

Induction Moulding Process Automation

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Abstract--- Induction moulding process automation refers to the utilization of automated systems and technologies in the manufacturing process of plastic components using electromagnetic induction heating. This process involves the rapid heating and shaping of thermoplastic materials to produce complex and precise products. Injection moulding process is producing plastic products by inserting the plastic granules, heating them, cooling them and finally giving the shape and size of the required plastic products. It is the rapid method of producing a large number of plastic products with high precision. It offers several advantages, including increased efficiency, improved quality, and enhanced production capabilities. By leveraging automation technologies, such as robotics, Computer Numerical Control (CNC), and advanced control systems, manufacturers can achieve higher productivity, reduced cycle times, and consistent quality. Induction moulding process automation has been developed with PIONEER Software, ASP.NET is used as backend and VB.NET is used for frontend development. The objective of this project is to automate various aspects of the induction moulding process, including mold preparation, material handling, and quality control, using Pioneer Software integrated with Microsoft Excel. By utilizing this software, aims to achieve higher precision, reduced production time, minimized errors, and improved overall productivity.

Keywords--- Induction Moulding Process, Automation, Computer Numerical Control (CNC), Injection Moulding Process.

I. INTRODUCTION

INJECTION molding is the most commonly used manufacturing process for the fabrication of plastic parts. A wide variety of products are manufactured using injection molding, which vary greatly in their size, complexity, and application. The injection molding process requires the use of an injection molding machine, raw plastic material, and a mold [1]. The plastic is melted in the injection molding machine and then injected into the mold, where it cools and solidifies into the final part. Injection molding is used to produce thin-walled plastic parts for a wide variety of applications, one of the most common being plastic housings [2]. This automobile product capabilities include safety seat belt application parts including buckle cover, spring plate & cover, Reservoir component, Power window and Gear Lifter parts, Tensioner for Transmission facility, Fuel Injector Protective Cap, Air bag application, Reservoir and Door Latch components.

One widely used traditional aeronautical composite system consists of carbon fibre reinforcement and epoxy cured at elevated temperatures (often 180°C although other temperatures can be used) in an autoclave. During the manufacturing, the resin undergoes phase changes from a liquid to a solid [3]. These phase changes cause volumetric shrinkage of the resin as it solidifies; also changing its mechanical properties and thermal expansion coefficient in

the process.

This symposium has been a significant venue for the sharing of innovations and collaborations on this very important scientific and technical topic. The purpose of this article is to present an overall summary of the main topics that have been addressed at these annual ESAFORM conferences and to highlight some of the progress that has been made during these two decades [4]. The main composite manufacturing processes that have been presented at these conferences are considered in the present paper

The IMP is the cyclical sequential execution of the following three subprocesses: injection, holding/packing, and cooling. The objective of the IMP is to produce without any quality issues such as short shot, warpage, or sink marks. For this reason, ensuring that the quality of plastic products meets the desired requirements is a major concern in the plastic injection industry [5]. Testing and quality control (QC) are conducted on the finished products to guarantee that they do not vary from the required standards. However, traditional QC processes entail costs for the company in terms of training of personnel and actual inspection time

Pioneer software emerged as a crucial tool during the internship. It provided a user-friendly interface that allowed for real-time monitoring and control of critical process parameters. The software enabled automation of temperature control, ensuring consistent and accurate heating throughout the induction moulding process. This automation includes

the process which plays a major role to deliver the products:

- Clamping
- Injection
- Mould
- Heaters
- Cooling channels
- Drive Unit

II. LITERATURE REVIEW

Harrison et.al [6] designed the application of tin as a medium to lubricate and heat the forming laminate is the main topic of the study. The process's basic principles are validated by preliminary experiments, which show that the tin sheet, melted by induction heating, can melt the carbon-nylon composite laminates' matrix phase when stacked in a hybrid composite/tin layup. How to extract most of the tin from the layup before consolidation is demonstrated using a new low-cost reconfigurable multi-step forming tool. Segmented tooling can be added to the multi-step tool to quickly produce composite parts with complex geometric design. This investigation uses a 'ripple' geometry with three 'cavities' to show how the method works. Experiments showed that the induction heating system can melt at least three inter-laminar tin sheets at once. Preliminary findings show that interlaminar tin can be removed while forming complex geometries with little to no wrinkling.

