Review in Controlling Analysis of Injection Molding Machine

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Abstract- An Injection molding machine, also known as an injection press, is a machine for manufacturing plastic products by the injection molding process. Injection molding is a method to obtain molded products by injecting plastic materials molten by heat into a mold and then cooling and solidifying them. The method is suitable for the mass production of products with complicated shapes, and takes a large part in the area of plastic processing. Review process involving 2 stage approaches has been undertaken for 20 research papers which were published in the period of year 2001 to year 2013. After an exhaustive review process, four key issues were found “Controlling Process of Injection Molding Machine, Trouble Shooting, Production & Stock Management and Controlling Process of Hot Runner Type Injection Molding Machine” which is mostly need to enhance of Industrial Automation aspects to get better solution approach. The outcome of the review was in the form of various findings, found under various key issues. The findings included algorithms and methodologies used to solve particular research problem, along with their strengths and weaknesses and the scope for the future work in the area.

Key words: IMM, PIDNN, MRAC, MRAS

I. INTRODUCTION

Injection molding is a method to obtain molded products by injecting plastic materials molten by heat into a mold and then cooling and solidifying them. The process of injection molding is divided into 6 major steps as shown below:

- Clamping
- Injection
- Dwelling
- Cooling
- Mold opening
- Removal of products

Injection molding machine is divided into 2 units i.e. a clamping unit and an injection unit. The functions of the clamping unit are opening and closing a die, and the ejection of products. There are 2 types of clamping methods, namely the toggle type shown in the figure below and the straight-hydraulic type in which a mold is directly opened and closed with a hydraulic cylinder. The functions of the injection unit are to melt plastic by heat and then to inject molten plastic into a mold. The screw is rotated to melt plastic introduced from the hopper and to accumulate molten plastic in front of the screw (to be called metering). After the required amount of molten plastic is accumulated, injection process is started. While molten plastic is flowing in a mold, the machine controls the moving speed of the screw, or injection speed. On the other hand, it controls dwell pressure after molten plastic fills out cavities. The position of change from speed control to pressure control is set at the point where either screws position or injection pressure reaches a certain fixed value.

II. REVIEW PROCESS ADOPTED

A literature review is necessary to know about the research area and what problem in that area has been solved and need to be solved in future. This review process approach was divided into five stages in order to make the process simple and adaptable. The stages were:-

Stage 0: Get a “feel”
This stage provides the details to be checked while starting literature survey with a broader domain and classifying them according to requirements.

Stage 1: Get the “big picture”
The groups of research papers are prepared according to common issues & application sub areas. It is necessary to find out the answers to certain questions by reading the Title, Abstract, introduction, conclusion and section and sub section headings.

Stage 2: Get the “details”
Stage 2 deals with going in depth of each research paper and understand the details of methodology used to justify the problem, justification to significance & novelty of the solution approach, precise question addressed, major contribution, scope & limitations of the work presented.
Stage 3: “Evaluate the details”
This stage evaluates the details in relation to significance of
the problem. Novelty of the problem, significance of the
solution, novelty in approach, validity of claims etc.

Stage 3+: “Synthesize the detail”
Stage 3+ deals with evaluation of the details presented and
generalization to some extent. This stage deals with
synthesis of the data, concept & the results presented by the
authors.

III. VARIOUS ISSUES IN THE AREA

After reviewing 20 research papers on Controlling Analysis
of Injection Molding Machine we have found following
issues, which has to be addressed, while the designing and
implementation of the Injection Molding Machine these
issues are:

1) Controlling Process of Injection Molding Machine
2) Trouble Shooting
3) Production & Stock Management
4) Controlling Process of Hot Runner Type Injection
Molding Machine

IV. ISSUE WISE DISCUSSION

Issue 1:- Controlling Process of Injection Molding Machine
Controlling Process of Injection Molding Machine is one of
the issue, some approaches are used for this issue which is
adaptive intelligent control algorithm based on Multi-
CPU,Back-propagation algorithm of the PIDNN , PID
neural network forward algorithm. Injection molding
machine controlling process very hard with relay logic, so
embedded system controlling process (logic) used for
injection molding machine, this process is better than the
relay logic & it provides an effective & easy way to control
the hydraulic system. PIDNN, in which proportional (P)
neuron, integral (I) neuron and derivative (D) neuron is
defined. Every neuron has an input u and an output x. The

properties of a neuron are decided by the input-output
function. The P-neuron, I-neuron and D-neuron are
different from each other because of the proportional (P)
function, the integral (I) function and the derivative (D)
function. A basic PIDNN had 2 inputs and 1 output and
three layers which were input layer, hidden layer and
output layer. The input layer has two neurons and the
output layer has one and their neurons are P-neurons. The
hidden layer has three neurons and they are P-neuron, I-
neuron and D-neuron respectively.

