

Predictive Maintenance

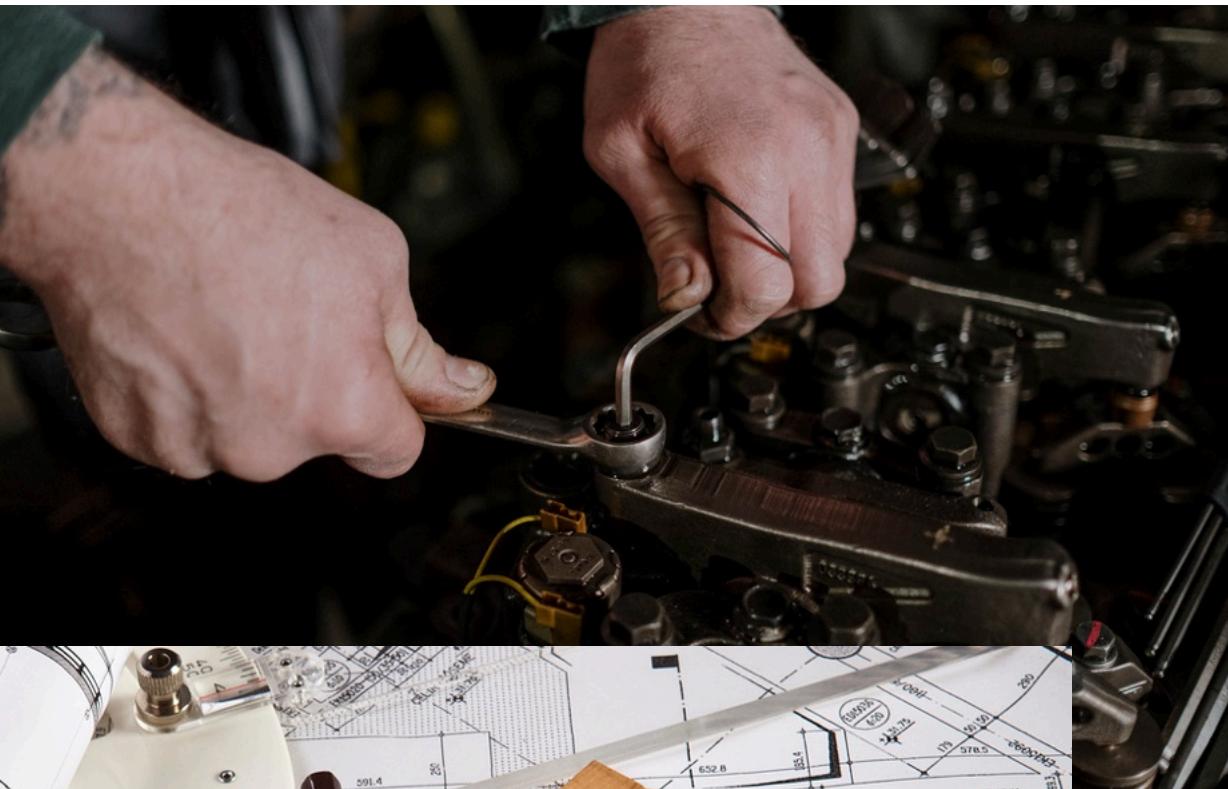
A FAILURE ANALYSIS APPROACH

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Agenda

- Dataset overview
- EDA Analysis
- Visual comparison
- Questions
- Conclusion



Identifying Operational thresholds for predictive Maintenance

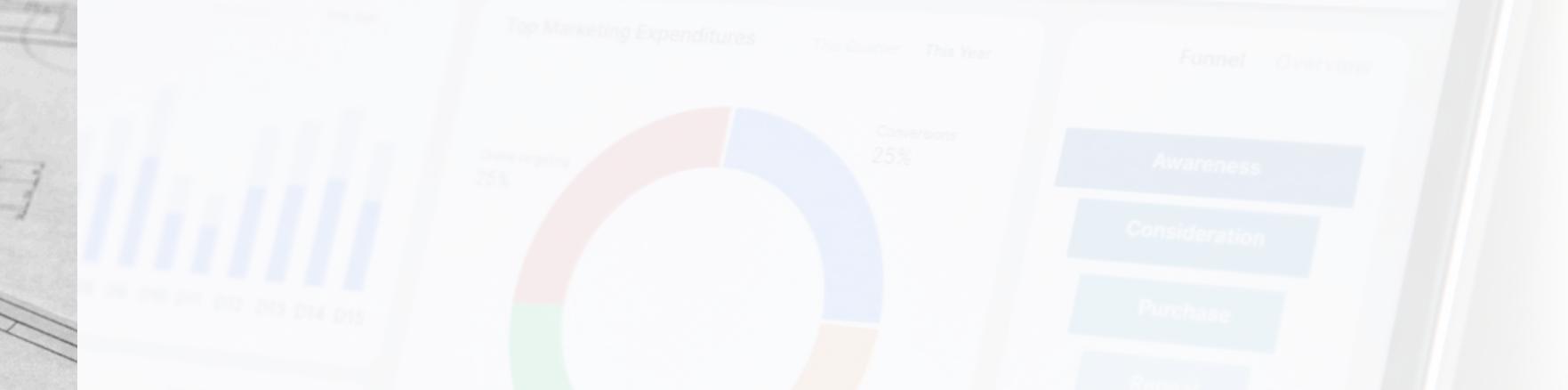
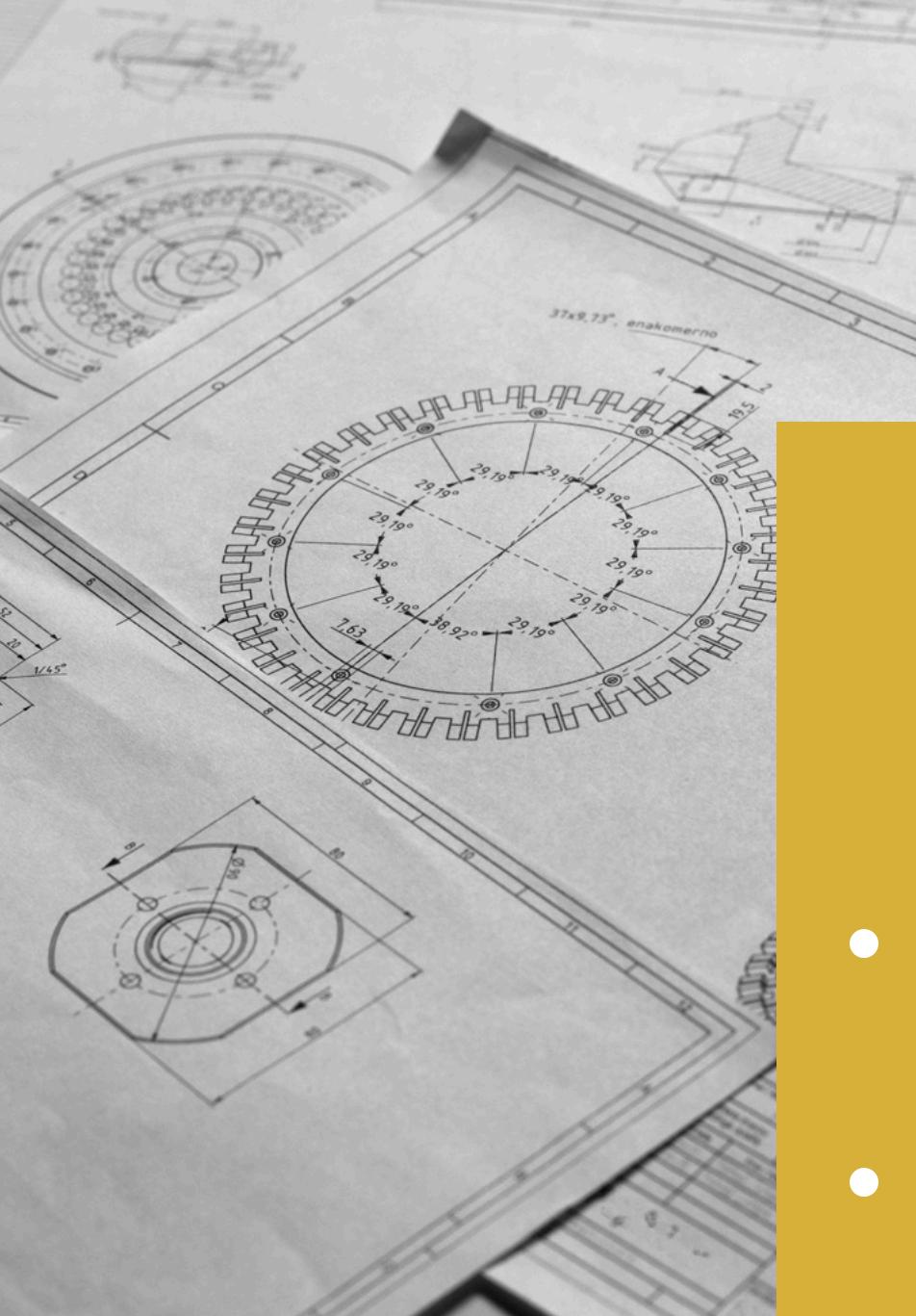
How can industrial operators reduce unplanned downtime and extend machine life by analyzing machine performance data and identifying early signs of mechanical failure



- Mechanical machine lifespan affected by several key factors eg tool wear, air, torque , rotational speed
- Failure analysis helps us analyse and predict problems before they even happen
- EDA Analysis powerful tool in visualisation these Failure points as well as thresholds



- Dataset derived from a synthetic milling machine
- Helps in failure prediction as well as classification

