**My Approach:**

* Since the objective is to know as soon as the machine enters in the faulty mode, I relied on rule-based approach for this challenge.
* The steps for my failure prognosis approach are given below.

1. Marking outliers considering X-bar control chart. i.e. 3-sigma limits
2. Imputing outliers using rolling averages considering window size as 5
3. Finding first two eigen values using principal component analysis
4. Taking square of both eigen values and adding them to make a degradation index
5. Finding rolling standard deviation with window size as 5
6. Based on the rolling standard deviation finding a threshold and marking the machine as failed when it goes beyond predefined threshold

* By utilizing principal components, I reduced the number of features and also found the axis along which there is high variations. I found a custom degradation index which shows the machine condition over time based on the plots. The square of eigen values is used to make degradation pattern significant and capture the failure signal easily. The standard deviation reduces noise and based on the plots, I used custom threshold.
* This approach might be limited to this type of machines and we cannot generalize it. For slightly different machines, we will have to change the failure threshold. However, it is very easy to implement, and it can be used to monitor real-time data very efficiently.

**Other approaches:**

* There are many approaches to address this problem. I have already worked on machine predictive maintenance before and implemented different approaches.
  + (Github: <https://github.com/archd3sai/Predictive-Maintenance-of-Aircraft-Engine>)
* We can broadly classify all approaches under two objectives.
* **(1) Remaining useful life prediction:**
  + [Similarity-based model](https://github.com/archd3sai/Predictive-Maintenance-of-Aircraft-Engine/blob/master/RUL%20Prediction%20Regression/Similarity-based%20RUL%20Prediction.ipynb): Based on past data we find most similar machines to our test machine and try to predict remaining useful life.
  + [Exponential degradation model](https://github.com/archd3sai/Predictive-Maintenance-of-Aircraft-Engine/blob/master/RUL%20Prediction%20Regression/Exponential%20Degradation%20Model.ipynb): We fit the exponential curve to degradation index and find remaining cycles to reach predefined failure threshold.
  + [Regression models](https://github.com/archd3sai/Predictive-Maintenance-of-Aircraft-Engine/blob/master/RUL%20Prediction%20Regression/LSTM%20RUL%20Prediction.ipynb): Based on current data point and lag values, we predict the remaining useful life. We can also use deep learning modules such as LSTM, RNN, etc.
* **(2) Machine Failure classification:**
  + [Classification models](https://github.com/archd3sai/Predictive-Maintenance-of-Aircraft-Engine/tree/master/Failure%20Prediction%20Classification): We can use supervised learning algorithms to predict whether the machine will fail or not. We can also predict this based on past sequential data using deep learning models such as RNN, LSTM, 1D-CNN, 1D-CNN-SVM etc.