so that any signs of damage can be addressed more easily.

Below are repair methods for each type of damage that often occurs in die casting machines.

### 1. *Damaged Sensor core*

Improvements were made by selecting high-temperature resistant sensors, physical protection, and self-diagnostic features, thereby directly reducing the probability of failure (Occurrence) and improving early detection capabilities (Detection). The installation of heat shields and the rearrangement of sensor positions prevented exposure to heat and molten metal splashes, which are the main causes of sensor damage. Thus, the RPN value can be significantly reduced and repeated failures can be prevented.

a. Use sensors with a high temperature rating (≥ 100°C) and IP67 or higher.
b. Install a metal shield or heat shield around the sensor.
c. Keep the sensor away from the direct path of molten metal splashes.
d. Regularly check the sensor cable connections and the condition of the casing.
e. Use sensors with self-diagnostics.

Below is a table of indications before repair.

TABEL VI
INDICATION BEFORE REPAIR

| No | Indication | February | | | | March | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | The sensor does not experience overheating during operation. | ✗ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| 2 | The temperature of the sensor area is more stable (heat reduction is felt/measured) | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ |
| 3 | No visible metal deposits, corrosion, or melting marks on the sensor. | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ |
| 4 | The cable is not loose, not peeled, and the casing is not cracked. | ✗ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| 5 | The sensor works consistently without any reading disturbances. | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ |

TABEL VII
INDICATION AFTER REPAIR

| No | Indication | April | | | | May | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | The sensor does not experience overheating during operation. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2 | The temperature of the sensor area is more stable (heat reduction is felt/measured) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3 | No visible metal deposits, corrosion, or melting marks on the sensor. | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4 | The cable is not loose, not peeled, and the casing is not cracked. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 5 | The sensor works consistently without any reading disturbances. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

The table above shows the indications after repairs have been carried out. A (✓) sign means the indication is working well and a (✗) sign means the indication is not working well.

2. *Stuck Extractor*

The repair steps focus on integrated mechanical, hydraulic, and sensor checks so that the root cause can be accurately identified. Manual testing allows for direct verification of the hydraulic system and sensor response, so repairs are not trial and error. This approach is effective in reducing downtime and preventing further damage to the ejector system.

a. Turn off the machine and perform a manual inspection.
b. Check the guide pin, ejector plate, and metal dust or ejector debris that may affect the movement of the extractor.
c. Check the hydraulic system, including pressure, valves, and hydraulic cylinders.
d. Check the position sensor and PLC interlock.
e. Try operating manually. This is to facilitate analysis of the hydraulic and sensor responses. If it still does not move, it is highly likely that the main problem lies in the hydraulics and sensors.

The following are common root causes and brief solutions for handling them.

TABLE VIII

ROOT CAUSES AND BRIEF SOLUTION

| Problem | Cause | Do? |
|---|---|---|
| Non moving Extractor | Valve Stuck | disassemble and clean the valve |
| sluggish movement | Insufficient lubrication / worn bushings | Lubrication or replacement of components |
| Alarm Ejector error | broken position sensor | Replace sensor / check wiring |
| extractor does not return to its original position | Weak back pressure | Check the pump and relief valve |

Below is a table containing indications before repairs are carried out.

TABEL IX

INDICATION BEFORE REPAIR

| No | Indication | April | | | | May | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | Guide pins are clean, straight, not worn or bent. | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ |
| 2 | The ejector plate moves freely without excess friction. | ✓ | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ |
| 3 | Hydraulic pressure is at the standard level of the machine specifications. | ✓ | ✗ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| 4 | The cable is not loose, not peeled, and the casing is not cracked. | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✗ |
| 5 | There was a decrease in the frequency of stuck extractors after applying the fix. | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

TABEL X

INDICATION AFTER REPAIR

| No | Indication | April | | | | May | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | Guide pins are clean, straight, not worn or bent. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2 | The ejector plate moves freely without excess friction. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3 | N Hydraulic pressure is at the standard level of the machine specifications. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4 | The cable is not loose, not peeled, and the casing is not cracked. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 5 | There was a decrease in the frequency of stuck extractors after applying the fix. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

The table above shows the indications after repairs have been carried out. A (✓) sign means the indication is working well and a (✗) sign means the indication is not working well.

### 3. *Damaged Tie Bar*

Repairs are carried out based on the identification of the type of damage and the main causes, such as excessive clamping load, inadequate lubrication, and mold misalignment. Corrective measures in the form of tonnage recalibration, lubrication scheduling, and mold alignment directly eliminate the source of excessive tension on the tie bar. This approach is effective because it is preventive, not just repairing damage that has already occurred.Examples of damage to tie bars include cracks, bends, breaks, or thread damage.

The following are steps for repairing tie bars
a. Identify the type and extent of damage
b. Check the root cause of the problem.

