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

Predictive Process Analytics

PRAVEEN BHAT & CHANDRASEKHAR ARCOT J

Predictive Engineering, Axiom Consulting Pvt. Ltd.

Bangalore, Karnataka, INDIA

axiom

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

axiom

PROCESS HIGHLIGHTS

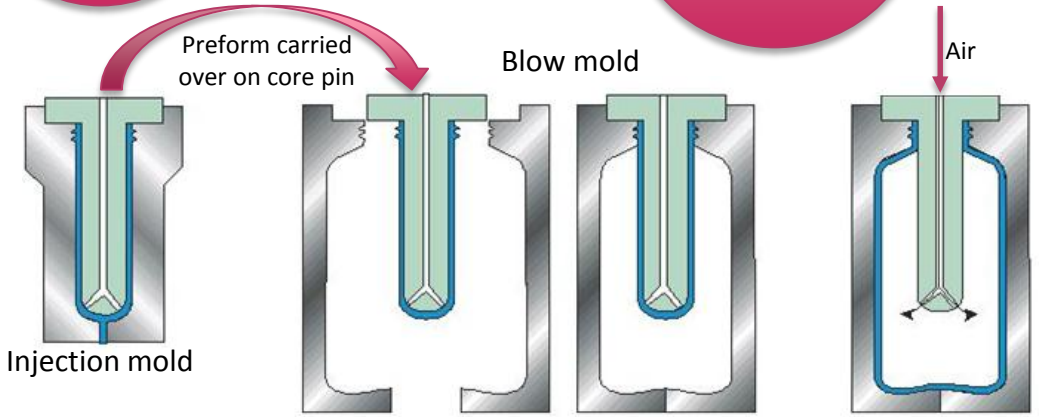
Polymer melt supplied to mold halves from injection molded machine

Pre-form 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.

Injection Blow Molding is more accurate and controllable process as compared to the Extrusion Blow Molding.

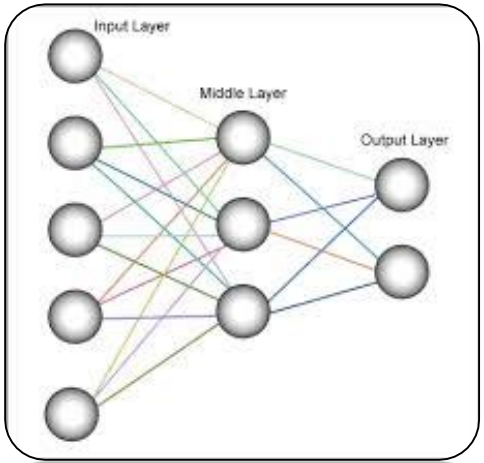


Air is injected under pressure through the mandrel blowing the polymer against the mold walls where it cools and freezes as with extrusion blow molding