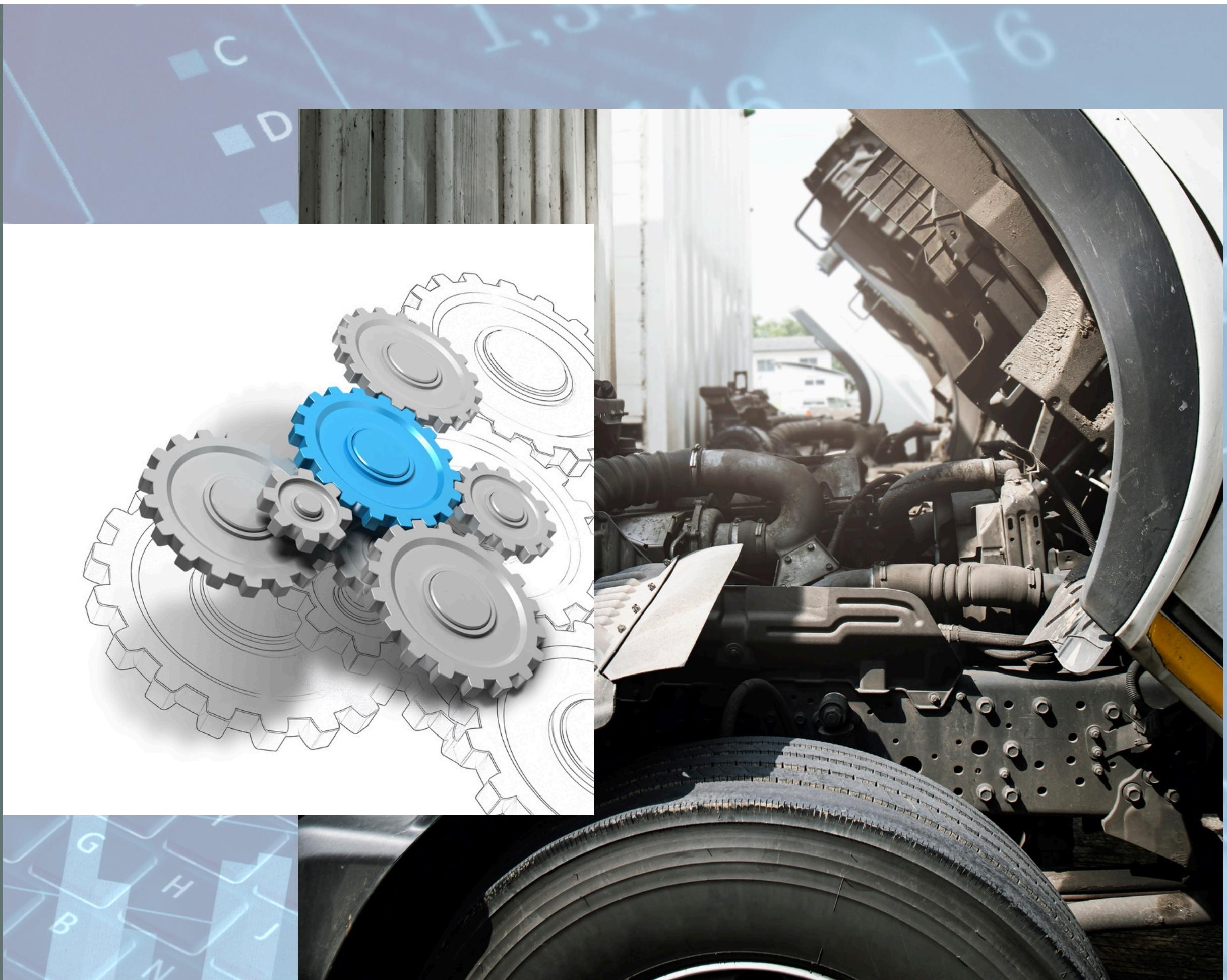


Data cleaning

- Dataframe contained column Machine Failure = 0,1(success, failure)
- Separated success columns from failure columns
- Converted Type, Product ID from Objects into integers

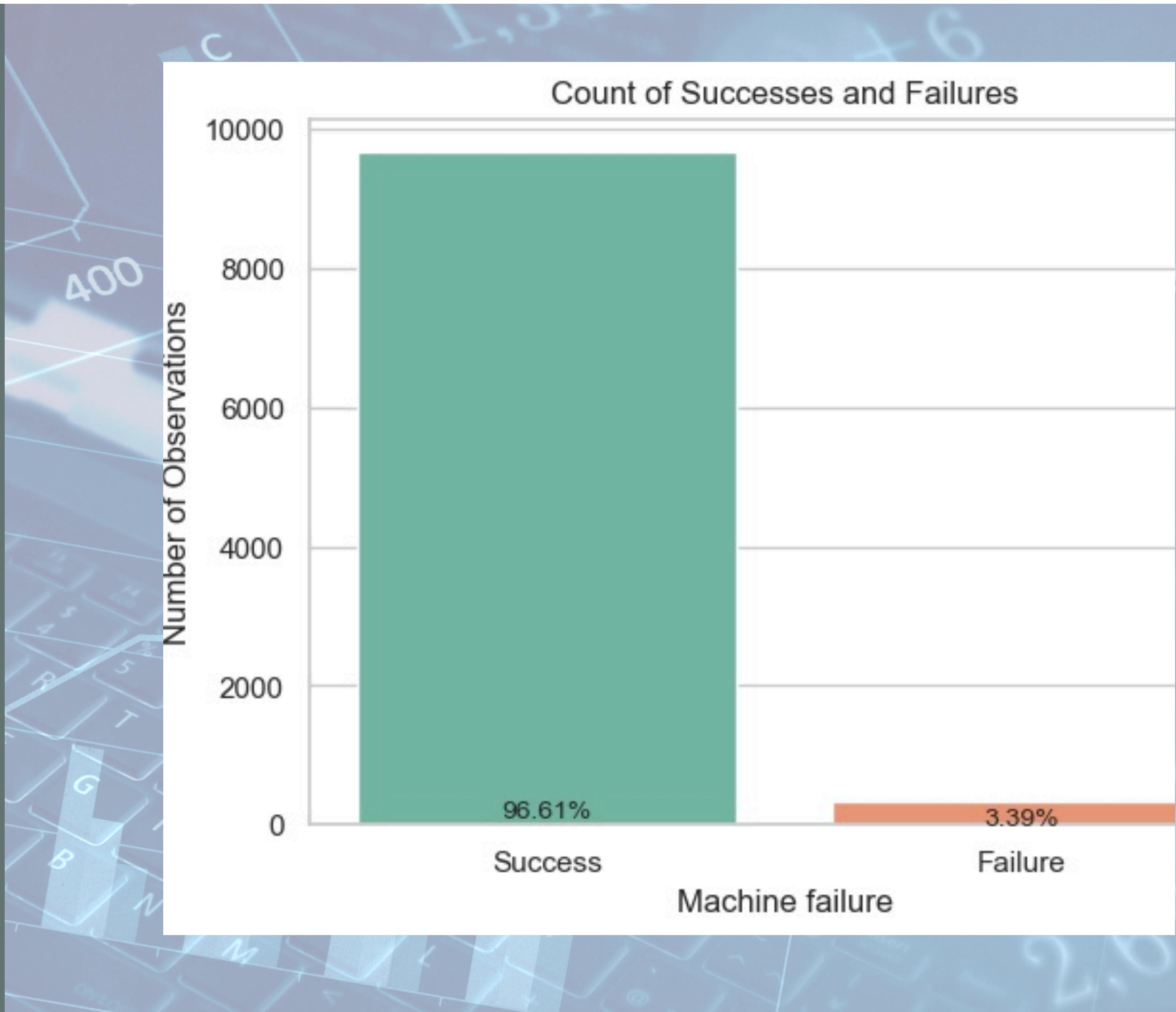
EDA Analysis

- Failures vs Success
- Main Goal : conduct univariate & bivariate analysis on scenarios where the machine failed
- Compare with univariate & bivariate analysis on scenarios where machine success occurred
- Determine differences between these two and establish threshold ranges and predictions



EDA Analysis

- General Overview of Dataframe
- 3 Product types : Low, Medium, High
- 96,61% machine success , 3.39 failure
- 5 failure modes
- TWF - tool wear failure
- HDF- heat dissipation failure
- PWF- power failure
- OVF- overheating failure
- RNF-random failures