Kumar et.al [7] proposed a clever quality-control system that can improve consistency in product quality is necessary to address inefficiencies. Understanding the occurrence of failures and the steps taken to correct them is greatly aided by constant monitoring and control of the injection molding. A cyber engineering analysis model is created in the paper to show how injection molding actually behaves, and several experiments are run to determine the optimal process window for a high-quality final product. A control boundary with cavity temperature and pressure threshold limits is set in order to identify process disturbances. An if-then rule-based control algorithm is developed to identify failures and modify process parameters appropriately. Lastly, the validity of the suggested method is confirmed through the production of an automotive product, such as a car door trim module. Following the implementation of the developed quality control methodology, study results show a significant decrease in the rates of quality failure and resource waste.

Velu et.al [8] designed the ability to create highly complex structures is restricted by the well-established nature of these materials and the conventional production methods used to create them. Additive manufacturing, or 3D printing, offers a degree of control over the process parameters and makes it simple to produce complex shapes. Although there have been prior attempts at fused deposition modeling using these polymers, more promising techniques like the robot-based extrusion method have received very little attention. Sufficient attention is especially needed for 3D printing mold structures using high-performance materials for the automated fiber placement (AFP) process.

This paper uses the robotic extrusion method to attempt PEEK experimental investigations. Thus, in relation to its application for molds for AFP, the thermal, the mechanism of material consolidation, the effects of important process parameters on critical responses, and the thermomechanical properties are determined.

Wegmann et.al [9] introduced a glass fiber mat is impregnated through thickness with a thermoplastic polymer in the first process, thermoplastic compression resin transfer molding. With the aid of a spacer, the glass fibers are impregnated in plane during the second procedure, which is a melt-thermoplastic Resin Transfer Molding (RTM). Glass fiber is produced by coating each fiber individually using the third process, stamp forming of hybrid bicomponent fibers. Stamp forming is a subsequent step in the processing of the cloth made from the coated fibers. In a life cycle analysis (LCA), these three procedures were contrasted with traditional resin compression resin transfer molding using glass or carbon fibers and metal procedures using either steel or aluminum that can be recycled entirely or partially.

González and Fernández-León [10] introduced the pressure, sensor location within the mold, and filling time were all represented by grey-level images created from the evolution of the pressure sensors throughout the filling process. In terms of detection accuracy, the trained CNN model met expectations by identifying the existence of a dissimilar material region from the input data. The goal of this work was to provide a general framework for machine learning models that have been fully synthetically trained to handle manufacturing disruptions, without focusing on the models' robustness, performance, or optimization. In the paper, accuracy and model robustness were also discussed. The impact of noise signals, the size of the pressure sensor network, and the existence of regions with dissimilar shapes, among other factors, were all carefully examined. ML models are especially innovative and highly aligned with Industry 4.0 concepts in their ability to examine and solve complex physical and engineering problems, such as defects produced during the manufacturing of materials and parts.

III. PROPOSED METHODOLOGY

This mainly focuses on the significance of automation in improving the efficiency, quality, and control of the induction moulding process. By utilizing Pioneer Software. Excel Plast can enhance its process automation capabilities, optimize resource utilization, and gain a competitive edge in the industry.

Real-time monitoring and control of process parameters such as temperature, pressure, and cycle times. Reporting and documentation functionalities for quality control, traceability, and compliance purposes.

3.1. The Need for Implementing the Process

Improved Efficiency

Automation reduces manual intervention and streamlines the induction moulding process, leading to

increased operational efficiency. By utilizing Pioneer Software, Excel Plast can automate repetitive tasks, optimize production schedules, and minimize downtime, resulting in higher productivity and reduced manufacturing costs.

Enhanced Quality Control

The use of Pioneer Software enables real-time monitoring and control of critical process parameters such as temperature, pressure, and cycle times. This ensures consistent and precise heating of the plastic material, leading to improved product quality and reduced variability in moulded components.