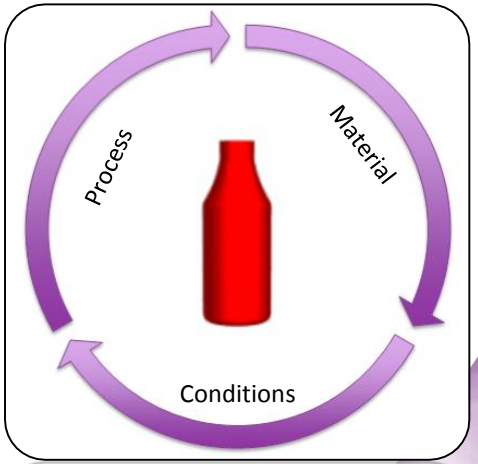
PROCESS OPTIMIZATION & NEURAL NETWORKS

Existing Process study

Neural Network

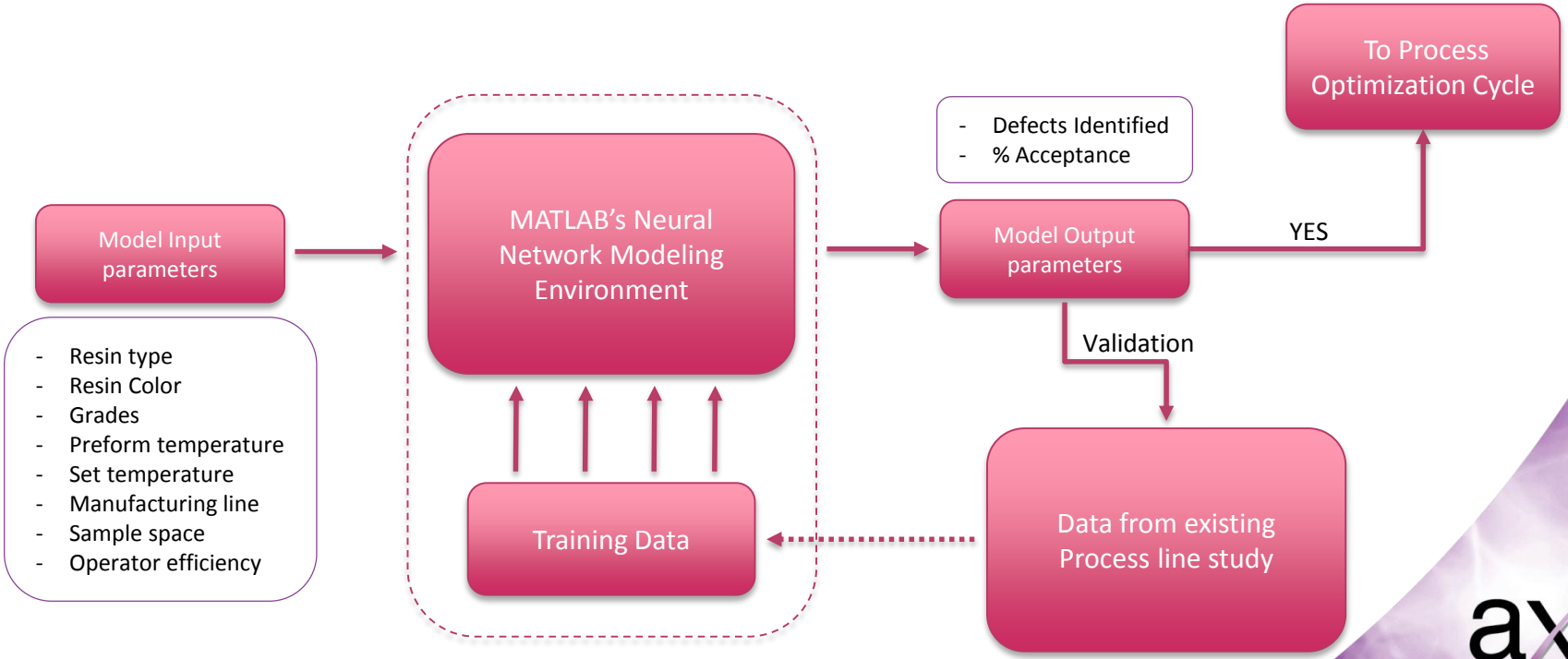


Optimized Parameters



axiom

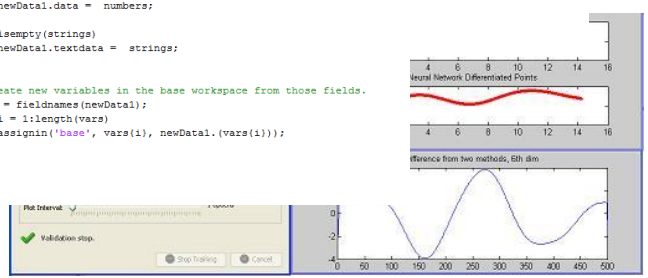
NEURAL NETWORK MODEL DEVELOPMENT



axiom

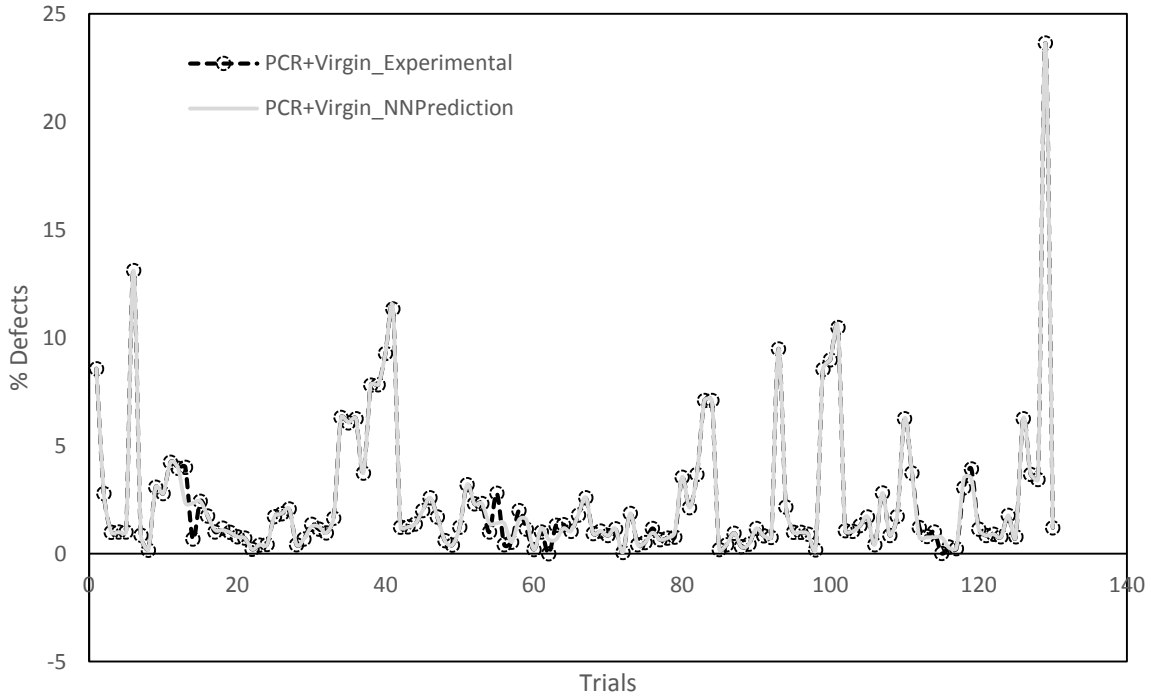
NEURAL NETWORK MODEL DEVELOPMENT

```
%IMPORTFILE(FILETOREAD1)
%  Imports data from the specified file
%  FILETOREAD1:  file to read

% Import the file
sheetName='Input';