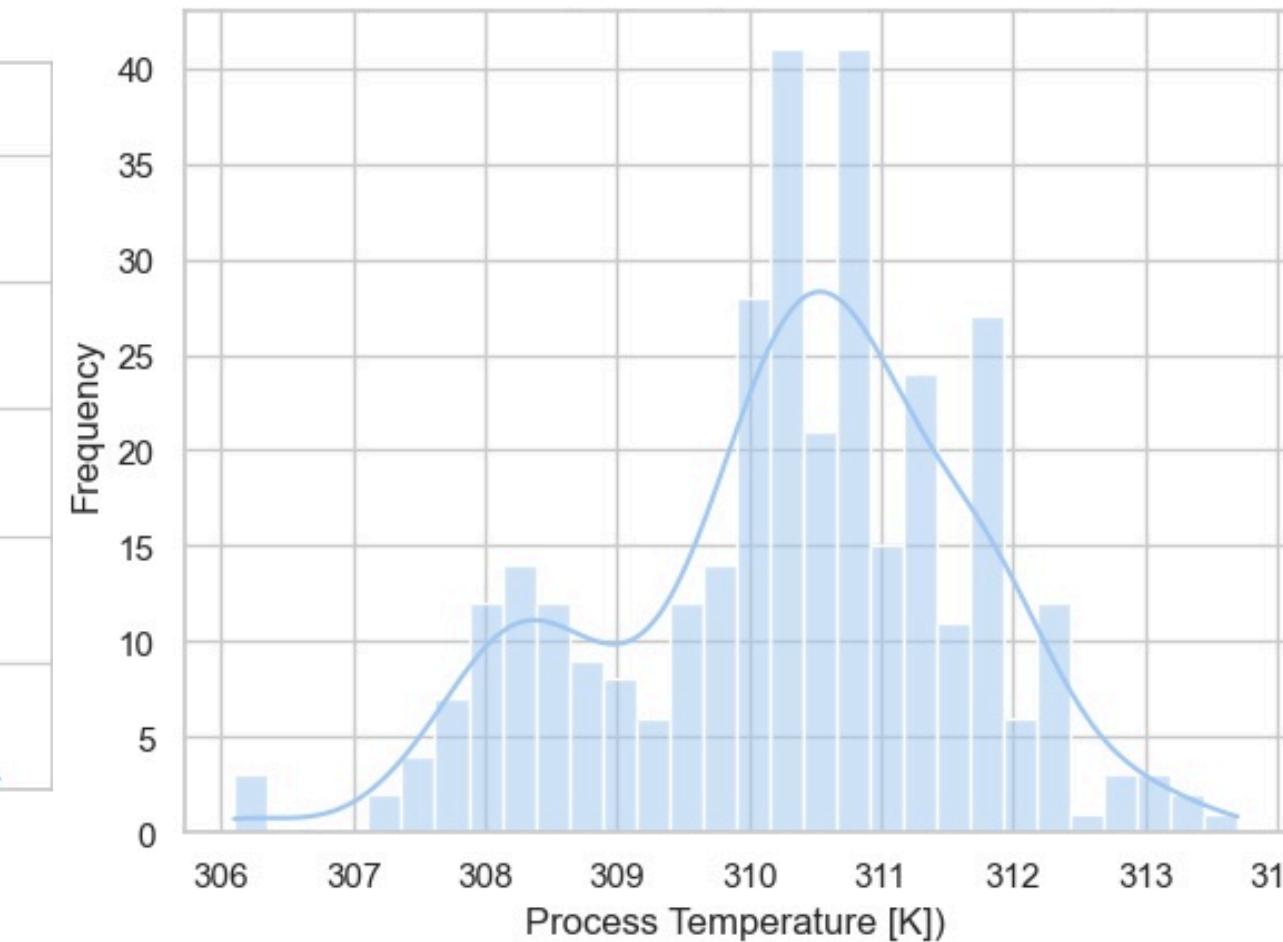
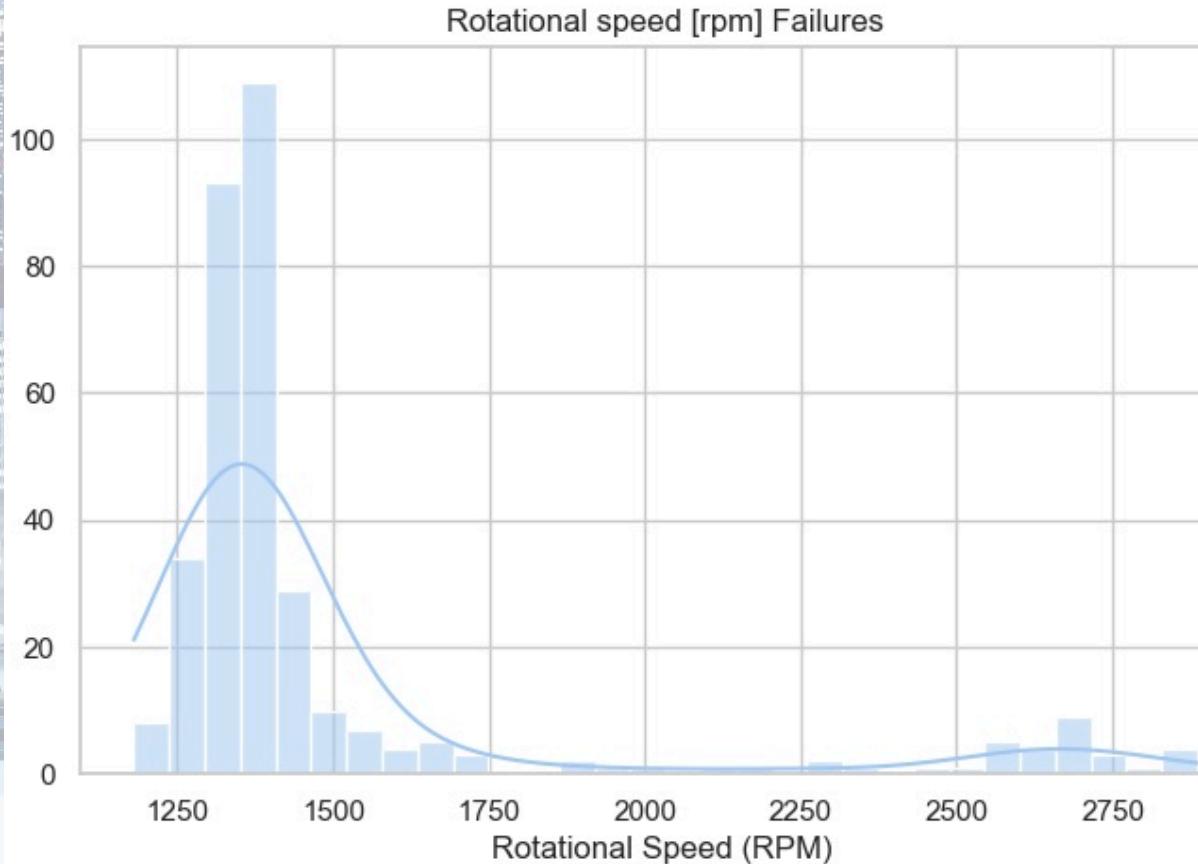
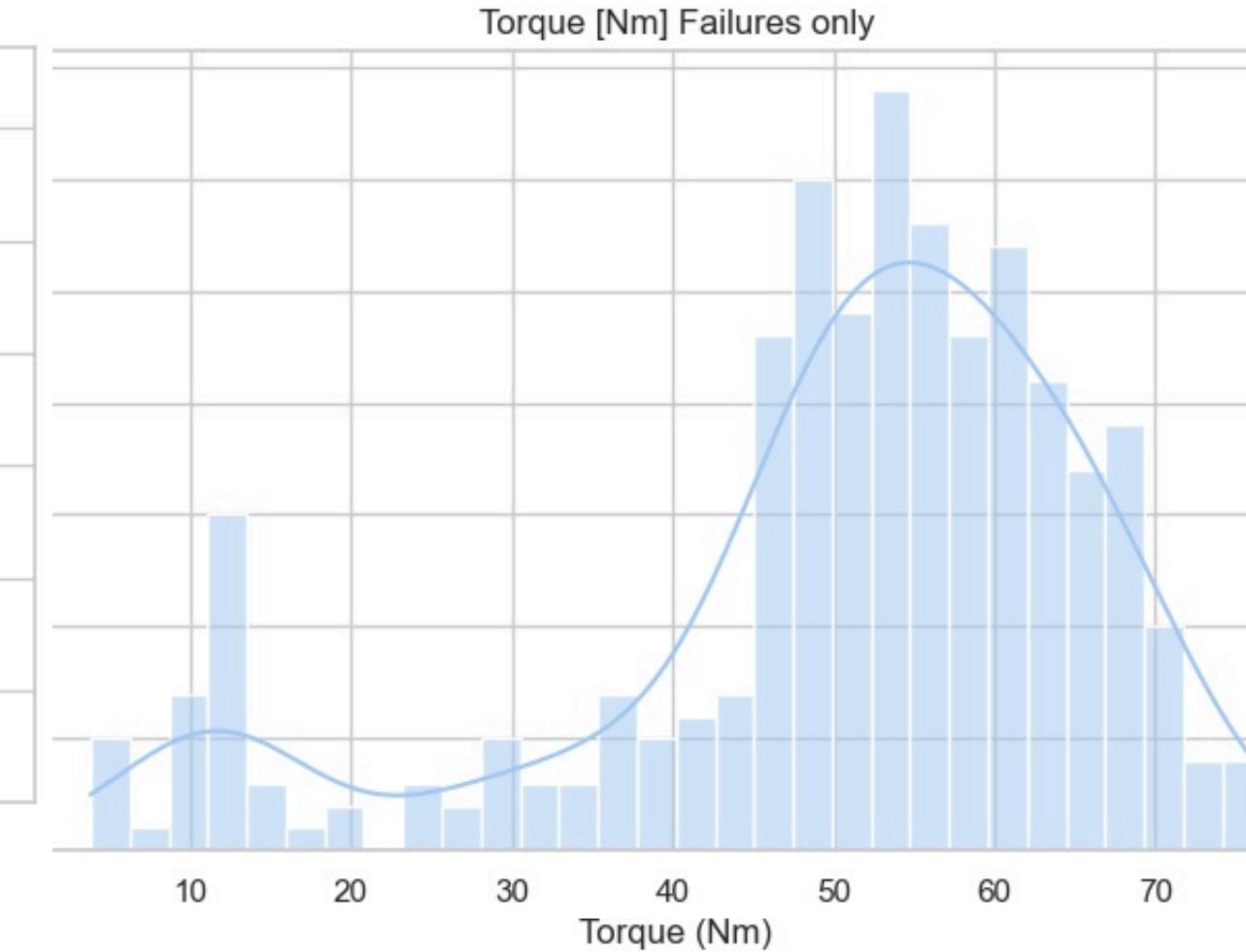
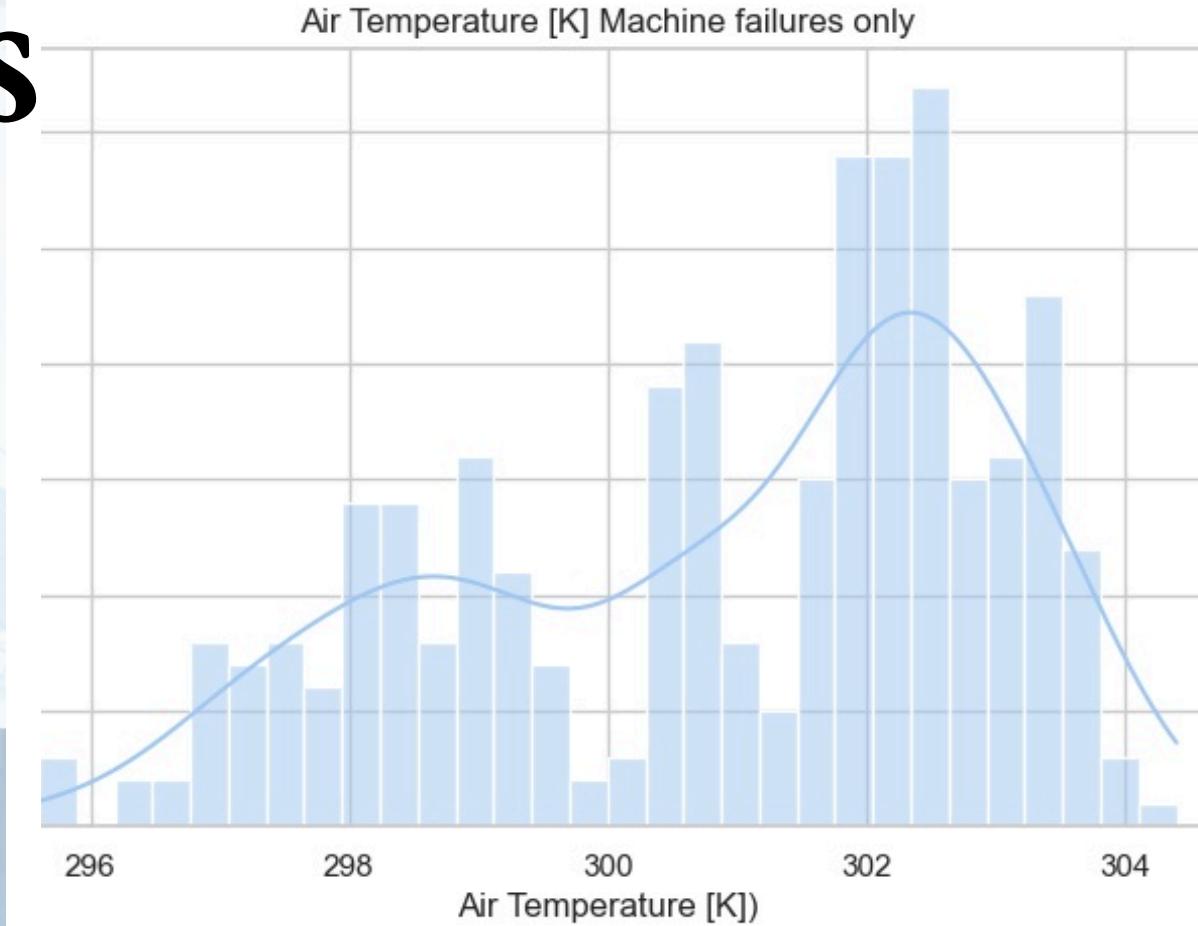