TABLE XI
ROOT CAUSES DEMAGED TIE BAR

| Common Causes | Preventive Measures |
|---|---|
| Clamping load too high | Recalibrate clamping tonnage. |
| Insufficient lubrication of toggle/tie bar | Schedule regular lubrication. |
| Mold misalignment | Perform mold centering and alignment. |
| Overstroke or excessive injection pressure | Adjust injection parameters. |

Below is a table containing indications before repairs are carried out.

TABEL XII
INDICATION BEFORE REPAIR

| No | Indication | February | | | | March | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | Tie bar is straight & no abnormal deflection occurs during clamp test | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ |
| 2 | Thread tie bar & nut did not slip after 8 hours of initial operation | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ |
| 3 | No alarm appears for clamp overload or unbalanced position. Clamp force readings are stable and even across all tie bars. | ✗ | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ | ✓ |
| 4 | Clamp force readings are stable & even across all tie bars | ✓ | ✗ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| 5 | No noise/friction is heard from the clamp system. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ |

TABEL XIII
INDICATION AFTER REPAIR

| No | Indication | April | | | | May | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | Tie bar is straight & no abnormal deflection occurs during clamp test | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2 | Thread tie bar & nut did not slip after 8 hours of initial operation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3 | No alarm appears for clamp overload or unbalanced position. Clamp force readings are stable and even across all tie bars. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4 | Clamp force readings are stable & even across all tie bars | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 5 | No noise/friction is heard from the clamp system. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

The table above shows the indications after repairs have been carried out. A (✓) sign means the indication is working well and a (✗) sign means the indication is not working well.

*4. Damaged Laddle*

Repairs are carried out by separating mechanical and sensor damage, so that the actions taken are more specific and efficient. Cleaning, lubrication, and replacement of worn components restore the smooth movement of the ladle, while sensor repair and calibration ensure synchronization with the control system. This combination ensures the stability of the molten metal supply and prevents production cycle disruptions.

The method for repairing the ladle on a die casting machine is as follows.

a. Identify the type of damage

TABLE XIV
TYPE OF DEMEGE LADDLE CASTING

| Type of damage | Common symptos |
|---|---|
| laddle arm stuck | laddle cannot rotate/move |
| position sensor damaged | laddle movement is not synchronized |

b. Repairs based on the type of damage

*1). Laddle arm stuck*

- Check the servo/pneumatic/hydraulic motor that drives the arm.
- Clean the movement path and lubricate the pivot points.
- Replace bushings or bearings if worn.
- Also check the gearbox/drive belt if used.

2*). Position sensor damaged*

- Check the sensors (proximity, limit switch, or encoder).
- Check the cables, connectors, and connections to the PLC.
- Replace the sensor if it does not respond when tested manually.
- Recalibrate the initial position of the ladle in the control system.

*3). Perform regular checks and cleaning.*

TABLE XV
ACTIVITY CHECH LADDLE

| activity | Frequency |
|---|---|
| Check cup ladle cracks | daily |
| Clean frozen metal residue | every shift |
| Lubricate pivot points | 1-2 times a week |
| Check position sensors | weekly |
| Replace cup if wear exceeds 30% | as a needed |

Below is a table containing indications before repairs are carried out.

TABEL XVI
INDICATION BEFORE REPAIR

| No | Indication | February | | | | March | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | Motor operates normally and moves the ladle arm smoothly | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✗ |
| 2 | Arm movement runs without friction or jamming | ✓ | ✗ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| 3 | Sensor responds correctly when tested manually | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ |
| 4 | Signal from sensor correctly detected by PLC | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 5 | Ladle returns to home and working position accurately | ✗ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ |

TABEL XVII
INDICATION AFTER REPAIR

| No | Indication | April | | | | May | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | Motor operates normally and moves the ladle arm smoothly | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2 | Arm movement runs without friction or jamming | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ |
| 3 | Sensor responds correctly when tested manually | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4 | Signal from sensor correctly detected by PLC | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| 5 | Ladle returns to home and working position accurately | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

The table above shows the indications after repairs have been carried out. A (✓) sign means the indication is working well and a (✗) sign means the indication is not working well.

*5). Oil piston stuck*

Repairing a stuck oil piston in a die casting machine (especially cold chamber machines such as Toyo, Toshiba, UBE, etc.) must be done carefully, as this system is at the heart of the molten metal injection process. A stuck piston will halt the injection process and can cause product defects, or even damage to the cylinder and chamber walls if forced.