[numbers, strings] = xlsread(fileToRead1, sheetName);
if ~isempty(numbers)
    newData1.data =  numbers;
end
if ~isempty(strings)
    newData1.textdata =  strings;
end

% Create new variables in the base workspace from those fields.
vars = fieldnames(newData1);
for i = 1:length(vars)
    assignin('base', vars{i}, newData1.(vars{i}));
end
```



axiom

NEURAL NETWORK PREDICTION

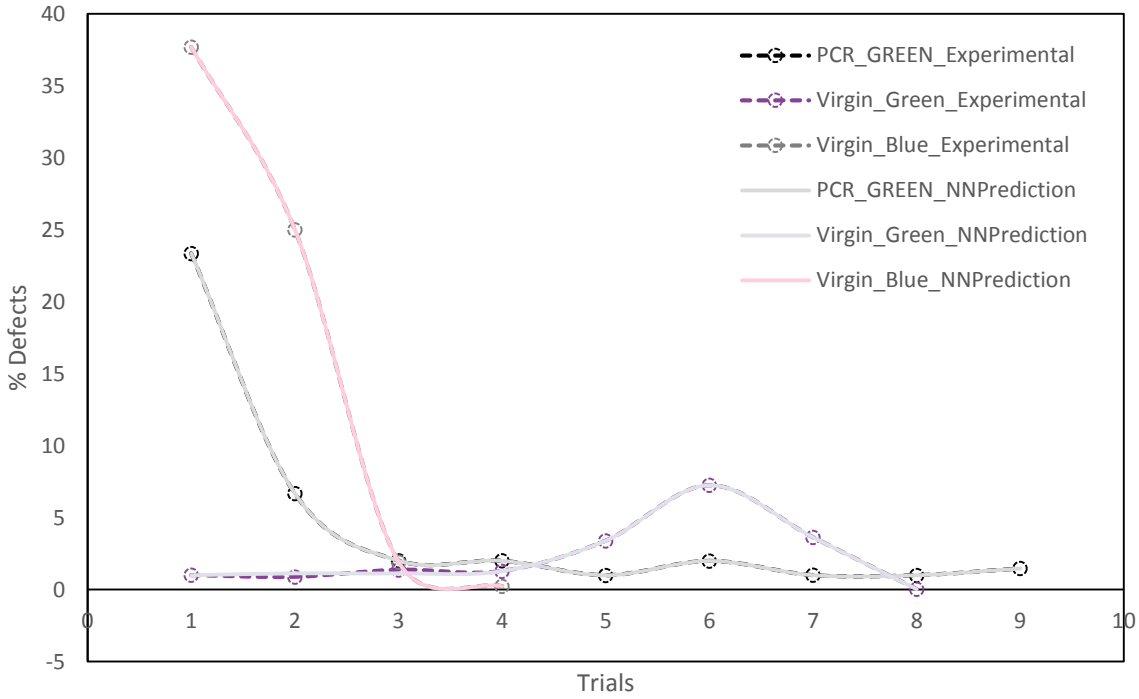


Defects predicted for different types of resins with out any colorants added.