3.2. Process Flow

The induction moulding process follows a systematic flow comprising several stages. It starts with material preparation, where thermoplastic pellets are fed into the moulding machine.

The material is then heated to its melting point using an induction heating system. Once molten, the material is injected into a pre-designed mold cavity. After the injection, the part undergoes a cooling phase to solidify and take the desired shape. Finally, the part is ejected from the mold, and the cycle repeats.

3.3. Pioneer Software

Pioneer software is a robust automation tool that provides a user-friendly interface for monitoring and controlling industrial processes.

Its key features include real-time data visualization, trend analysis, alarm management, and remote access capabilities. With Pioneer software, operators can monitor critical parameters such as temperature and pressure, make real-time adjustments, and track process performance.

The software's intuitive interface simplifies operations and enables efficient process control, enhancing productivity and ensuring consistency in the induction moulding process.

3.4. Advantages

Process Control and Optimization

Pioneer Software provides comprehensive process control capabilities, allowing operators to monitor and adjust key parameters in real-time. This enables precise control over the induction heating process, ensuring consistent and accurate heating of plastic materials. By optimizing the process, Pioneer Software helps achieve higher quality outputs and reduces variability in product properties.

Real-time Monitoring and Alerts

The software offers real-time monitoring of critical process parameters such as temperature, pressure, and cycle times. It provides visual representations and alerts to operators, enabling them to promptly address any deviations or abnormalities in the induction moulding process. Real-time monitoring enhances process visibility and facilitates proactive decision making to maintain quality and efficiency.

Automation and Workflow Management

Pioneer Software supports automation and workflow management, streamlining the induction moulding process. It integrates with robotics and other automation components, enabling automated material handling, mould insertion, and component ejection. This reduces manual intervention, enhances productivity, and minimizes the risk of human errors.

User-friendly Interface

Pioneer Software features a user-friendly interface that simplifies operation and reduces the learning curve for operators. The interface is intuitive, providing easy access to key functionalities, process visualization, and control settings. This enhances operator productivity and minimizes the risk of errors.

Support and Updates

Pioneer Software typically comes with ongoing support and regular updates from the software provider. This ensures that Excel Plast Company can receive technical assistance, access new features, and benefit from enhancements to the software over time.

3.5. Dis Advantages

Cost

Pioneer Software may come with a significant upfront cost for implementation and licensing. Depending on the scale and complexity of the induction moulding operations, the cost of acquiring and implementing the software may pose a financial challenge for smaller or budget constrained companies.

Learning Curve

Adopting a new software solution like Pioneer Software may require training and familiarization for operators and technicians. There could be a learning curve associated with understanding the software's features, functionalities, and best practices. This may require investing time and resources into training programs and adjusting to new workflows.

Compatibility and Integration

While Pioneer Software is designed to integrate with induction power supplies, robotics, and other automation components, there may be compatibility issues with specific hardware or systems. Ensuring seamless integration and compatibility with existing infrastructure may require additional configuration, customization, or hardware upgrades.

Vendor Dependency

The use of Pioneer Software may result in a level of dependency on the software vendor for ongoing support, updates, and maintenance. Relying on a single vendor for critical software components may pose risks if the vendor discontinues support or if issues arise in the software that cannot be addressed in a timely manner.

Limited Customization

Pioneer Software may have limitations on customization options based on the specific needs and preferences of Excel Plast Company. The software may not offer extensive customization capabilities or may require additional development efforts to tailor it precisely to the company's unique requirements.

3.6. Modules in the System

A system requirements specification is normally produced in response to a user requirements specification or other expression of requirements and is then used as the basis for system design.

In this process of induction moulding process automation, the modules include:

- Master
- Store Transaction
- Quality Control
- Pre-sales transaction
- Production Transaction
- Sales Transaction
- Stock

Master

This Master consists of more categories that includes the information about the customers like, Country, GSTIN State Code, City, Suppliers, Customers, Sub Contractors, GST types, GST details, Raw Materials Location, FG Locations, Primary Packings (Polythene Covers), Secondary Packings (Carton Boxes), Products Information, Shift Production Idle Hour Reasons, Shift Production Rejection Reasons, Transporter Details, Human Resources, Machine Details, Bank Details, Purchase order Terms and Conditions.

