Characterization of key process parameters in Blow Molding using Artificial Neural Networks

*Predictive Process Analytics*

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PURPOSE

• Overall Objective of this study is to characterize the key process variables such as ambient, operating temperatures, process line operators, resin types, resin colors and operating lines associated with the polymer bottle manufacturing.

• Identify definitive relationship between the selected process parameters for the production machine and ensure product quality

• Evaluate the performance characteristics of Post Consumer Resin (PCR) with that of Virgin material and identify diverse variations with in them.
INTRODUCTION

• Blow molding is one of the well-known manufacturing techniques that is used to manufacture bottle of complex shapes.

• Final optimal process parameters are one of the key drivers in the blow molding process that improves the quality of the molded parts.

• Combined effects of geometry, part, material characteristics, mold design and processing conditions on the part manufacturing is challenging to analyse through analytical/mathematical model because of the complexity in the process as well as multiplicity of the parameters and its interactive effects on one another.
PROCESS HIGHLIGHTS

**Injection Mold**
- Polymer melt supplied to mold halves from injection molded machine.

**Blow Mold**
- Preform injection molded over a mandrel and transferred to the blowing die.
- In Injection Blow Molding method a parison is produced by injecting a polymer into a hot injection mold around a blow tube or core rod.
- The blow tube together with the parison is removed from the injection mold and transferred to a blow mold.
- Air is injected under pressure through the mandrel blowing the polymer against the mold walls where it cools and freezes as with extrusion blow molding.

- Injection Blow Molding is more accurate and controllable process as compared to the Extrusion Blow Molding.
- Air is injected over on core pin.
- Blow mold
- Preform expanded into final bottle shape inside the mold.

Injection Blow Molding method a parison is produced by injecting a polymer into a hot injection mold around a blow tube or core rod. The blow tube together with the parison is removed from the injection mold and transferred to a blow mold. Air is injected under pressure through the mandrel blowing the polymer against the mold walls where it cools and freezes as with extrusion blow molding.
PROCESS OPTIMIZATION & NEURAL NETWORKS

Existing Process study

Neural Network

Optimized Parameters
NEURAL NETWORK MODEL DEVELOPMENT

Model Input parameters:
- Resin type
- Resin Color
- Grades
- Preform temperature
- Set temperature
- Manufacturing line
- Sample space
- Operator efficiency

MATLAB’s Neural Network Modeling Environment

Training Data

Data from existing Process line study

Model Output parameters

Validation

To Process Optimization Cycle

YES

- Defects Identified
- % Acceptance
NEURAL NETWORK MODEL DEVELOPMENT
Defects predicted for different types of resins without any colorants added.

The defects predicted is for both Virgin and PCR Resin materials from different source of suppliers.
Defects predicted for different types of resins with colorants added.

The defects predicted is for both Virgin and PCR Resin materials with green and blue colors.
NEURAL NETWORK PREDICTION

Bottle sample acceptance in % predicted for PCR Green Resin at different set point and Preform temperature. The acceptance rate prediction is also based on the operation conditions, manufacturing line, different resin supplier etc.
Bottle sample acceptance in % predicted for Virgin Green Resin at different set point and Preform temperature. The acceptance rate prediction is also based on the operation conditions, manufacturing line, different resin supplier etc.
Bottle sample acceptance in % predicted for Virgin Blue Resin at different set point and Preform temperature. The acceptance rate prediction is also based on the operation conditions, manufacturing line, different resin supplier etc.
Bottle sample acceptance in % predicted for PCR Clear Resin at different set point and Preform temperature. The acceptance rate prediction is also based on the operation conditions, manufacturing line, different resin supplier etc.
Defect rates by operators predicted at different iterations along with cumulative percentage defects. The defect rate prediction is also based on the operation conditions, Set point & preform temperatures, manufacturing line, different resin supplier etc.
Defects predicted at different manufacturing lines. The defects predicted is for both Virgin and PCR Resin materials from different source of suppliers with different colors and manufactured under different conditions.
CONCLUSION

- The Neural network platform developed in MATLAB was used
  - In evaluating the variability in virgin grade of resin when compared to PCR. Variability in this context is the increased defects with in PCR when compared to virgin material.
  - Providing the correlation between the preform temperature and product quality. The exercise showcased no significant impact made by the preform temperatures on the Injection blow molding process.
  - Providing the correlation between the set point temperature and product quality. The exercise showcased no significant impact made by the set point temperatures, where it shows minimal defects with accepted production level.
  - Identifying product quality on different manufacturing lines with different operating conditions
  - Providing quantitative difference with respect to the variability's observed in Colored resins when compared to the clear resin.

- Process operators can employ range of suitable temperatures to reduce the amount of defects. The resin type, operating lines and resin colour have found to have significant impact on the variability of the product manufactured using Injection blow molding process.
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