The defects predicted is for both Virgin and PCR Resin materials from different source of suppliers.

axiom

NEURAL NETWORK PREDICTION

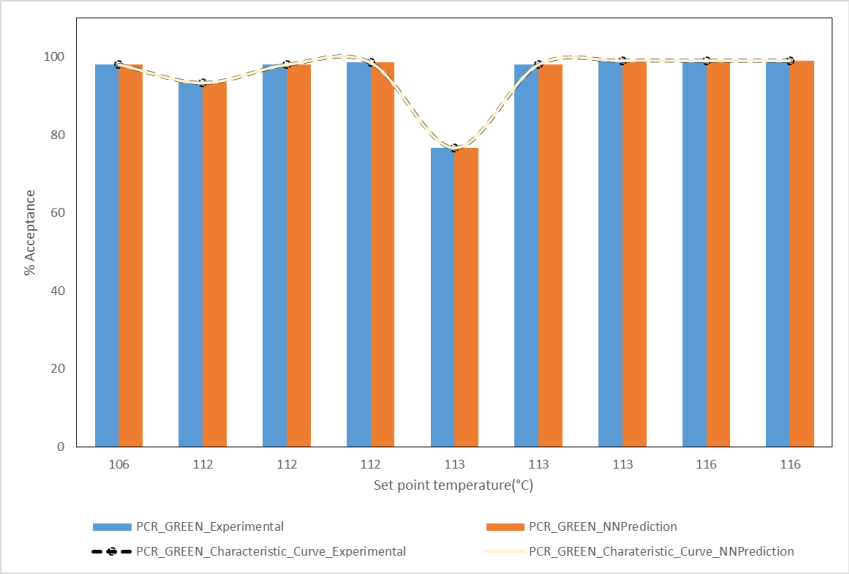


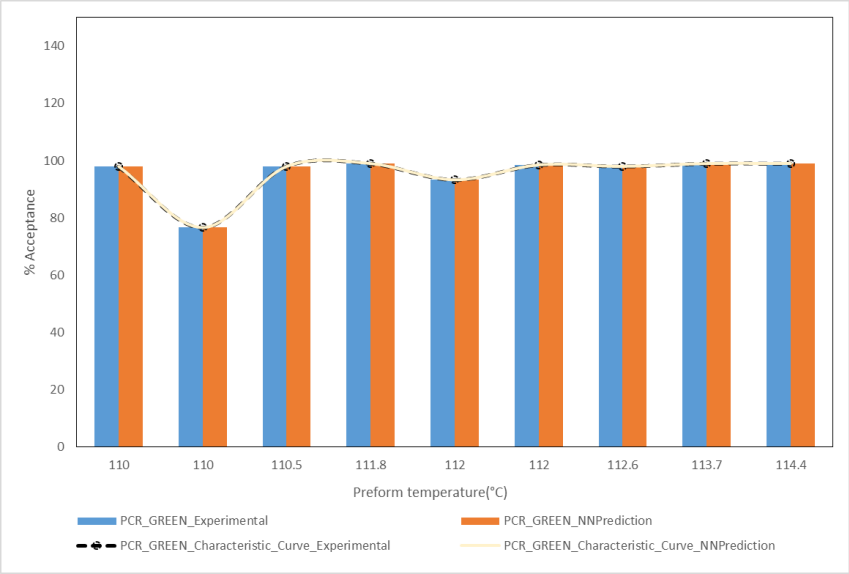
Defects predicted for different types of resins with with colorants added.