Issue 2:- Trouble Shooting
Trouble shooting is second issue, some approaches are
used for this issue which is object-oriented technology &
case based reasoning technology. Object-oriented
technology, case based reasoning technology and Rule-
based expert system have been suggested to model the
injection molding process reduces the dependency on
human expertise needed for decision-making. Case based
and rule-based reasoning to form a model for solving
trouble-shooting problems in molding processes.

Issue 3:- Production & Stock Management
Production & Stock Management is third issue, some
approaches are used for this issue which is Model
Reference Adaptive Control (MRAC) scheme. Mold cavity
pressure in injection molding machine plays an important
role in determining the quality of molded products. The
Model Reference Adaptive Control (MRAC) is an
important adaptive controller, in which the desired
performance is expressed in terms of reference model,
which give the desired response to a command signal. In
the MRAC the desired behaviour of the system is specified
by a model and the parameters of the controllers are
adjusted based on the error, which is the difference
between the output of the system and the output of the
reference model. The mechanism for adjusting the
parameters in a MRAS could obtain in two ways: by using
a gradient method (MIT Rule) or by applying stability
(Lyapunov) theory.

Issue 4:- Controlling Process of Hot Runner Type
Injection Molding Machine
Controlling Process of Hot Runner Type Injection Molding
Machine is fourth issue, some approaches are used for this
issue which is special purpose controller & a human
machine interface for hot runner type micro injection
molding module. The performance of this hot runner type
micro injection molding module is tested with a
reciprocating injection molding machine. The test results
showed that the metering precision of using this module is
at least as good as a two stage reciprocating screw. A hot
runner type micro injection molding module is successfully
developed.
V. ISSUE WISE SOLUTION APPROACHES USED

The solution approaches under the various issues have been shown in the Table 6.1 to 6.4, which includes additional information like hardware, software, variable/parameters used along with results obtained. The same table also describes the Comparative analysis between various solution approaches.

VI. ISSUE WISE DISCUSSION ON RESULTS

<table>
<thead>
<tr>
<th>Issue</th>
<th>Solution Approach</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue 1: Controlling Process of Injection Molding Machine</td>
<td>Artificial Intelligent Technology</td>
<td>It can improve the control capability, decrease the preparation time, reduce the default rate, enhance the safety performance of the system.</td>
</tr>
<tr>
<td></td>
<td>Plastic Rheological Approach</td>
<td>This approach is suitable for setting up the injection parameters automatically when installing new mold on injection molding machine.</td>
</tr>
<tr>
<td></td>
<td>PID Neural Network Forward Algorithm, ARM technology</td>
<td>Increase processing speed, quality of product &amp; ARM technology achieve better temperature control effect.</td>
</tr>
<tr>
<td></td>
<td>Adaptive Algorithm</td>
<td>Improve the overall performance of Injection molding machine.</td>
</tr>
<tr>
<td></td>
<td>High Order Reaction Force Observer &amp; Reaction Force Observer based on two Inertia Resonant Model</td>
<td>Improve the accuracy in the screw back-pressure process &amp; holding process also improved by adding a periodical signal to the force command.</td>
</tr>
<tr>
<td></td>
<td>Back Propagation Algorithm</td>
<td>By using this algorithm it can give small overshoot value &amp; zero steady state error every kind of inputs.</td>
</tr>
<tr>
<td></td>
<td>Adaptive Intelligent Control Algorithm</td>
<td>By using this algorithm it can improve the processing speed of system &amp; reduces the cost of controller hardware.</td>
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<table>
<thead>
<tr>
<th>Issue 2: Troubleshooting</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S. No.</td>
<td>Solution Approach</td>
<td>Results</td>
</tr>
<tr>
<td>8</td>
<td>Component &amp; Object Oriented technology</td>
<td>Improve the response speed &amp; provides a plate form for further research in terms of intelligent control of molding processes.</td>
</tr>
<tr>
<td>9</td>
<td>Dynamic Model Turning Minimum Variance Method</td>
<td>This method is used to control the whole process &amp; control the product quality.</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Issue 3: Production &amp; Stock Management</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S. No.</td>
<td>Solution Approach</td>
<td>Results</td>
</tr>
<tr>
<td>10</td>
<td>MS Visual Web Developer 2005 Express &amp; MySQL Database tools</td>
<td>It can reduce time &amp; cost for the organization.</td>
</tr>
</tbody>
</table>