Failure Analysis

- 5 operational variables: air temperature, process temperature, rotational speed, torque, and tool wear

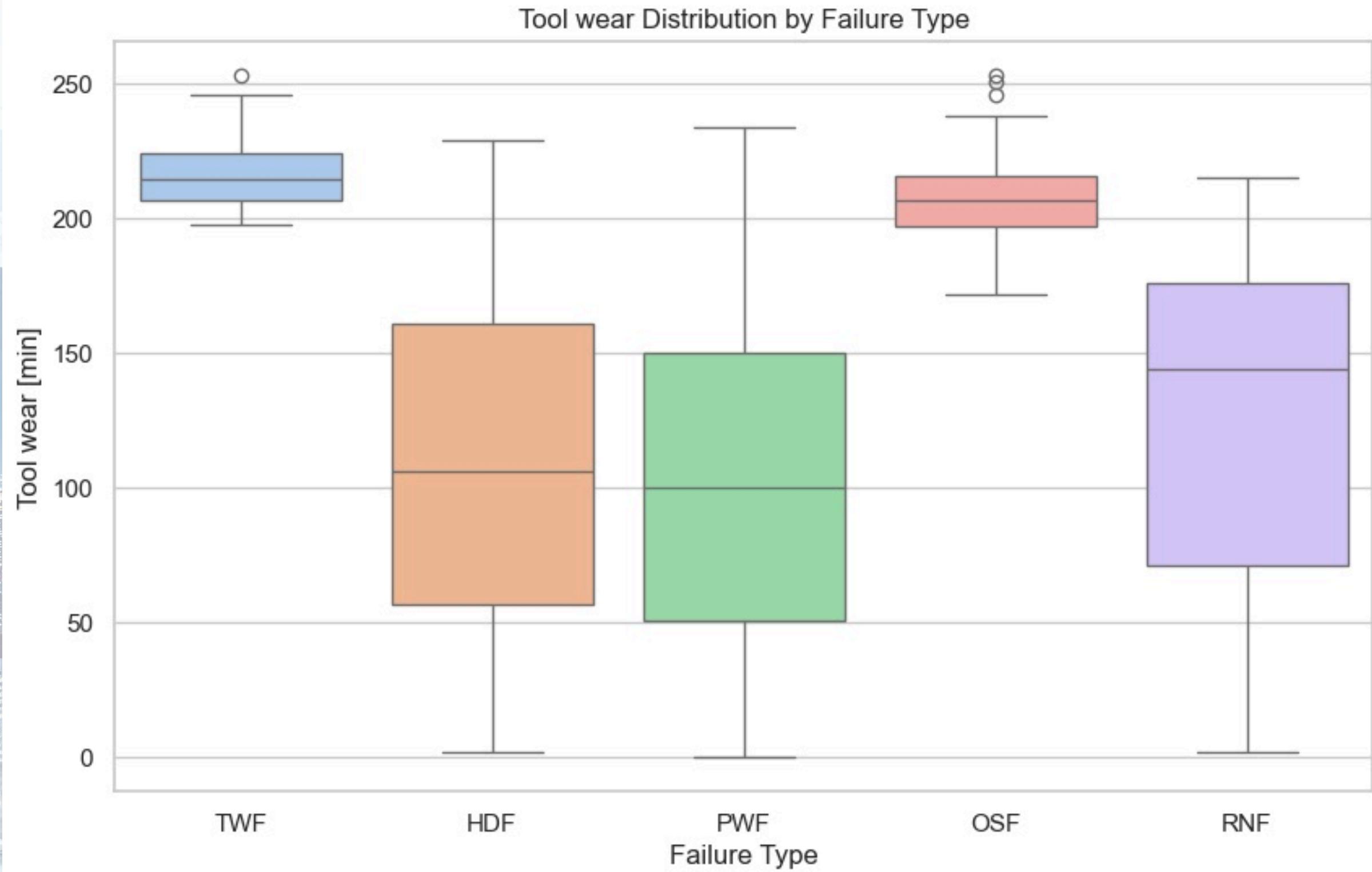
- Univariate test of each variable

- Key Takeaways
- Torque failure zone 50Nm-65Nm
- Rotational speed failure zone 1300rpm -1500rpm
- high failures recorded for temperatures 300-320K



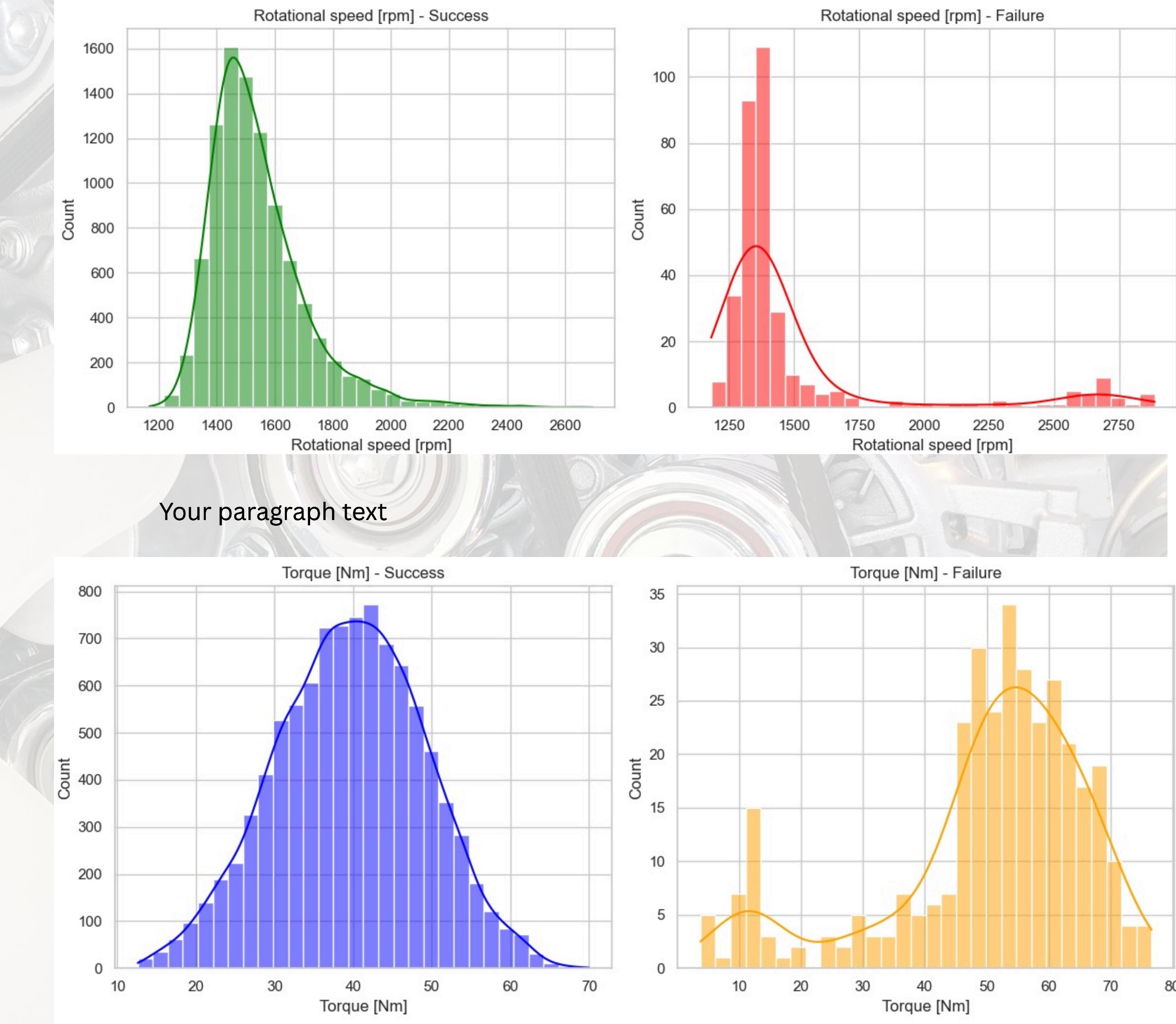
Failure Analysis

- Bivariate Analysis on the various failure modes and tool wear (operational variable)
- Key Takeaways
- Safe zone for machine operations should be set for tool wear around 160min in order to heat and power failures
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EDA Analysis Success vs Failures