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

axiom

NEURAL NETWORK PREDICTION

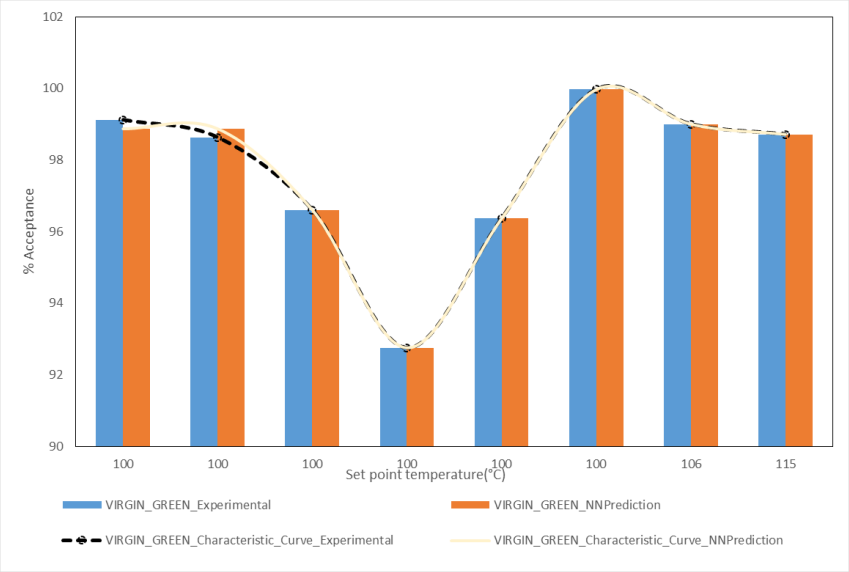


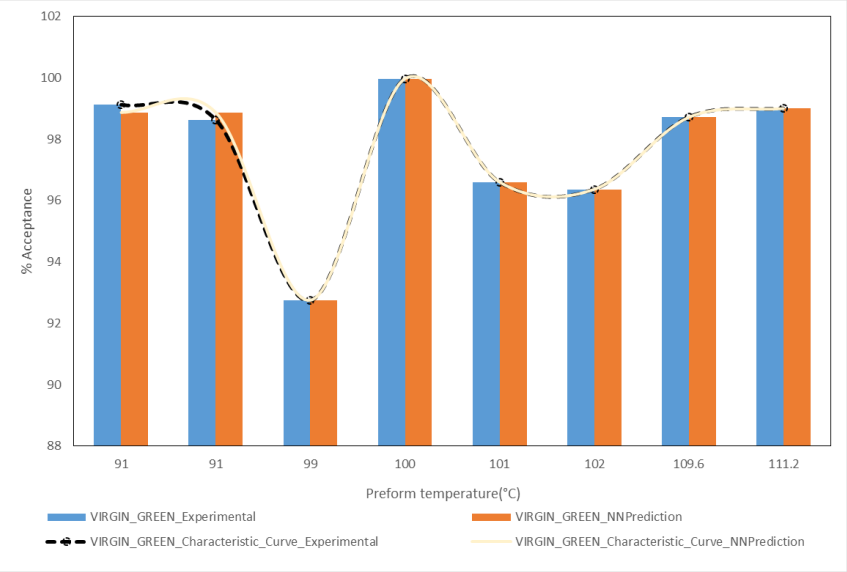


Bottle sample acceptance in % predicted for PCR Green Resin at different set point and Preform temperature. The acceptance rate prediction is also based on the operation conditions, manufacturing line, different resin supplier etc.