A. Identify early symptoms
B. Analysis of common causes and solutions

TABLE XIX
CAUSE AND SOLUTION

| Cause | Explanation | Solution |
|---|---|---|
| Dirt/metal enters the cylinder | Dross, aluminum shavings enter | Disassemble and clean the cylinder |
| Dirty hydraulic oil or mixed with air | Causes unstable piston movement | Replace oil and bleed |
| Worn or torn piston seal | Oil leakage, pressure not formed | Replace the piston seal kit |
| Bent piston rod | Due to excessive pressure or poor mold alignment | Remove the piston, straighten if possible, or replace |
| Stuck injection control valve | Solenoid valve clogged or stuck | Disassemble and clean the valve |
| Position sensor error | PLC not issuing injection command | Check linear encoder sensor or limit switch |

C. Detailed Repair Steps
- Turn Off the Machine & Secure Pressure
- Disassemble the Piston Cylinder
- Clean and Inspect Components
- Replace Seal Kit if Necessary
- Inspect Valve & Sensor

D. Test after Repair

Bleed the oil from the hydraulic system → ensure there is no air.
Run the machine in manual or semi-auto mode.
Test the injection piston slowly, monitor pressure and cycle time.

E. Preventing Piston Sticking in the Future

TABLE XX
ACTIVITY CHECHK PISTON PLUNGER

| Activity | Frequency |
|---|---|
| Check cup ladle cracks | daily |
| Clean frozen metal residue | every shift |
| Lubricate pivot points | 1-2 times a week |
| Check position sensors | weekly |
| Replace cup if wear exceeds 30% | as needed |

Below is a table containing indications before repairs are carried out.

TABEL XXI
INDICATION BEFORE REPAIR

| No | Indication | February | | | | March | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | The piston moves smoothly without stuttering in manual, semi-auto, and auto modes. | ✗ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| 2 | Injection pressure is stable & according to normal settings without significant fluctuations | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ |
| 3 | Injection cycle time returns to normal & consistent | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✗ |

| No | Indication | February | | | | March | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 4 | There are no oil leaks on the piston, seal, or hose after 8 hours of operation. | ✗ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| 5 | No injection alarm, abnormal pressure, or sensor error appears | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

TABEL XXII
INDICATION AFTER REPAIR

| No | Indication | April | | | | May | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | The piston moves smoothly without stuttering in manual, semi-auto, and auto modes. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2 | Injection pressure is stable & according to normal settings without significant fluctuations | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3 | Injection cycle time returns to normal & consistent | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4 | There are no oil leaks on the piston, seal, or hose after 8 hours of operation. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 5 | No injection alarm, abnormal pressure, or sensor error appears | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

The table above shows the indications after repairs have been carried out. A (✓) sign means the indication is working well and a (✗) sign means the indication is not working well.

*6). Control Panel Error.*

Repairing the control panel of a die casting machine is a task that must be carried out with great care, as this system is the main brain of the entire automation process — from clamping, injection, core pull, to ejection. Any disruption to the control panel can bring the production process to a complete halt.

*1). identify symptoms of disorders*

TABLE XXIII
TYPES OF CONTROL PANEL MULTIFUNCTION

| Symptoms | Indications of Problems |
|---|---|
| Panel does not light up at all | Power supply issue |
| HMI screen is dead/frozen | HMI damaged or communication cable disconnected |
| An error alarm appears on the screen. | Sensor, relay, or PLC input malfunction |
| Certain functions are inactive (e.g., ejector, core) | PLC output or relay damaged |
| The button does not respond | Broken switch or loose wiring |

*2). Electrical inspection and power supply*
*3).HMI (Human Machine Interface) inspection*
*4). PLC (Programmable Logic Controller) inspection*
*5). Cable & Terminal Inspection*
*6). Manual Function Test (Jog Mode)*
*7). Replacement of Components If Necessary*

Below is a table containing indications before repairs are carried out.

TABEL XXIV
INDICATION BEFORE REPAIR

| No | Inondication | February | | | | March | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | Power supply stable, no voltage drop or surge detected | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ |
| 2 | Power supply stable, no voltage drop or surge detected | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ |
| 3 | HMI operates smoothly, all functions and displays responsive | ✓ | ✗ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| 4 | All cables and terminals firmly connected, no damage found | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✗ |
| 5 | Machine responds correctly to all manual control inputs | ✓ | ✓ | ✗ | ✗ | ✓ | ✓ | ✗ | ✓ |

TABEL XXV
INDICATION AFTER REPAIR

| No | Indication | April 1 | April 2 | April 3 | April 4 | May 1 | May 2 | May 3 | May 4 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Power supply stable, no voltage drop or surge detected | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2 | Power supply stable, no voltage drop or surge detected | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3 | HMI operates smoothly, all functions and displays responsive | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4 | All cables and terminals firmly connected, no damage found | ✓ | ✓ | ✓ | ✓ | ❌ | ✓ | ✓ | ✓ |
| 5 | Machine responds correctly to all manual control inputs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ❌ |

The table above shows the indications after repairs have been carried out. A (✓) sign means the indication is working well and a (❌) sign means the indication is not working well.