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<tr>
<th>Issue 4: Controlling Process of Hot Runner Type Injection Molding Machine</th>
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</tr>
</thead>
<tbody>
<tr>
<td>S. No.</td>
<td>Solution Approach</td>
<td>Results</td>
</tr>
<tr>
<td>11</td>
<td>Reciprocating screw &amp; Plunger type mechanism &amp; Control Algorithm are used</td>
<td>The performance of precisely metering is as good as the Sodick Plustech Tuparl TR30EH. (Machine Name)</td>
</tr>
<tr>
<td>12</td>
<td>Adaptive Algorithm</td>
<td>Improve the overall performance of IMM.</td>
</tr>
</tbody>
</table>

Table 6.1 Issue wise Solution Approaches & Results

Table 6.2 Issue wise Solution Approaches & Result

Table 6.3 Issue wise Solution Approaches & Result

Table 6.4 Issue wise Solution Approaches & Result
VII. COMMON FINDINGS

Issue 1:- Controlling Process of Injection Molding Machine

- Adaptive intelligent control algorithm is used for the temperature control.
- Adaptive intelligent control algorithm based on Multi-CPU.
- ARM-based distributed intelligent control system of the injection molding machine could improve the control capability, the management level by optimizing the process parameters, dynamically tracking, controlling the molding process, establishing and updating the processing knowledge base. Dual ARM processor control system is better approach to provide a reference for the control system software design on different models of injection molding machine.
- PID neural network control algorithm combined with the ARM technology could achieve better temperature control effect.

Issue 2:- Trouble Shooting

- Proposed object-oriented technology & case based reasoning technology.
- Case based and rule-based reasoning to form a model for solving trouble-shooting problems in molding processes.
- Reduce the dependency on human expertise needed for decision-making.

Issue 3:- Production & Stock Management

- Proposed Model Reference Adaptive Control (MRAC) scheme.
- The mechanism for adjusting the parameters in a MRAS could obtain in two ways: by using a gradient method (MIT Rule) or by applying stability (Lyapunov) theory.
- Proposed control scheme is prospective to implement in the real system.

Issue 4:- Controlling Process of Hot Runner Type Injection Molding Machine

- Proposed a special purpose controller & a human machine interface for hot runner type micro injection molding module.
- Hot runner type micro injection molding module is tested with a reciprocating injection molding machine & find out the test results showed that the etering precision of using this module is at least as good as a two stage reciprocating screw.

VIII. SCOPE FOR THE WORK IN AREA

- Further work can be done on Injection Molding Machine for controlling process like that Mold close, Mold open, Unit return, Unit forward etc.
- In Future we can use the Multi CPU process technology than increases the product quality & consumption time.
- Further work can be done on Injection Molding Machine for controlling process with the help of Servo Motor.

IX. CONCLUSION

We have elaborated review of 20 research papers ranging from 2001 to 2013 based on controlling analysis of Injection Molding Machine. The review process consists of 3 stage analysis. Basically we found four main issues in the field of Controlling parameters of Injection Molding Machine viz. Controlling Process of IMM Trouble shooting problem, Production & Stock Management, Problem of IMM, Controlling process of Hot Runner Type IMM. Here after finding the solution approaches we concluded that controlling parameters of Injection Molding Machine is the main area into which the future work can be done. We found different Solution approaches out of which Case based reasoning, Control Algorithm, Control Algorithm MS Visual Web Developer 2005 Express Model, Predictive Control Methodology, Temperature Control by training & self learning process, Multilayer group method of data handling algorithm.

The exhaustive review could finally lead to extract findings in the area of Controlling analysis of Injection Molding Machine, strengths and weaknesses and scope of work during M. Tech II semester Research work.

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REFERENCES