axiom

NEURAL NETWORK PREDICTION

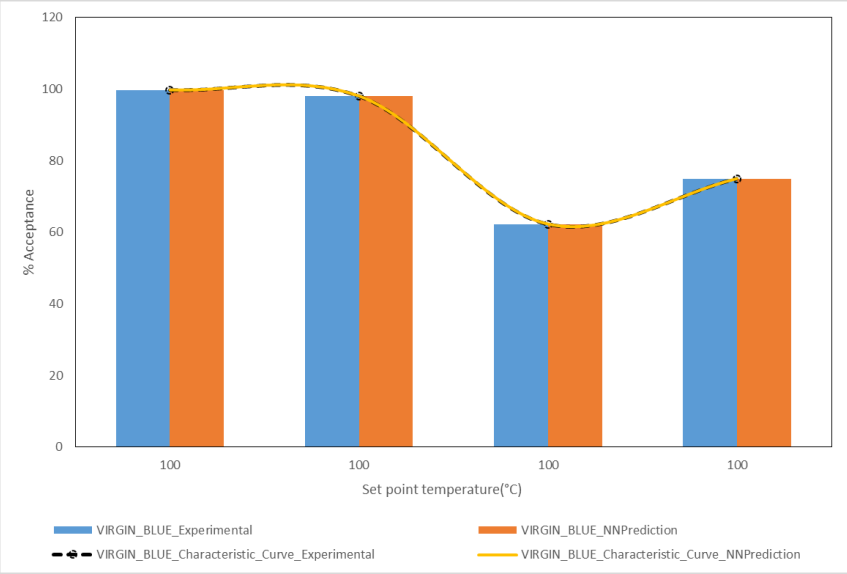


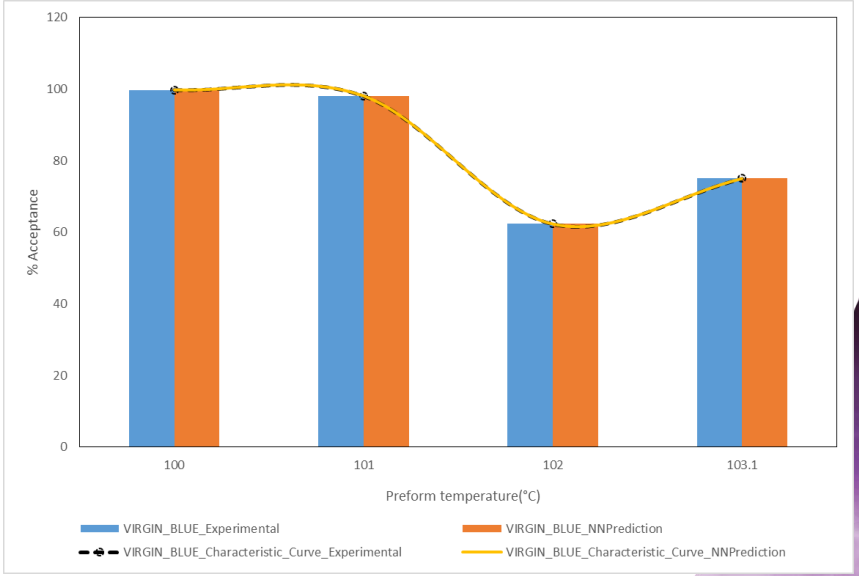


Bottle sample acceptance in % predicted for Virgin Green Resin at different set point and Preform temperature. The acceptance rate prediction is also based on the operation conditions, manufacturing line, different resin supplier etc.

axiom

NEURAL NETWORK PREDICTION

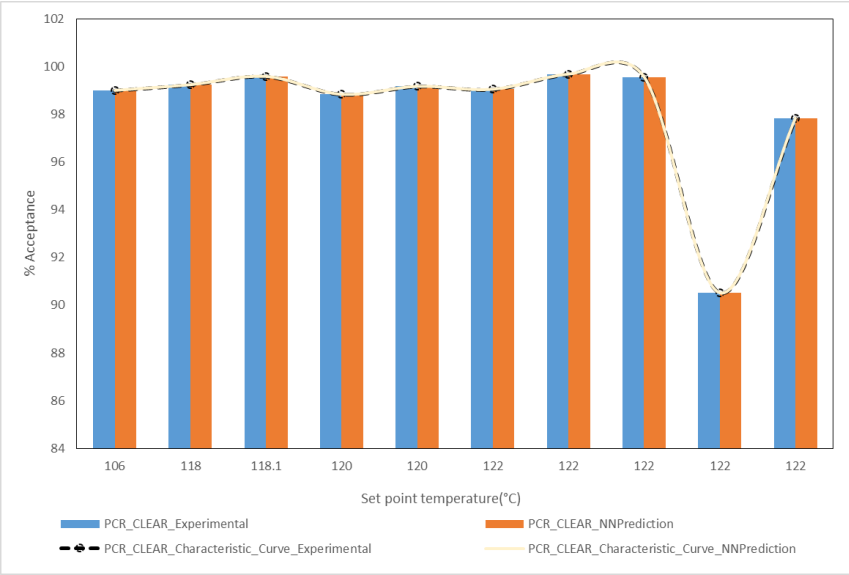


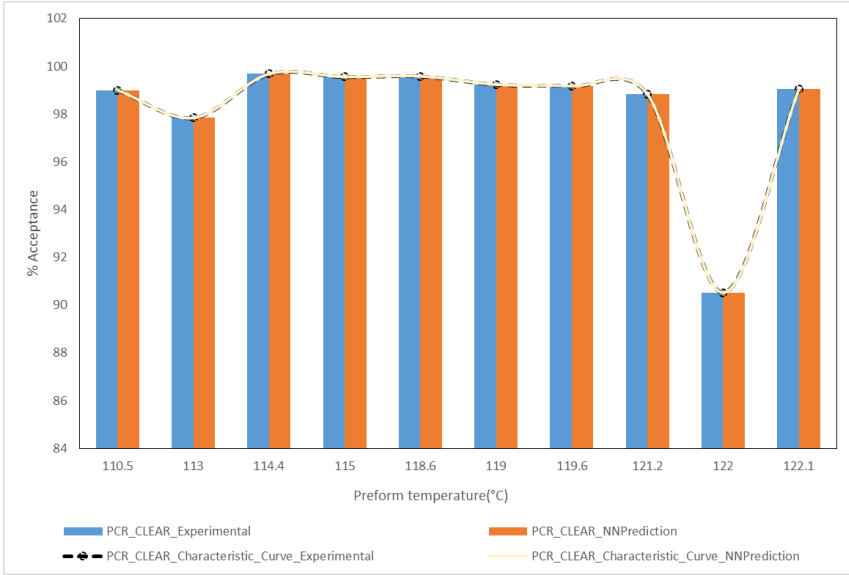


Bottle sample acceptance in % predicted for Virgin Blue Resin at different set point and Preform temperature. The acceptance rate prediction is also based on the operation conditions, manufacturing line, different resin supplier etc.