- Key Takeaways
- Threshold values for rotational speed lay between 1359 rpm to 1700 rpm
- Safe zone for the operational variable Torque is values under 45Nm
- Machine operations outside these zones lead to machine failure



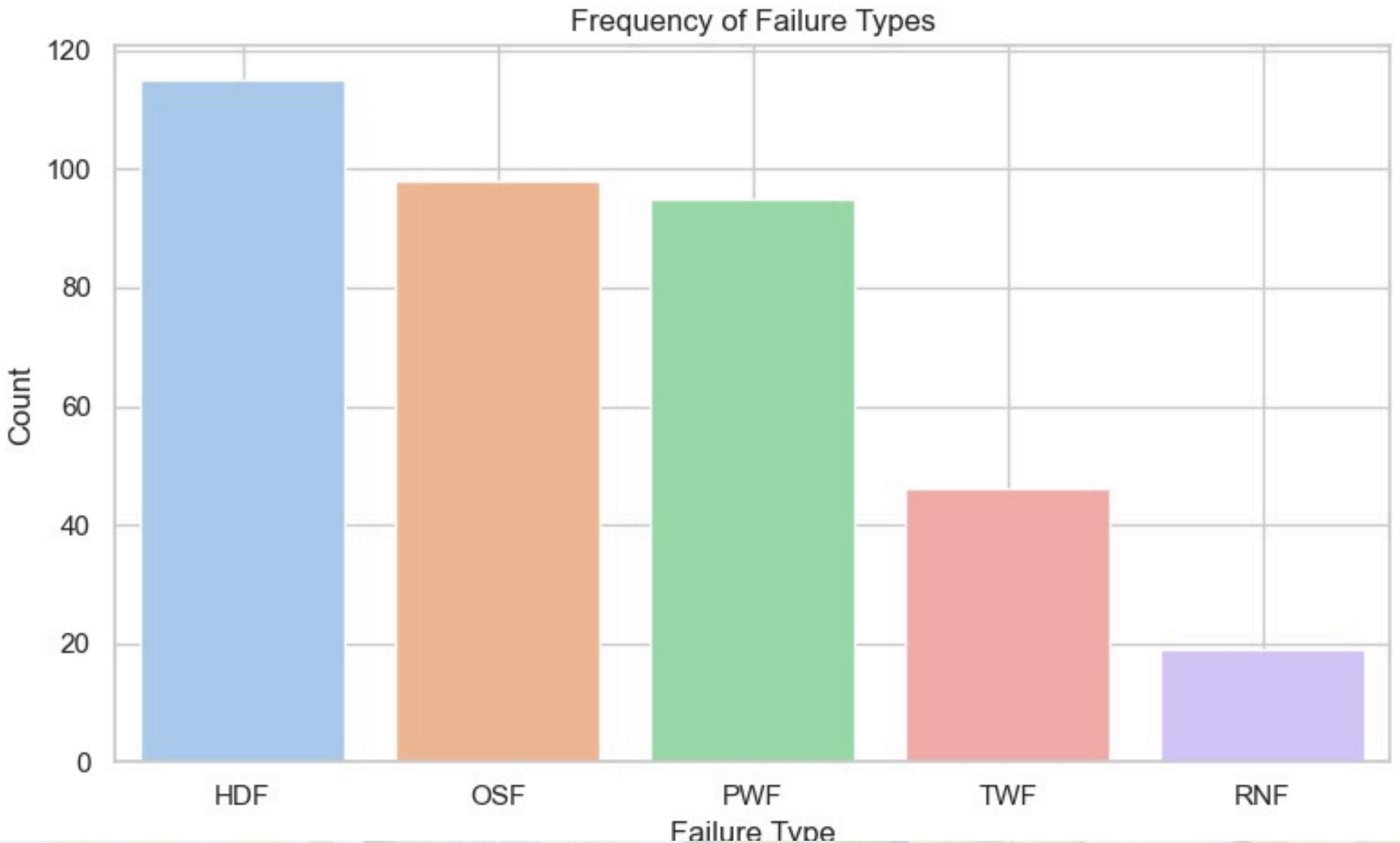
Business Objective

To minimize downtime and optimize machine performance by identifying:
Which variables are most associated with machine failures ,What value ranges (thresholds) define a safe operating window ,How to flag risk conditions early using real-time data



Question 1

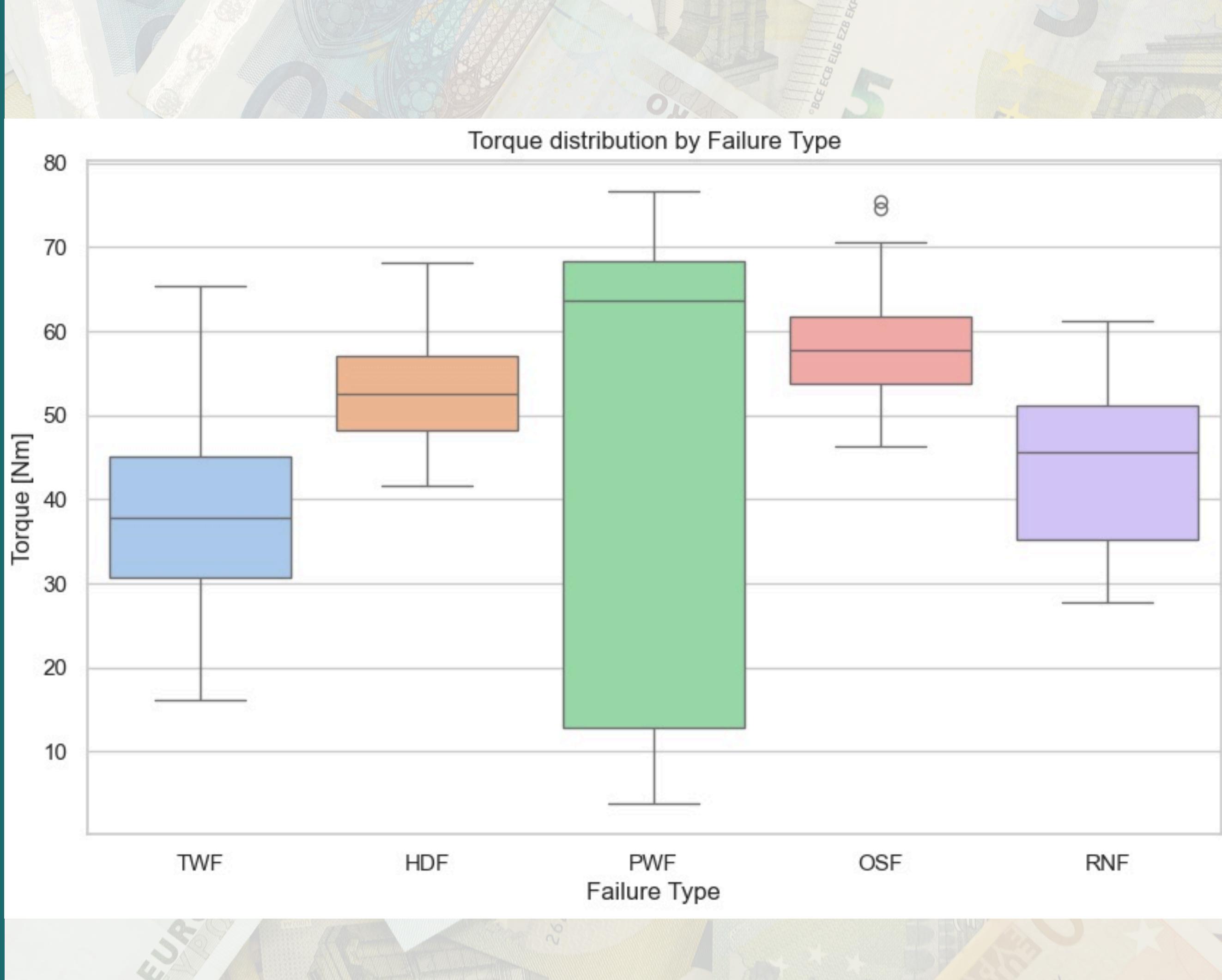
Which failure mode occurs most frequently in the dataset?