TABLE XXVI
REPLACEMENT COMPONENT

| Panel Components | Action |
|---|---|
| Power supply damaged | Replace SMPS 24VDC / 5V |
| HMI damaged | Replace + re-upload program |
| PLC module error | Replace or reprogram |
| Relay output is broken | Replace with the same type (pay attention to current and voltage). |
| Button/selector broken | Replace and tighten the terminal |

*After action to Repair The Machine At April and May.*

TABLE XXVII
PRODUCTION AND PRODUCT DAMAGE AFTER IMPROVEMENT

| Normal Production Volume | production volume in April | Defect Product in April | production volume in May | Defect Product in May | Week |
|---|---|---|---|---|---|
| | 3100 | 37 | 3350 | 32 | 1 |
| 13.000 | 3250 | 39 | 3150 | 34 | 2 |
| | 3300 | 39 | 3300 | 30 | 3 |
| | 3350 | 41 | 3200 | 26 | 4 |
| TOTAL | 13000 | 156 | 13000 | 122 | |

Based on the comparison between production data before and after the implementation of repair and optimization measures, there is a significant improvement in the reliability of the die casting machine and the quality of the products produced. Before the improvement (February–March), the total production volume reached **24,700 units** with a total of **824 defective products**, resulting in an average defect rate of:

$$DR(\%) = \frac{\sum R_{before} - \sum R_{after}}{\sum R_{before}} \times 100\% \quad (1)$$

$$DR(\%) = \frac{24.700}{824} \times 100\% = 3{,}33\%\% \quad \textbf{(2)}$$

After the implementation of FMEA-based maintenance improvements (April–May), the total production increased to **26,000 units**, with a total of **278 defective products**, resulting in an average defect rate of:

$$\frac{26.000}{278} \times 100\% = 1{,}07\% \quad \textbf{(3)}$$

This indicates a reduction in defect rate of approximately **2.26%,** equivalent to a **68%** improvement in product quality.

The improvement was achieved through the application of structured corrective methods such as repairing damaged sensors, optimizing extractor and ladle mechanisms, and preventing oil piston sticking using the FMEA-based approach. This method allowed for early identification of potential failures, prioritization of corrective actions based on risk levels (RPN), and implementation of preventive maintenance strategies.

As a result, machine downtime decreased, production efficiency increased, and product consistency improved significantly.

TABEL XXVIII

DEFECT REDUCTION AND MARGIN

| Parameter | Before | After | Reduction |
|---|---|---|---|
| Product | 24700 | 26000 | |
| Defect | 824 | 278 | 66,26% |
| Margin Of Error | ±0.35 | ±0.20 | |

The margin of error (MoE) is a value indicating the level of uncertainty or maximum deviation of measurement results from the true value. Based on the data, the margin of error decreased from ±0.35 to ±0.20, indicating increased stability and accuracy of the production process after improvements. Mathematically, the margin of error can be calculated using the formula:

$$\text{MoE}=Z\times\frac{p(1-p)}{\sqrt{n}} \quad \textbf{(4)}$$

where $Z$ is the standard normal distribution value (usually 1.96 for a 95% confidence level), $p$ is the proportion of errors or defects, and $n$ is the total number of samples or products measured. A decrease in the MoE value indicates that the variation in the proportion of defects (p) is decreasing, which means the production process is becoming more consistent and product quality is improving, in line with the decrease in defects from 824 to 278 units, or approximately 66.26%.

## IV. DISCUSSION

The analysis and improvement process carried out on the die casting machine has resulted in significant positive developments, both in terms of machine performance and overall operational efficiency. Based on the evaluation, the implementation of systematic repair and maintenance procedures has effectively reduced the frequency and severity of mechanical failures. This indicates that the proposed improvements were successful in addressing the root causes of machine malfunctions, which previously contributed to production delays and unplanned downtime. The reduced occurrence of damage not only improves the reliability of the die casting machine but also supports the continuity of the production process, ensuring that targets can be achieved more consistently without unnecessary interruptions.

Another important aspect of this improvement is the positive impact on workplace safety. The reduction in the risk of machine failure directly contributes to minimizing the likelihood of accidents during machine operation. Workers are now able to perform their duties more confidently and efficiently, as the possibility of sudden breakdowns or hazardous malfunctions has been greatly decreased. This improvement also demonstrates the importance of integrating preventive maintenance strategies with safety management practices in the industrial environment. When machines operate under optimal conditions, both productivity and safety standards can be maintained at a high level.

The implementation of a more effective and structured repair method also plays a crucial role in enhancing the overall workflow. By introducing clear standard operating procedures (SOPs) and utilizing data-driven maintenance techniques, the repair process has become faster, more accurate, and easier to execute. This development not only simplifies the technicians' work but also reduces the dependency on external maintenance services, leading to a more cost-efficient operation. In addition, the systematic documentation of maintenance activities enables better monitoring and continuous improvement, aligning with the principles of Total Productive Maintenance (TPM) and continuous quality enhancement.

