# CNC Calibration Model Explanation

## 1. Problem Description:

Adam faced several challenges with his dual rack-and-pinion CNC system, including:

- Inaccurate travel distances: Software overestimated motion due to incorrect steps-per-unit settings.

- Synchronization issues: Dual racks required alignment for coordinated motion.

- Backlash compensation: Mechanical play caused inaccuracies, needing precise tuning.

## 2. Key Components:

### a. Calculate Steps Per Unit:

Formula:  
Steps Per Unit = (Motor Steps Per Revolution × Microstepping) / Travel Distance Per Revolution

This calculation determines the number of steps needed for the CNC machine to move a single unit of distance. Accurate steps-per-unit are essential for proper motion control.

### b. Adjust Steps Per Unit:

Formula:  
Adjusted Steps Per Unit = Current Steps Per Unit × (Commanded Distance / Actual Distance)

This adjustment recalculates steps-per-unit to align the software's commands with the machine's actual motion.

### c. Synchronize Dual Racks:

Formula:  
Average Steps Per Unit = (Motor 1 Steps + Motor 2 Steps) / 2

Synchronizing dual racks ensures both racks move in harmony, preventing mechanical misalignments.

### d. Fine-Tune Backlash:

Formula:  
Tuned Backlash = Current Backlash × Adjustment Factor

Backlash tuning reduces errors caused by mechanical play, improving the accuracy of CNC operations.

## 3. GUI (Graphical User Interface):

Purpose:  
- Provide a user-friendly interface for viewing calibration results.  
- Display key metrics like steps-per-unit, adjusted calibration values, travel distance, and backlash tuning results.

## 4. Assumptions:

- Motor steps, microstepping, and pinion dimensions are accurate.  
- Dual racks are mechanically aligned for synchronized motion.  
- Backlash adjustment is feasible within the system’s tolerances.

## 5. Workflow:

1. Input Parameters: Provide motor, pinion, and motion details.

2. Calculate Steps Per Unit: Use motor specs and pinion geometry.

3. Adjust Calibration: Recompute based on commanded vs. actual distances.

4. Synchronize Racks: Average steps-per-unit for dual racks.

5. Display Results: Visual feedback for user understanding and precision tuning.

This explanation clarifies the logic and usability of the CNC Calibration Model, providing step-by-step insights into how it resolves challenges like inaccurate motion, synchronization issues, and backlash adjustments.