Store Transaction

Store Transactions consists of Purchase Orders, Close/Open Purchase Orders, Amend P.O., Goods Receipts Notes, Purchase Returns, Raw Material Request, Outsourced De flashing, Branch issue Notes, Branch Receipt Notes, Returnable Non-Returnable DCs, Returnable DCs, Sub Contract Outward, Sub Contract Inward.

Quality Control

Quality Control checks the GRN (Goods Receipt Notes) Inward Quality Check, De flashing & final Inspection (Manufactured), and Final Inspection (Outsourced).

Pre-sales Transaction

Pre-Sales Transactions refer to business activities that occur before a sale is finalized which includes, Customer Mould Inward, Customer Mould Outward, Open Orders, Supply Scheduling, Job Work Raw Material Inward, Amend Open Order, Amend Supply Schedule, Close/Open Order and Supply Schedule.

Production Transaction

Production transactions refer to the various activities and processes involved in manufacturing goods or producing

services. This transaction is essential in converting raw materials, labor, and other inputs into finished products or deliverable services.

This category includes two transactions;

- Raw Material Request from Production
- Shift Production Entry

Sales Transactions

Sales transactions refer to the exchange of goods or services for monetary payment between a seller and a buyer. These transactions are the core activities of any business and involve the process of selling products or services to customers. This Transaction consists of Job Work Delivery Challans, Job Work Delivery Challan Invoices, GST Invoices, and Update GST Invoices with Barcodes, Sales Return and Tracking Defects.

Stock

Stocks represent ownership in a publicly traded company which includes Stocks Statements about the Transactions.

3.7. Current System

By using this web application, businesses can process customer orders and requests in a timely and accurate manner while also managing ongoing customer and vendor accounts, tracking customer activity, turning a user into a customer, vendor contracts, product and sales data, etc. It also includes typical sales generation activities, such as creating and maintaining a customer database (which refers to all customer-related data, such as contacts, requirements, buyers, etc.), which can then be used to improve and personalize client interactions. It lets companies to precisely define policies and duties on who is responsible for what tasks at what times. As a result, production increased and customer needs were better met.

IV. SYSTEM SPECIFICATION

Table 1: Hardware Requirements

Processor	AMD PRO A4-3350B APU with Radeon R4 Graphic 2.00 GHz
RAM memory	4.00 GB
Device ID	F7BE7A06-C4D4-4236-B3F5-AEC981C9EC7C
System type	64-bit operating system, x64-based processor.

Table 2: Software Requirements

Microsoft windows	Windows 10 (64 bit)
Microsoft windows	10 version
Front end	ASP.net
Back end	VB.net

4.1. Frontend

Extensibility and Customization

ASP.NET offers extensibility points that allow you to extend and customize its behavior. You can create custom server controls, HTTP modules, and handlers, and integrate third-party components and libraries to enhance the functionality of your web application.

Server-Side Rendering

ASP.NET enables server-side rendering, allowing the web application to generate HTML dynamically on the server and send it to the client browser. This provides a consistent and reliable rendering experience across different devices and browsers.

Rich Control Set

ASP.NET provides a vast collection of server controls, such as text boxes, buttons, dropdowns, grids, and more. These controls encapsulate complex functionality and offer built-in event handling, validation, and data binding capabilities, making it easier to create interactive and user-friendly interfaces.

4.2. Backend

Object-Oriented Programming (OOP) Support

VB.NET is an object-oriented programming language that supports key OOP concepts such as classes, objects, inheritance, and polymorphism. This allows for modular and structured code development, promoting code reusability and maintainability.

Language Integration with .NET Framework

VB.NET is part of the Microsoft .NET framework, which provides a wide range of libraries and APIs. This integration enables seamless access to the extensive functionality offered by the framework, including database connectivity; file handling, security, and networking.

Database Connectivity

VB.NET offers robust database connectivity options through ADO.NET. It allows for efficient interaction with various databases such as SQL Server, Oracle, MySQL, and more.