Furthermore, the economic benefits of this improvement are highly significant. The reduction in repair and maintenance costs has a direct impact on the company's operational budget. Funds that were previously allocated for frequent machine repairs can now be redirected toward other productive investments, such as upgrading production technology, employee training, or research and development. This financial efficiency ultimately strengthens the company's competitive advantage by allowing it to produce more efficiently and at a lower cost per unit.

From a managerial perspective, these improvements also highlight the importance of collaboration between maintenance, production, and engineering departments. Effective communication and coordination among these divisions ensure that every issue related to machine performance is identified and addressed promptly. The adoption of data analysis in the maintenance process—such as failure mode tracking and performance trend monitoring—also helps in predicting potential issues before they lead to significant breakdowns. This predictive approach aligns with the growing trend of smart manufacturing, where data plays a central role in optimizing operations.

In conclusion, the analysis and improvement of the die casting machine have led to notable advancements in reliability, safety, and cost efficiency. By reducing the risk of machine damage, minimizing downtime, and optimizing repair processes, the overall production system becomes more stable and productive. These outcomes are not only beneficial in the short term but also serve as a foundation for sustainable operational excellence in the long term. Therefore, the impact of this improvement can be considered highly valuable for the company, both in maintaining competitiveness and ensuring

## V. Conclusion

Based on the research conducted throughout this project, it can be concluded that machine damage on the die casting production line is caused by various factors, each requiring specific repair and maintenance methods. Through systematic data collection, root cause analysis, and the implementation of corrective actions, the study successfully identified the main problems and applied effective solutions to minimize equipment failures.

The results obtained demonstrate a significant improvement in machine performance and reliability, with damage frequency reduced by up to 68% after the corrective measures were implemented. This reduction not only enhances the operational stability of the production process but also directly contributes to achieving production targets more efficiently. Furthermore, the improvement in maintenance procedures has led to better time management, lower repair costs, and reduced downtime, which in turn increases overall productivity.

From a broader perspective, the outcomes of this research highlight the importance of continuous improvement and preventive maintenance in industrial environments. By applying systematic repair methods supported by accurate data analysis, companies can maintain the longevity and reliability of their machines while ensuring workplace safety and production efficiency.

In conclusion, the implementation of the improvement plan developed in this study has proven to be highly beneficial for the company. It not only minimizes the risk of machine damage but also contributes to cost savings and sustainable operational growth. Therefore, the approach used in this research can serve as a reference for future maintenance strategies aimed at achieving optimal machine performance and long-term productivity.

## VI. References


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[3] Rajamanickam, V. (2018). Analysis and Implementation of FMECA in Die-Casting Machines. *International Journal of Manufacturing Technology and Managemen*, 30-53.

[4] Salawu, E. (2018). Impact of Maintenance on Machine Reliability. *E3S Web of Conferences*, 1-8.

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## VII. Attachment

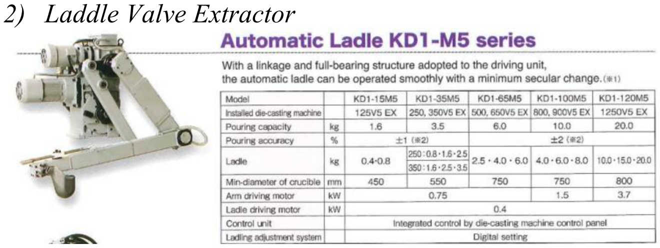
### 1) *Spesification machine*

TABLE XXVIII
SPESIFICATION

| spesification | Metric/U.S. Standard |
|---|---|
| Locking Force | 350 tons/ 385 tons |
| Platen Size | 935 x 1008 mm/ 36,8 x 39,6 inchies |
| Clearance between tie bars (V x H) | 652 x 652 mm/ 25,6 x 25,6 inchies |
| Die Stroke(mas - min) | 420 - 300 mm/ 16,5 - 11,8 inchies |
| Die Height ( max - min ) | 300 - 700 mm/ 11,8 - 27,5 inchies |
| Injection Force | 34 tons/ 37,6 tons |
| Shot Position | -150 mm / -5,9 inchies |
| Ejection Stroke | 0- 100 mm/ 0- 3,9 inchies |
| Ejection force | 190KN/20,5 tons |
| Number of core circuits | 3/3 |
| machine weight | 15 tons/ 16,5 tons |
| machine size | 6,47 x 1,99 x 2,8 meters/ 21,2 x 6,2 x 13,9 feet |