axiom

NEURAL NETWORK PREDICTION

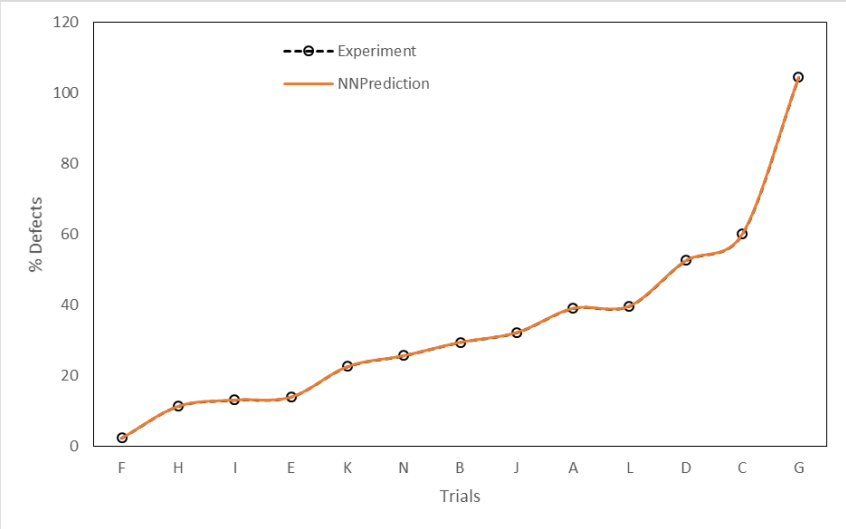


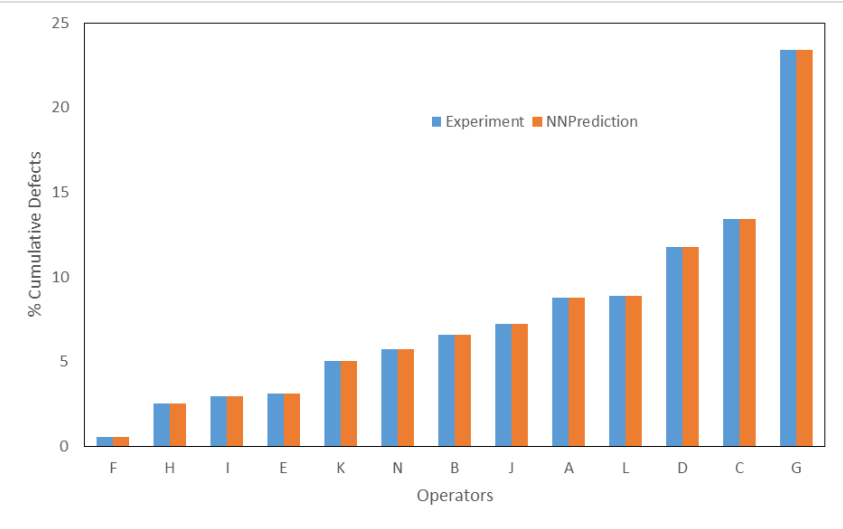


Bottle sample acceptance in % predicted for PCR Clear Resin at different set point and Preform temperature. The acceptance rate prediction is also based on the operation conditions, manufacturing line, different resin supplier etc.

