**Mapping Parameters to Each Requirement:**

**1️⃣ Predicting the Best Time to Put Machines into Maintenance Mode**

**Relevant Parameters:**

* **Process variables from all machines** (StageX.MachineY.VariableZ)
* **Controlled & Uncontrolled variable values** (StageX.Output.MeasurementY.C.Actual, StageX.Output.MeasurementY.U.Actual)
* **Historical trends in performance decline** (detect deviations over time)
* **Environmental conditions** (Factory Ambient Temperature, Factory Ambient Humidity)

**New Features to Create:**

* **Performance Degradation Score:** Compare Actual values with historical trends.
* **Mean Time Between Failures (MTBF):** Compute based on machine downtime anomalies.
* **Cumulative Operational Hours:** Track total runtime of each machine before performance drops.

**2️⃣ Identifying When Machines Operate at Best Performance**

**Relevant Parameters:**

* **Process parameters at each stage**
* **Output measurements from the first stage** (important as they directly impact later stages)
* **Setpoints vs. Actual values** (StageX.Output.MeasurementY.C.Setpoint vs. StageX.Output.MeasurementY.C.Actual)

**New Features to Create:**

* **Deviation from Setpoint Score:** abs(Setpoint - Actual), smaller is better.
* **Efficiency Ratio:** (Output Flow Rate / Input Raw Material).
* **Rolling Average of Performance Metrics:** Capture stable, high-efficiency periods.

**3️⃣ Detecting Anomalies in the Manufacturing Process**

**Relevant Parameters:**

* **Controlled & Uncontrolled variables**
* **Combiner stage process parameters** (potential sources of fluctuations)
* **Output measurements from both stages**
* **Historical trends in machine outputs and environmental conditions**

**New Features to Create:**

* **Z-Score / Standard Deviation-based Anomaly Detection:** Flag sudden deviations.
* **Moving Average Smoothing:** Detect abrupt fluctuations.
* **Drift Detection in Measurements:** Track long-term parameter changes.

**4️⃣ Optimizing Parameters for Overall Performance**

**Relevant Parameters:**

* **All Process Variables from Each Machine**
* **Combiner stage outputs** (where machines 1-3 merge)
* **Factory environmental conditions**
* **Setpoint vs. Actual deviations**

**New Features to Create:**

* **Multivariate Optimization Analysis:** Find parameter values that maximize throughput.
* **Regression Models:** Predict best process parameters based on historical efficiency.
* **Feature Importance Scores:** Identify the most critical factors for optimization.