Figure 9. Die Casting Machine

### 2) *Laddle Valve Extractor*



**Automatic Ladle KD1-M5 series**

With a linkage and full-bearing structure adopted to the driving unit,
the automatic ladle can be operated smoothly with a minimum secular change.(※1)

| Model | | KD1-15M5 | KD1-35M5 | KD1-65M5 | KD1-100M5 | KD1-120M5 |
|---|---|---|---|---|---|---|
| Installed die-casting machine | | 125V5 EX | 250, 350V5 EX | 500, 650V5 EX | 800, 900V5 EX | 1250V5 EX |
| Pouring capacity | kg | 1.6 | 3.5 | 6.0 | 10.0 | 20.0 |
| Pouring accuracy | % | ±1 (※2) | | ±2 (※2) | | |
| Ladle | kg | 0.4·0.8 | 250:0.8·1.6·2.5<br>350:1.6·2.5·3.5 | 2.5·4.0·6.0 | 4.0·6.0·8.0 | 10.0·15.0·20.0 |
| Min-diameter of crucible | mm | 450 | 550 | 750 | 750 | 800 |
| Arm driving motor | kW | 0.75 | | | 1.5 | 3.7 |
| Ladle driving motor | kW | 0.4 | | | | |
| Control unit | | Integrated control by die-casting machine control panel | | | | |
| Ladling adjustment system | | Digital setting | | | | |

| | Model name | BD-125V5 EX | BD-250V5 EX | BD-350V5 EX | BD-500V5 EX | BD-650V5 EX | BD-800V5 EX | BD-900V5 EX | BD-1250V5 EX |
|---|---|---|---|---|---|---|---|---|---|
| | Control system | SYSTEM 500 | | | SYSTEM 500 | | | | |
| | Injection system | New Multi Injection | | | New Multi Injection | | | | |
| Clamping | Clamping force [kN] | 1250 | 2500 | 3500 | 5000 | 6500 | 8000 | 9000 | 12500 |
| | Die plate (H×W) [mm] | 700×700 | 850×904 | 935×1008 | 1070×1070 | 1230×1230 | 1400×1400 | 1400×1400 | 1800×1800 |
| | Tie-bar distance (H×W) [mm] | 460×460 | 584×584 | 652×652 | 748×748 | 852×852 | 941×941 | 931×931 | 1150×1150 |
| | Die stroke (Max. Min.) [mm] | 350~200 | 380~250 | 420~300 | 560 | 660 | 760 | 760 | 900 |
| | Die thickness (Max. Min.) [mm] | 500~250 | 600~250 | 700~300 | 850~350 | 900~350 | 950~400 | 950~400 | 1500~600 |
| | Tie-bar diameter [mm] | 85 | 110 | 125 | 150 | 160 | 180 | 190 | 230 |
| Injection | Injection force [kN] | 139~177 | 221~281 | 264~335 | 383~491 | 410~525 | 472~605 | 537~688 | 797~1020 |
| | Intensity ratio | 1 : 2.04 | 1 : 2.16 | 1 : 2.16 | 1 : 2.3 | 1 : 2.5 | 1 : 2.5 | 1 : 2.5 | 1 : 2.37 |
| | Plunger stroke [mm] | 305 | 370 | 425 | 580 | 670 | 750 | 750 | 950 |
| | Tip jog-out stroke [mm] (from fixed die plate surface) | 125 | 150 | 165 | 250 | 300 | 325 | 325 | 400 |
| | Injection position [mm] | -100 | -125 | -150 | -175 | -225(※) | -275(※) | -275(※) | -350 |
| | Tip diameter [mm] (○Standard) | 45 · 50 · 55 · 60 | 50 · 55 · 60 · 65 · 70 | 60 · 65 · 70 · 75 · 80 | 70 · 75 · 80 · 85 · 90 | 70 · 75 · 80 · 85 · 90 | 80 · 85 · 90 · 95 · 100 | 80 · 90 · 100 · 110 · 120 | 100 · 110 · 120 · 130 |
| | Injection pressure [MPa] (standard tip diameter) | 90.6 | 99.5 | 87 | 97.7 | 104.9 | 95.1 | 95.1 | 90.2 |
| | Low injection speed [m/s] (maximum 9 point setting) | 0.03~1.0 | 0.03~1.0 | 0.03~1.0 | 0.03~1.0 | 0.03~1.0 | 0.03~1.0 | 0.03~1.0 | 0.05~0.7 |
| | High injection speed [m/s] | 1.0~9.0 | 1.0~9.0 | 1.0~9.0 | 1.0~9.0 | 1.0~9.0 | 1.0~9.0 | 1.0~8.0 | 1.0~8.0 |
| Ejector | Ejection force [kN] | 80 | 123 | 193 | 254.4 | 294.5 | 342 | 342 | 586 |
| | Ejection stroke [mm] | 0~75 | 0~80 | 0~100 | 0~110 | 0~125 | 0~125 | 0~125 | 0~200 |
| Core | Core hydraulic outlet [Rc×sets] | 1/2×1 | 3/4×3 | 3/4×3 | 3/4×2 | 3/4×2 | 3/4×2 | 3/4×2 | 1×2 |
| | Number of hydraulic core (sets) | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 |
| Coolant | Coolant inlet pipe diameter [Rc] | 1 | 1 | 1 | 1.1/4 | 1.1/4 | 1.1/4 | 1.1/4 | 1.1/2 |
| | Coolant drain pipe diameter [Rc] | 2 | 2 | 2 | 2.1/2 | 2.1/2 | 2.1/2 | 2.1/2 | 3 |
| | Oil cooler coolant inlet [Rc] | 3/4 | 3/4 | 3/4 | 1 | 1 | 1 | 1 | 1 |
| | Oil cooler coolant outlet [Rc] | 3/4 | 3/4 | 3/4 | 1 | 1 | 1 | 1 | 1 |
| | Die coolant adjustment valve (fixed side) (size × quantity) | 3/8×5 | 3/8×7 | 3/8×7 | 3/8×9 | 3/8×9 | 3/8×11 | 3/8×11 | 3/8×15 |
| | Die coolant adjustment valve (movable side) (size × quantity) | 3/8×5 | 3/8×7 | 3/8×7 | 3/8×12 | 3/8×15 | 3/8×15 | 3/8×15 | 3/8×15 |
| | Required coolant volume (oil cooler) [L/min] | 40 | 40 | 40 | 80 | 80 | 100 | 100 | 100 |
| | Required coolant volume (die cooling) | 25~50 | 30~70 | 30~70 | 50~90 | 50~90 | 150 | 150 | 150~240 |
| Electrical | Motor (hydraulic pump) [kW] | 15 | 22 | 22 | 37 | 37 | 45 | 45 | 45/37 |
| | Motor (die height) [kW] | 0.2 | 0.4 | 0.75 | 1.5 | 1.5 | 2.2 | 2.2 | 3.7 |
| | Motor (lubrication pump) [kW] | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| | Power supply capacity [kVA] | 25 | 40 | 40 | 60 | 60 | 70 | 70 | 102 |
| | Power supply voltage [V] (50Hz/60Hz) | AC200/220(±10%) | AC200/220(±10%) | AC200/220(±10%) | AC200/220(±10%) | AC200/220(±10%) | AC200/220(±10%) | AC200/220(±10%) | AC200/220(±10%) |
| Air | Air connection port [Rc] | 1 | 1 | 1 | 1.1/2 | 1.1/2 | 1.1/2 | 1.1/2 | 2 |
| Other | Machine dimensions (L×W×H) [mm] | 4519×1549×2197 | 5770×1942×2601 | 6395×2021×2814 | 7517×2445×2944 | 7722×2600×2940 | 9618×2750×3439 | 9618×2750×3439 | 13003×3273×4542 |
| | Machine weight [t] | 5.0 | 8.5 | 13.0 | 19.0 | 26.0 | 33.0 | 33.0 | 71.0 |
| | Hydraulic fluid tank capacity [L] | 280 | 360 | 400 | 600 | 600 | 750 | 750 | 1290+400(1690) |