VB.NET provides features for executing queries, retrieving and manipulating data, and performing database transactions.

4.3. Data Flow Diagram

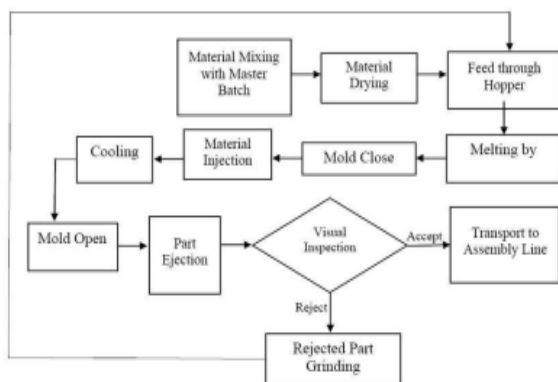


Figure 1 - Data Flow Diagram

4.4. Systematic Process

Effective control plans and procedures are formulated for incoming material. Systematic sampling, in-house testing and inspection facilities further strengthen these controls.



Figure 2 - Systematic Process

4.5. Control Plans



Figure 3 - Control Plans

V. RESEARCH AND DISCUSSION

Systems design is the process of defining a system's components, including modules, architecture, components, their interfaces, and data, depending on the requirements that have been given. Systems that meet the unique goals and requirements of a business or organization are defined, developed, and designed in this manner.

5.1. Input Screen

The input screen allows operators to input or select information related to the production batch, such as the batch number, production date, and any additional batch-specific details. This information can be used for tracking, traceability, and production management purposes. The main use of software is of two types:

- Master and Transactions
- Management Information Systems and Reporting



Figure 4 - Input Screen (login page-Master and Transactions)

The Fig 4 describes about how the user login to the software that consists of five types of Modules, but there are two important modules is used frequently for their transactions and for maintaining reports in which this includes Master and Transactions.

Master and Transactions

In Induction Moulding Process Automation, Master records contain information regarding a business partner and materials. Settings are made on the master record drive how transactions are processed in Pioneer.

Transactional data is the data created from processing business transactions in the system.

Management Information Systems & Reporting

MIS Report stands for Management Information System and is an umbrella term to describe a set of reports in Induction moulding process that gives a view of the day-to-day activities of a business which allows the business's functions to be analyzed.



Figure 5 - Input Screen (login page- Management Information Systems and Reporting)

The Fig 5 describes about the Management Information Systems and Reporting which consists of Reports and Utilities.

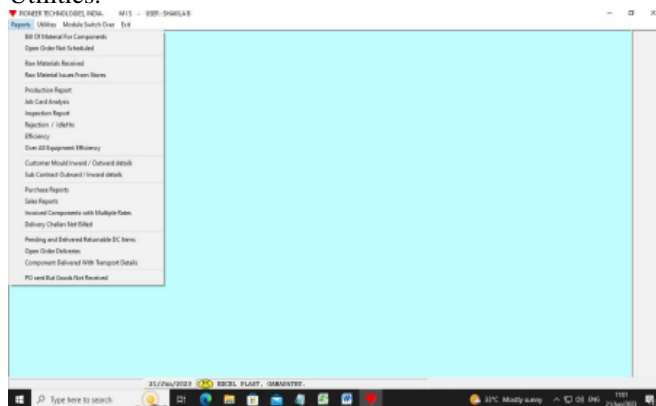


Figure 6 - Reports in Management Information System & Reporting

The Fig 6 describes about the Reports which includes Bill of Material for components, Raw materials information, Production reports, Customer in and outward details, Purchase reports, pending and returnable DC items and Purchase order Details.

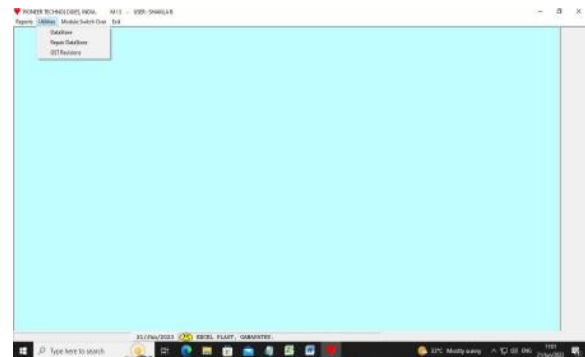


Figure 7 - Utilities in Management Information Systems and Reporting

The Fig 7 describes about the Utilities which consists of Data store, Repair Data store and GST Reviews.