axiom

NEURAL NETWORK PREDICTION

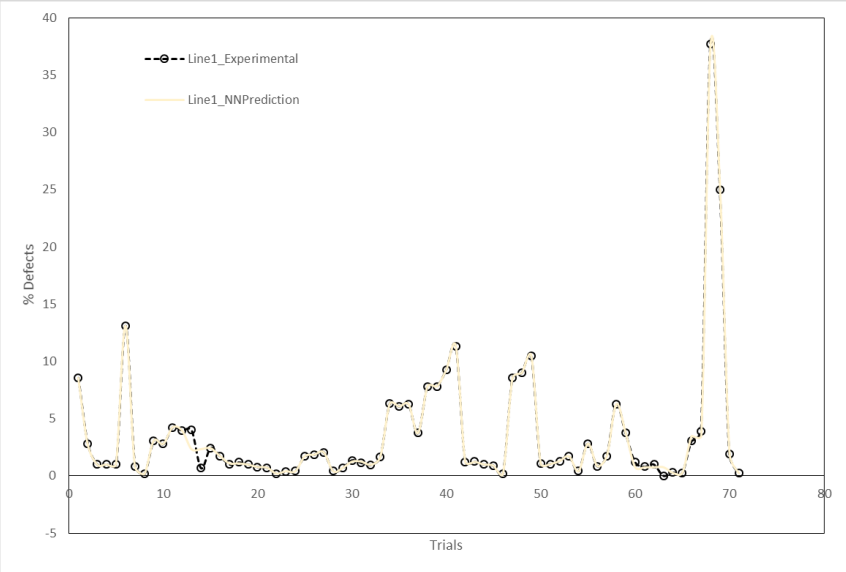


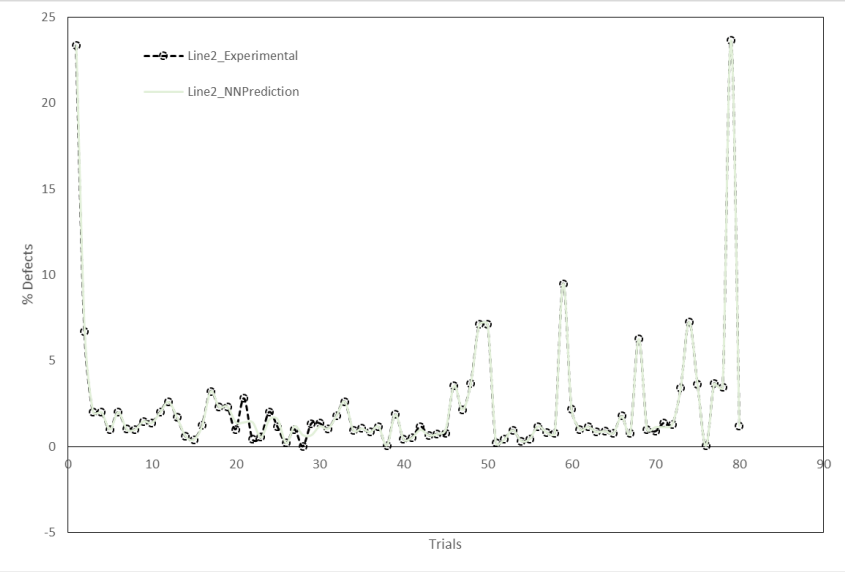


Defect rates by operators predicted at different iterations along with cumulative percentage defects. The defect rate prediction is also based on the operation conditions, Set point & preform temperatures, manufacturing line, different resin supplier etc.

axiom

NEURAL NETWORK PREDICTION





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.

axiom

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.

axiom

ABOUT AUTHORS

Praveen Bhat, **Team lead, Predictive Engineering, Axiom Consulting, Bangalore**, holds a Masters degree in Mechanical Engineering (Design and Analysis) from Manipal University and has over Twelve plus years experience in the field of Finite Element Methods (FEM), Advanced Computational Fluid Dynamics (CFD), Computational Tribology, Multiphysics Engineering Design, Paper & Package Development, Predictive Engineering tool development. During his career, he has been involved in several Multi-field innovation and developmental projects. His expertise includes structural and thermal modeling in consumer electronics & packaging, Predictive tool and methods development, Optics, Acoustics & vibration. He has been working in different domains that includes Automotive & Aerospace, Consumer Package goods, Engineered Products, consumer electronics, Healthcare and medical devices. He has 4 Patents filed with 20+ International Conference & Journal papers

Chandrasekhar A J, **Director, for Predictive Engineering, Axiom Consulting**, holds a Master's degree in Heat transfer from National Institute of Technology, Karnataka. He has his engineering roots in the automotive and aerospace industries with specialty in applying Predictive Engineering methods and tools (CAE) to solve engineering problems. He has spent the past 20 years working on various product development programs, evolving methodologies for complex families of problems and developing "libraries" of applications that can be used across verticals to assist OEM's and their suppliers with creative solutions. He also has extensive experience with Mechatronics and Instrumentation for data capture and it's applications in building correlated Predictive Engineering models. In his current role, he drives the vision and charter for the Predictive Engineering Group within Axiom.

axiom

THANK YOU

axiom