### 3) *Project Percentage Evidence to Department*

ColleaguesThe following is documentation that I presented my project, which has been implemented by colleagues in the department where I carried out my internship program.

TABLE XXIX
PERCENTAGE EVIDENCE

| Name | Signature | Presentation Time |
|---|---|---|
| Yudi Haloho | | Monday, April 14, 2025 |
| Zuar Diki | | Monday, April 14, 2025 |
| Endro Utomo | | Monday, April 21, 2025 |
| Fakhri | | Friday, April 25, 2025 |

After giving a presentation and implementing it in engine repairs, I gave a quiz in the form of a G-Form to test the extent of the progress I had made to my colleagues in the department.

Project Presentation Questionnaire with the title Improving Die Casting Machine Reliability through FMEA-Based Failure Analysis and Repair Optimization

Name *

Yudi Haloho

Departement *

maintanance

What is the main purpose of applying the FMEA method to a die casting machine? *

- ○ Reduce the number of products produced
- ○ Optimizing production costs
- ◉ Identify potential failures and improve machine reliability
- ○ Increases engine energy consumption

The first step in implementing FMEA on a die casting machine is *

- ○ Develop improvement solutions
- ○ Determines the RPN value
- ◉ Identify all system components
- ○ Determine maintenance intervals

One of the common causes of failure in die casting machines is *

- ○ Too much coolant
- ◉ Damage to the hydraulic control system
- ○ Use of plastic raw materials
- ○ No painting process

Which repair strategy is the MOST APPROPRIATE to overcome damage to the sensor core due to high temperatures and molten metal splashes? *

- ○ Reduces machine duty cycle
- ○ Moving sensors outside the production area
- ◉ Using sensors with high temperature rating (≥ 100°C) and IP67 or higher protection
- ○ Replace the sensor with a non-contact type every week.

