**Parameters to Extract for Each Requirement**

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

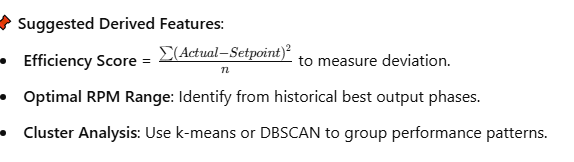
* **Machine1/2/3/4/5.MotorAmperage.U.Actual** → Increasing amperage could indicate wear or mechanical resistance.
* **Machine1/2/3/4/5.MotorRPM.C.Actual** → Unstable or dropping RPM could signal mechanical issues.
* **Machine1/2/3.MaterialPressure.U.Actual** → Increasing pressure could indicate clogging or inefficiencies.
* **Machine1/2/3.MaterialTemperature.U.Actual** → High temperatures may indicate overheating or inefficiencies.
* **Machine1/2/3.ExitZoneTemperature.C.Actual** → Anomalous exit temperatures could signal blockages or equipment degradation.
* *Stage1/2.Output.Measurement.U.Actual*\* vs *Stage1/2.Output.Measurement.U.Setpoint*\* → Deviations from setpoints can indicate wear or suboptimal performance.

📌 **Suggested Derived Features**:

* **Rolling Mean & Standard Deviation for Key Sensors** (e.g., moving averages for amperage, temperature, pressure).
* **Anomaly Scores** (e.g., Z-score or Isolation Forest on motor amperage, RPM, and pressure).
* **Time Since Last Maintenance** (based on timestamp differences).

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

* **Machine1/2/3/4/5.MotorRPM.C.Actual** → Stable RPM in an optimal range.
* **Machine1/2/3.MaterialPressure.U.Actual** → Pressure within a defined optimal range.
* **Machine1/2/3.MaterialTemperature.U.Actual** → Stable material temperature ensuring uniform processing.
* **Machine1/2/3/4/5.ExitTemperature.U.Actual** → Ideal exit temperature indicating proper processing.
* *Stage1/2.Output.Measurement.U.Actual*\* vs *Stage1/2.Output.Measurement.U.Setpoint*\* → Small deviations from setpoints indicate efficiency.



**3. Detecting Anomalies in the Manufacturing Process**

* **Machine1/2/3/4/5.Zone1Temperature.C.Actual & Zone2Temperature.C.Actual** → Sudden spikes may indicate sensor faults or overheating.
* **Machine1/2/3/4/5.MotorAmperage.U.Actual** → Unexpected surges may indicate mechanical faults.
* *FirstStage.CombinerOperation.Temperature.U.Actual*\* → Deviations can suggest process inefficiencies.
* *Stage1/2.Output.Measurement.U.Actual*\* vs **Setpoint** → Significant deviations can signal process failures.

📌 **Suggested Derived Features**:

* **Z-score for Each Parameter**: Standardize sensor readings and detect values >3 standard deviations.
* **Rolling Window Variance**: Sudden changes in variance can indicate instability.
* **Time-Series Anomaly Detection**: Use ML techniques (e.g., LSTM Autoencoders) to spot irregularities.

**4. Optimizing Parameters for Overall Performance**

* **Machine1/2/3/4/5.MotorAmperage.U.Actual** vs **Output Efficiency** → Find optimal energy consumption range.
* **Machine1/2/3.MaterialPressure.U.Actual** & **MaterialTemperature.U.Actual** → Identify ideal material conditions for performance.
* *Stage1/2.Output.Measurement.U.Actual*\* vs **Setpoint** → Identify configurations that consistently produce the best outputs.

📌 **Suggested Derived Features**:

* **Feature Importance Analysis**: Use Random Forest or SHAP to identify the most influential parameters.
* **Parameter Tuning Using Optimization Algorithms** (e.g., Bayesian Optimization) to find ideal operating conditions.