Question 2

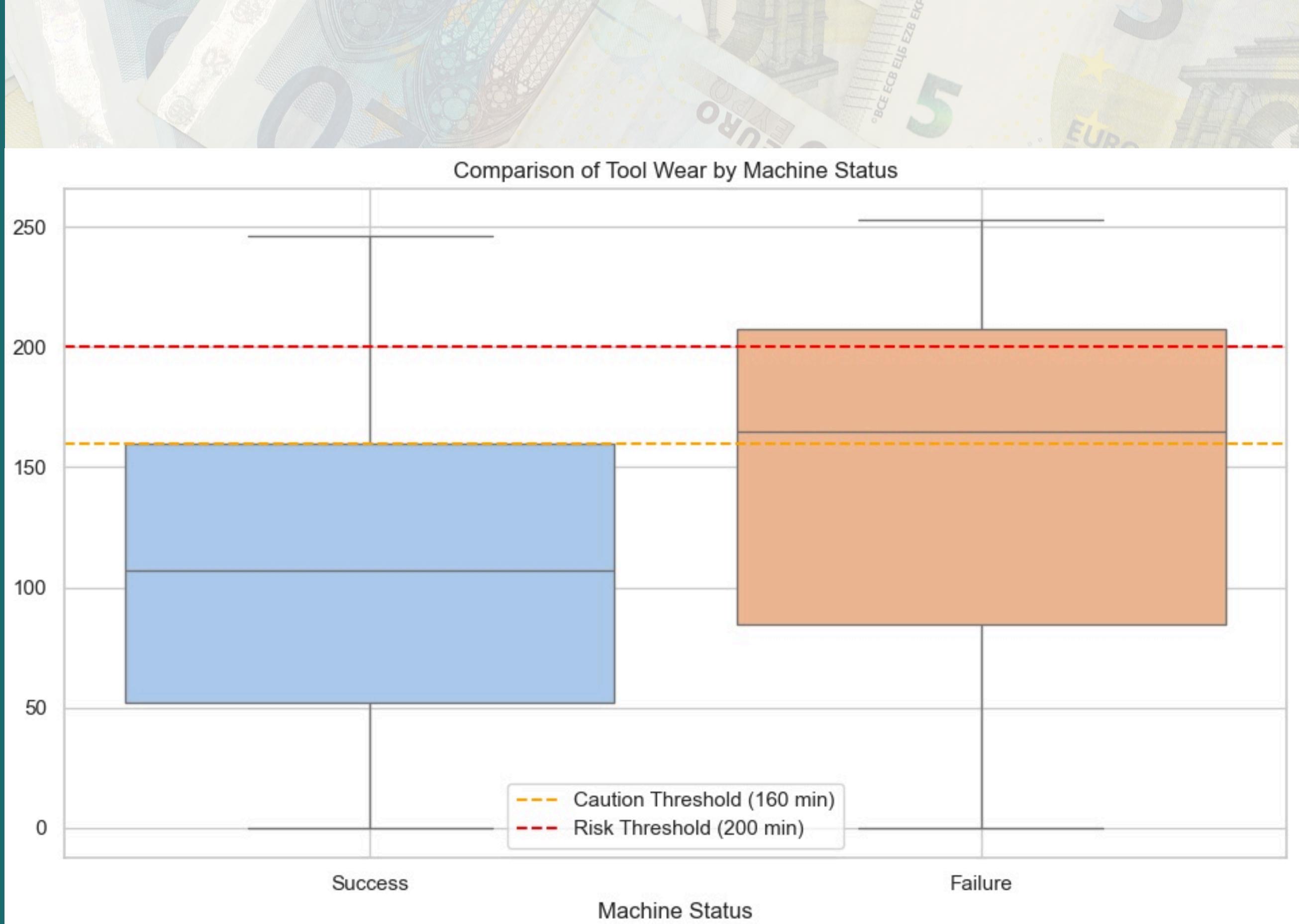
What is the distribution of each operational variable (Torque, Tool Wear, Rotational Speed, Process and Air Temperature) across different failure types?

This is an example of Torque [Nm] across the different failure types



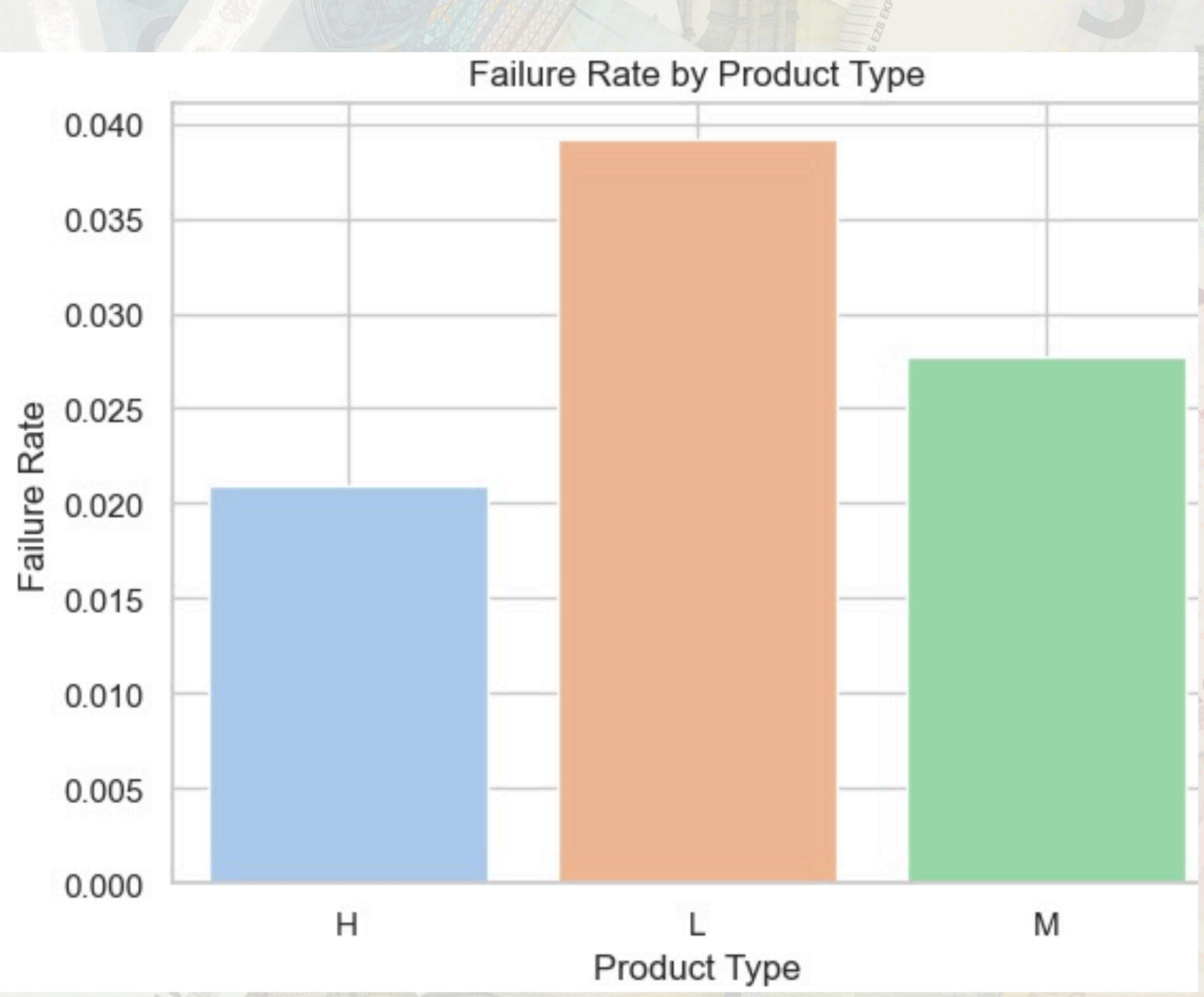
Question 3

Are there critical thresholds in operational variables beyond which failures occur more frequently?



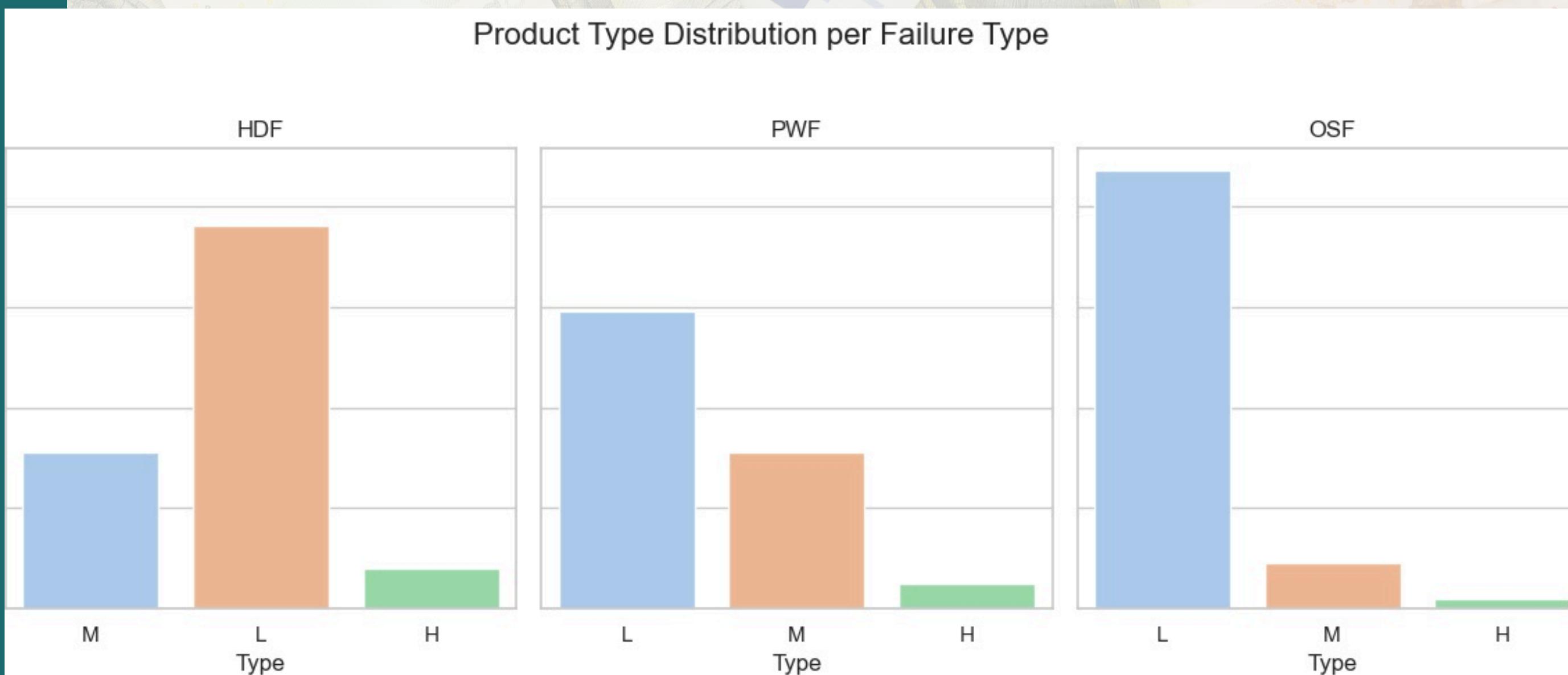
Question 4

Do machines of a specific product type (L, M, or H) fail more frequently?