What is the first step to take when the extractor on a die casting machine gets stuck? *

- ◯ Increase hydraulic pressure
- ◯ Turn on automatic mode
- ◉ Turn off the engine and perform a manual inspection.
- ◯ Directly replace the hydraulic cylinder

If after manual operation the extractor remains immobile, most likely the main problem lies in? *

- ◯ Cooling system
- ◯ Machine frame
- ◉ Hydraulic system and sensors
- ◯ Lubrication system

**FMEA( Failure Mode and Effects Analysis)**

| No | Potential Effects | Severity (S) | Potential Causes | Occurrence (O) | Current Control | Detection (D) | RPN | Recommended Action | S/O/D Target | RPN targets |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Reading error / process shutdown / quality defect | 7 | Overheat, molten metal splashes, damaged cables, poor sealing | 5 | Periodic inspection, standard sensors | 4 | 140 | Replace sensor, heat shield, self-diagnostic sensor, routine connection check | 6/2/2 | 24 |
| 2 | Ejector not working → mold stuck → downtime, scrap | 6 | Debris/metal dust, guide pin wear, hydraulic fault, position sensor error | 6 | Visual check ad hoc, manual operation | 5 | 180 | Clean ejector, dust filter, hydraulic maintenance, install position sensor | 5/2/2 | 20 |
| 3 | Clamp misalignment → flash, mold damage, catastrophic failure | 9 | Overload, mold misalignment, fatigue, improper installation | 4 | Periodic visual inspection | 5 | 180 | Routine NDT, measure straightness, torque balancing, replace tie bar if cracked | 7/1/2 | 14 |
| 4 | Molten metal spill → safety hazard, product defect | 8 | Impact during handling, cast wear, robot/hoist errors | 3 | SOP for manual handling, visual check | 6 | 144 | Strengthen SOPs, preventive inspections, limit switches, operator training | 6/1/2 | 12 |
| 5 | Injection failure → scrap, possible cylinder/chamber damage | 9 | Seal wear, oil contamination, air in hydraulic, valve failure | 6 | Periodic inspection, ad hoc bleeding | 5 | 270 | Full cleaning, replace seal kit, install filter, routine bleeding, alarm sensor | 7/2/2 | 28 |

<table>
<tr><th colspan="3">Serevity</th></tr>
<tr><th colspan="2">Rank</th><th>Criteria</th></tr>
<tr><td>1</td><td>Minor</td><td>No significant effect on machine performance or product quality; process continues normally.</td></tr>
<tr><td>2</td><td rowspan="2">Low</td><td rowspan="2">Minor machine stoppage or small product defect; easily corrected without process interruption.</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td rowspan="3">Moderate</td><td rowspan="3">Temporary production slowdown or moderate product defect; may require rework or short downtime.</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td rowspan="2">High</td><td rowspan="2">Machine experiences partial failure, process interruption occurs, and product quality is significantly affected.</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td><td rowspan="2">Very High</td><td rowspan="2">Complete machine shutdown, severe safety risk, or major quality failure; process cannot continue until corrective action is taken.</td></tr>
<tr><td>10</td></tr>
</table>

| Detection | | |
|---|---|---|
| Rank | | Criteria |
| 1 | Very High | Failure will almost certainly be detected by existing controls or monitoring systems before affecting production. |
| 2 | High | Failure likely to be detected through routine inspection, automated alarms, or sensor feedback |
| 3 | | |
| 4 | Moderate | Detection possible through manual checks or scheduled maintenance but not immediate |
| 5 | | |
| 6 | | |
| 7 | Low | Failure is difficult to detect; often identified only after minor process disturbance or quality issue |
| 8 | | |
| 9 | Very Low | No existing control or system is able to detect the failure before it causes machine downtime or product defect. |
| 10 | | |

| Occurance | | |
|---|---|---|
| Rank | | Criteria |
| 1 | Unlikely | Failure is extremely rare; process is highly stable and well-controlled (<1 failure per year). |
| 2 | Very Low | Failure occurs occasionally (1–2 times per year); easily prevented through routine maintenance. |
| 3 | | |
| 4 | Moderate | Failure occurs about once per month; indicates need for process monitoring and control improvement. |
| 5 | | |
| 6 | | |
| 7 | High | Failure occurs weekly; suggests persistent weaknesses in equipment, design, or maintenance. |
| 8 | | |
| 9 | Very High | Failure happens almost continuously; indicates systemic issue requiring major corrective action. |
| 10 | | |

This table presents the Failure Mode and Effects Analysis (FMEA) conducted on several critical components of the TOYO 350 Ton die casting machine, including the sensor core, ejector, clamp, and injection system. The purpose of this analysis is to systematically identify potential failure modes, their root causes, and the resulting effects on machine performance and product quality.

Each failure mode is evaluated based on three parameters—**Severity (S)**, **Occurrence (O)**, and **Detection (D)**—which are used to calculate the **Risk Priority Number (RPN)**. The RPN value determines the priority level for corrective actions to minimize the likelihood of recurrence and improve system reliability.

Recommended corrective actions include replacing or recalibrating sensors, cleaning and lubricating ejector mechanisms, implementing periodic inspections, and improving SOPs for handling and maintenance. These measures are expected to significantly enhance the reliability of the die casting machine and reduce the risk of production downtime.