

## 1D SYSTEM ANALYSIS OF COFFEE GRINDER MODULE

### Overview

The project centered on creating a 1D Model-Based Systems Engineering (MBSE) model for the coffee grinder module within a larger coffee machine system. Utilizing Modelica software, the team aimed to develop a detailed model reflecting the grinder's dynamics. This model would enable comprehensive analysis and optimization, offering insights into the grinder's performance within the broader system. The goal was to enhance understanding and facilitate improvements in coffee grinder functionality and efficiency, contributing to the overall enhancement of the coffee machine's performance and user experience.

### Customer Name

Versuni (Philips Domestic Appliances)

### Challenge

Software Exploration, Component Selection, Parameter Correlations, Boundary Identification

### Cyient's Role

Cyient implemented 1D MBSE for the coffee grinder module, addressed software challenges, selected components, and delivered an accurate model accepted by the customer.

### The Challenges

Several challenges were encountered during the development of the 1D MBSE model.

#### Modelica Software Exploration

The team had to familiarize themselves with the Modelica software, which presented a learning curve for efficient modeling and simulation.

#### Defining Model Limits

Setting the boundaries and limits of model parameters within the grinder model, including deducing the no-load rpm at zero friction, was a critical challenge.

Identifying and incorporating the appropriate components into the coffee grinder model was a nuanced task. The challenge lay in accurately representing the diverse set of components within the grinder system.

Establishing correlations between the grinder and various coffee bean-related parameters required thorough research and analysis to ensure a realistic and accurate representation.

#### Component Deduction

#### Correlations with Parameters

### Our Solution

To address these challenges, the team followed a systematic methodology:

#### Model Development:

The initial step involved building the grinder circuit with relevant components in Modelica, laying the foundation for subsequent analysis.

#### Identification of Inputs and Outputs:

The team identified key inputs and outputs of the grinder model, along with dependencies, to create a comprehensive understanding of the system.

#### Transfer Function Development:

Building essential transfer functions, such as Flow to be ground (FTBG), Particle Size Distribution (PSD), RPM, and Damping Coefficient, was crucial for capturing the dynamics of the grinder system.

#### Verification and Validation:

The model underwent rigorous verification and validation against experimental data, including data from Coffee Quality Monitor (CQM), Beattle ICQ, and Roast\_UI. This ensured the model's accuracy and reliability.

## Achievements

**Final Model Framework:** The team successfully delivered the final model framework for the coffee grinder, providing a comprehensive and accurate representation of the system.

**Documentation:** Thorough documentation of the Modelica code and results at different stages facilitated transparency and future development.

**Value Addition:** The model contributed valuable insights by providing trends of PSD and FTBG for different coffee bean datasets, enhancing the overall understanding of the grinder system.

**Accuracy:** The developed model closely matched experimental results, with a deviation of within 2% for RPM and 7% for FTBG, demonstrating the reliability and accuracy of the 1D MBSE approach.

**Customer Acceptance:** The MBSE grinder system received positive feedback from the customer, highlighting its effectiveness and applicability within the larger coffee machine system.



Cyient has been an invaluable partner, proficiently supporting us in navigating complex pre-development projects, particularly in system modeling. Despite tight timeframes, we saw commitment, professionalism, and adaptability from Cyient. Their expertise seamlessly integrated into our workflow, leading to the successful realization of project goals in both timing and quality. We appreciate Cyient's collaboration and look forward to future endeavors.

**Ted Pajak**  
Director R&D Technology Engineering, Versuni

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### North America Headquarters

USA  
T: +1 860 528 5430

### Europe, Middle East, and Africa Headquarters

UK  
T: +44 118 3043720

### Asia Pacific Headquarters

Australia  
T: +61 3 8605 4815

### Global Headquarters

Hyderabad  
T: +91 40 6764 1000