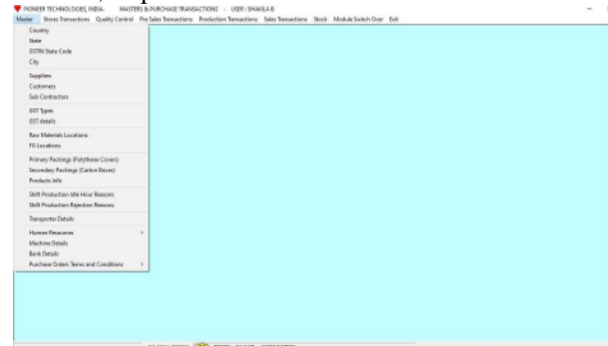


Figure 8 - Master and Transactions

The Fig 8 describes about the customer details which includes country, state, GST details, Transporter details and etc.

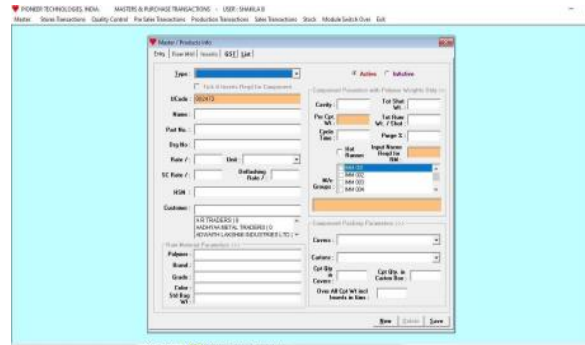


Figure 9 - Input Screen (Master and Transactions-Main page)

The Fig 9 describes about the interface of master/product information which includes Entry, Raw material, Inserts, GST and List.

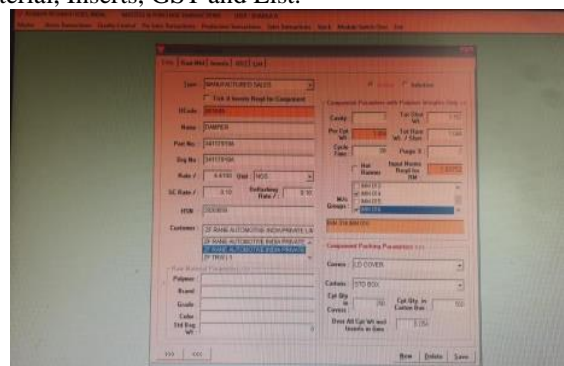


Figure 10 - Input Screens (Master and Transactions-Entries)

The Fig 10 describes about the inputs given in Raw material which includes the details about the product type, product name, rate, customer name, part number, product code, HSN etc..

5.2. Output Screen

The output screen represents the quality control metrics and indicators, such as the number of rejected components, reject rate, dimensional accuracy, or other quality related parameters.

These metrics give operators insights into the quality of the moulded products and allow them to take appropriate actions if deviations or issues are detected.

This output screen allows generating reports summarizing the key process parameters, production data, quality metrics, and other relevant information. These reports can be saved, printed, or exported for documentation, analysis, and sharing with stakeholders.

VI. CONCLUSION

Induction molding process automation brings significant advantages to the manufacturing industry, enhancing efficiency, productivity, and product quality. The integration of automated systems with induction molding processes streamlines production, reduces cycle times, and minimizes human error. By leveraging advanced technologies like robotics, sensors, and artificial intelligence, manufacturers can achieve consistent and precise molding results. Automation enables continuous monitoring and control of crucial parameters, ensuring adherence to strict quality standards and reducing waste. It also enhances worker safety by reducing manual interventions in hazardous processes. The ability to collect real-time data allows for data-driven decision-making and predictive maintenance, optimizing equipment performance and reducing downtime.

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