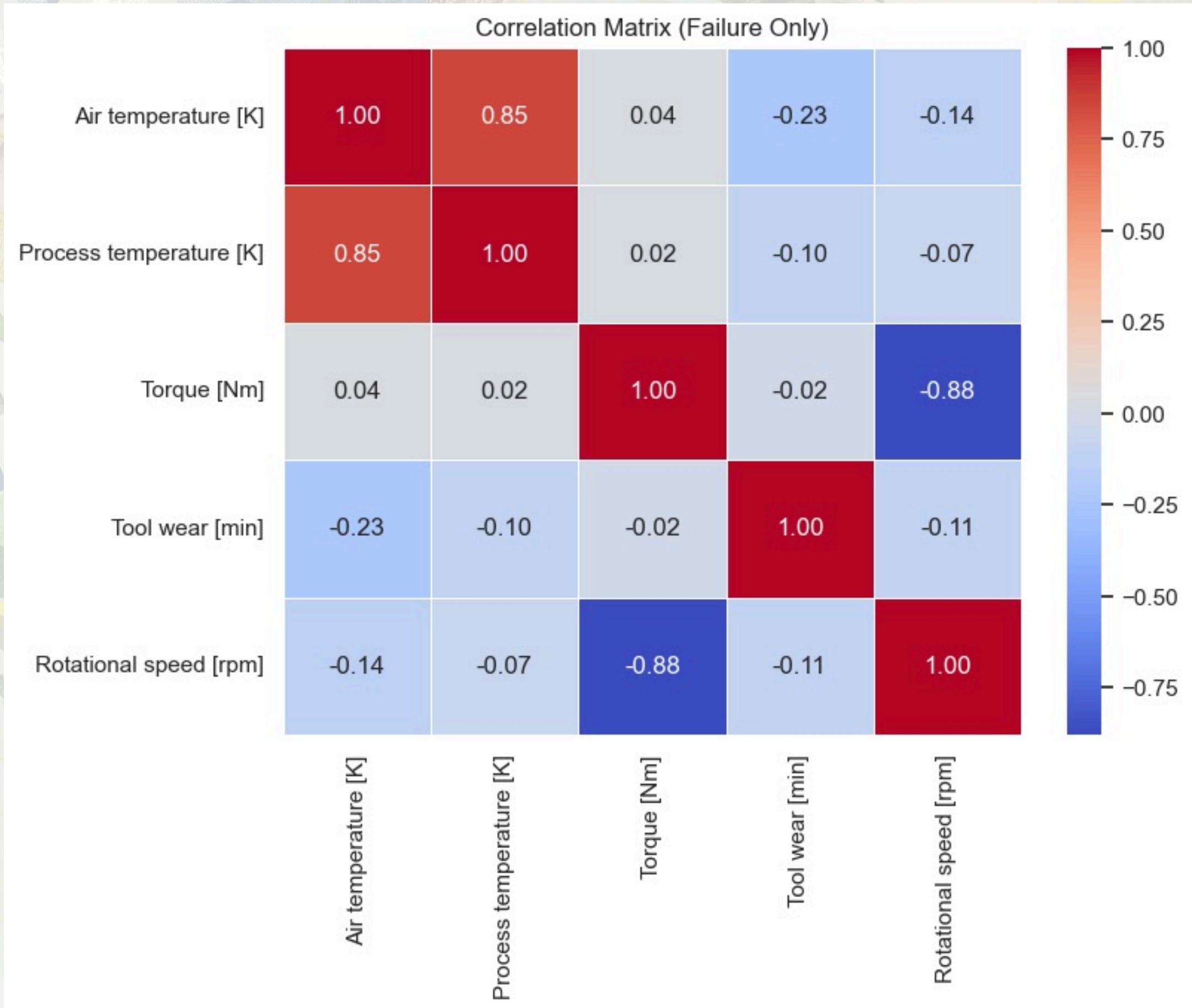
Question 5

.How are the failures spread across
the various Product Types?



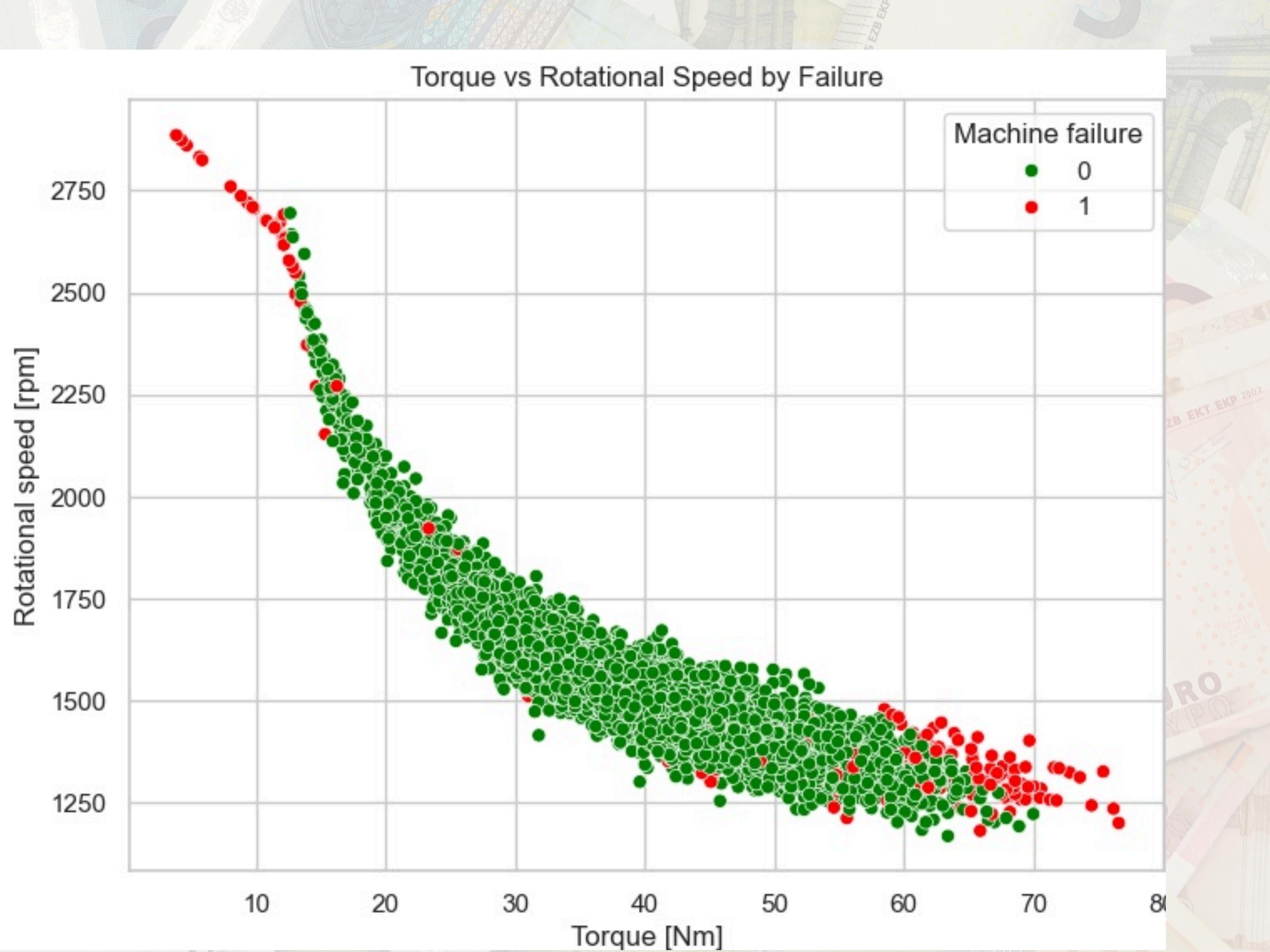
Question 6

Which operational variables are most strongly correlated with each other during machine failures



Question 7

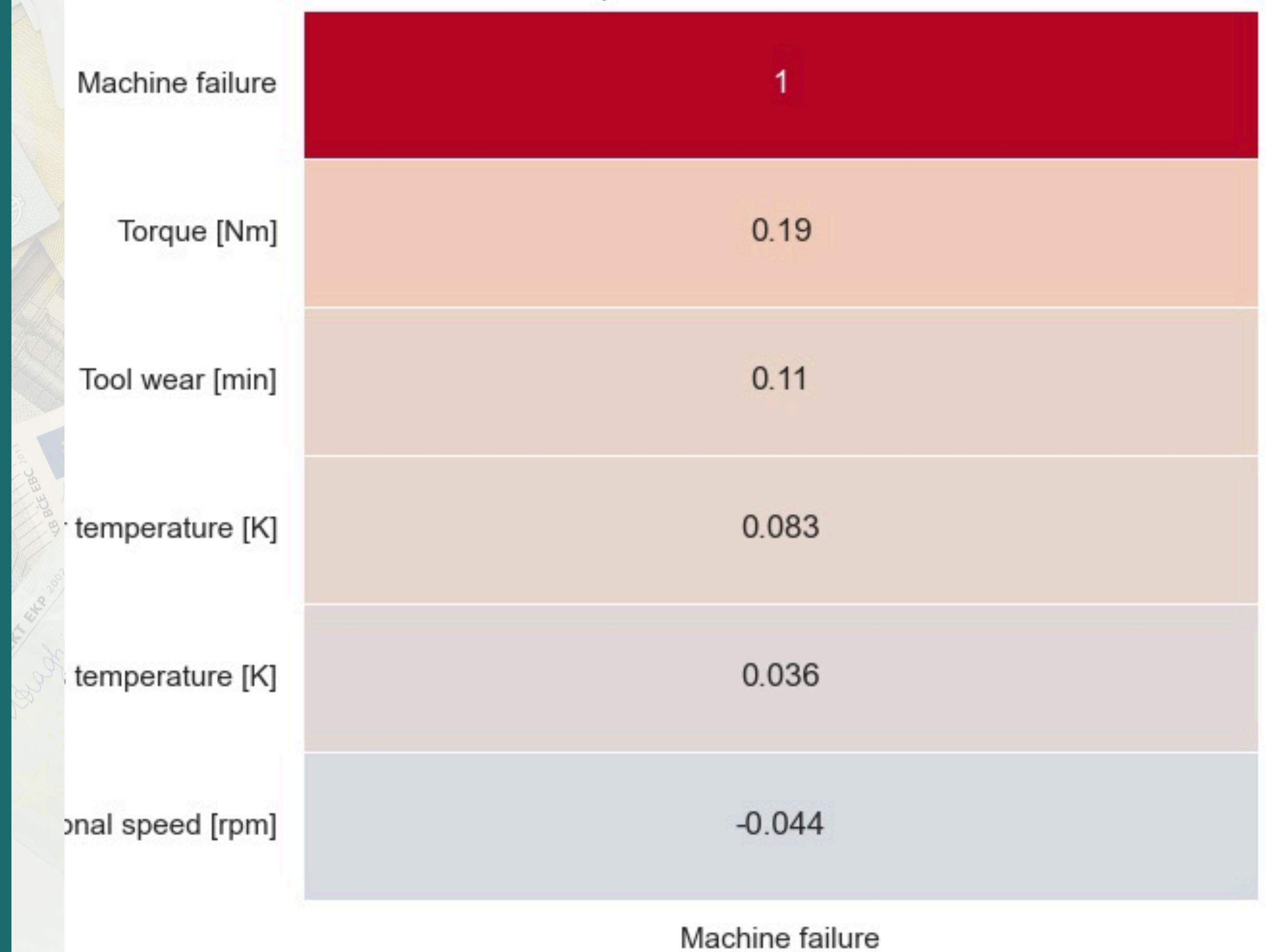
How does the relationship between torque and rotational speed influence the likelihood of machine failure?



Question 8

.Which operational variables are most correlated with machine failure

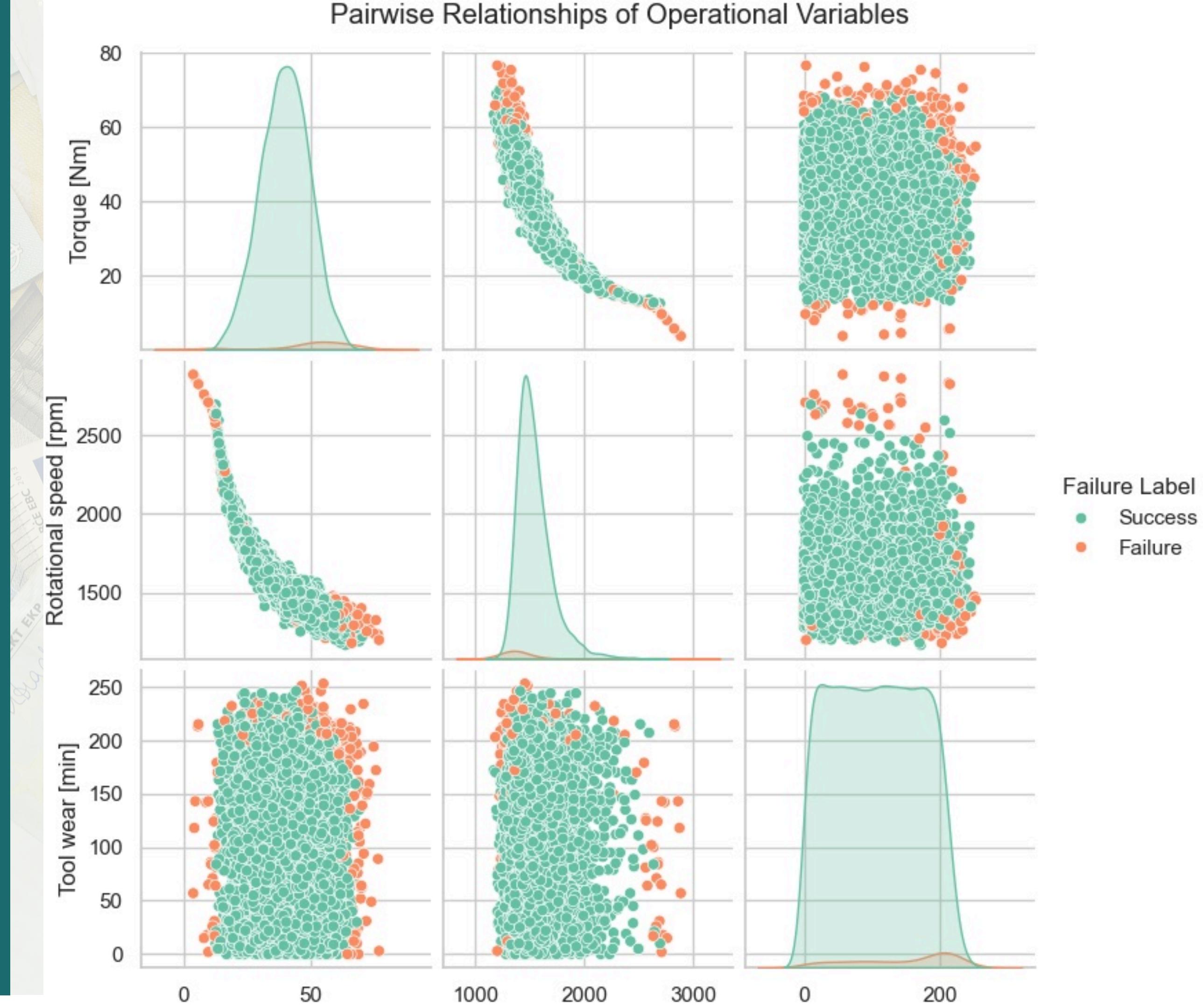
Correlation of Operational Variables with Machine Failure



Question 9

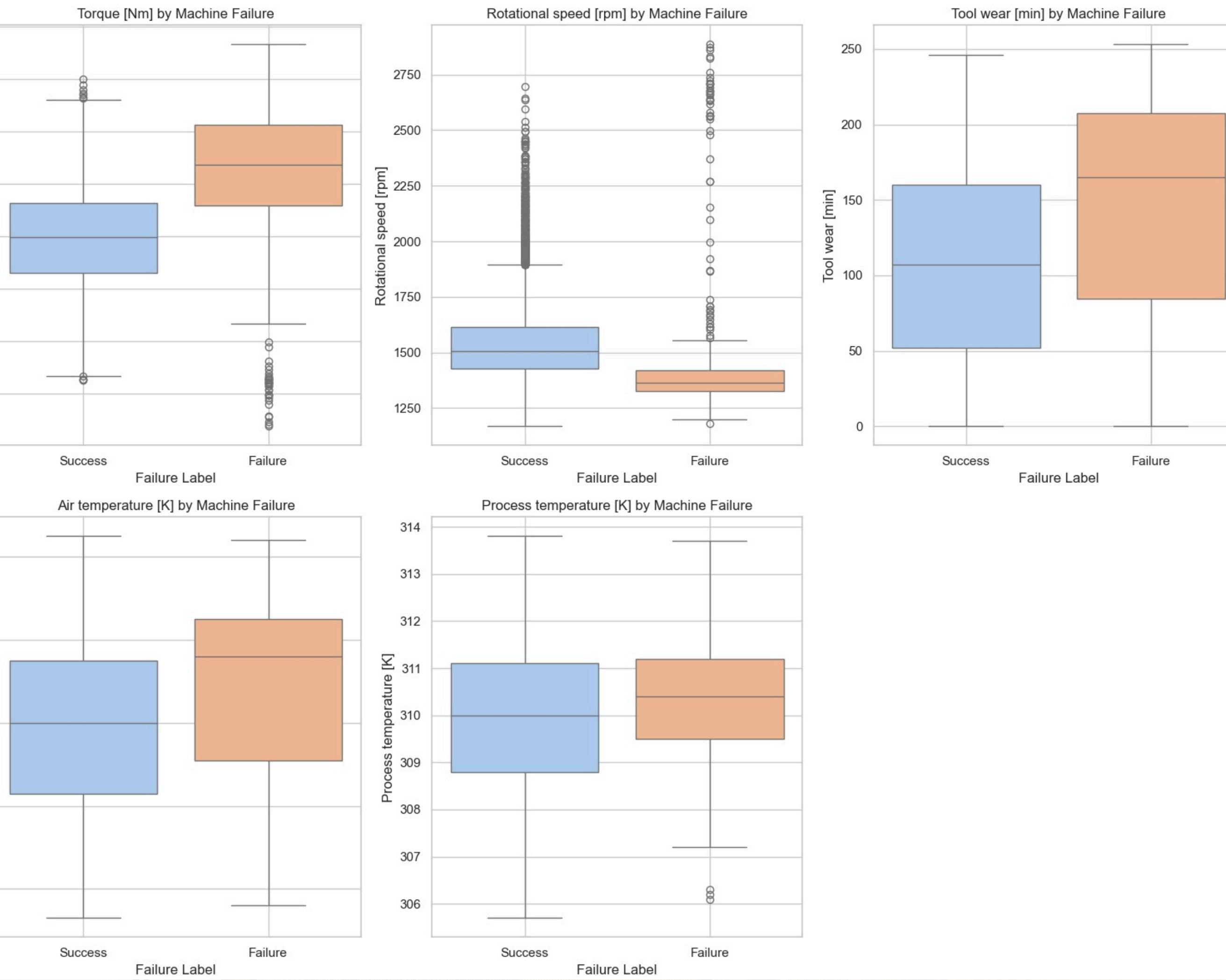
How do operational variables interact with each other, and how do those interactions differ between machine failures and successes?

Pairwise Relationships of Operational Variables



Question 10

How do the distributions of operational variables differ between successful operations and machine failures?





Conclusion & Summary

- EDA Analysis displayed several thresholds for machine failure prediction
- Aids in the development of machine learning models that can implement these predictions and stop machines from reaching failure

A photograph showing a close-up of a person's hands working on a small electronic component, likely a circuit board or sensor, mounted on a breadboard. The hands are using a green-handled soldering iron to solder wires to the board. A metal stand holds the breadboard in place. In the background, there's a white box with some red text and a black smartphone. The lighting is dramatic, coming from the side, which creates strong highlights and shadows.

Thank you

