majorproj

February 4, 2025

1 Machine Failure Prediction

1.1 Data Set

[1]:

```
import pandas as pd
```

[2]:

```
df = pd.read_csv("majorproj/data (1).csv")
df
```

[2]:

```
     footfall  tempMode  AQ  USS  CS  VOC  RP  IP  Temperature  fail
0           0         7   7    1   6    6  36   3            1     1
1         190         1   3    3   5    1  20   4            1     0
2          31         7   2    2   6    1  24   6            1     0
3          83         4   3    4   5    1  28   6            1     0
4         640         7   5    6   4    0  68   6            1     0
..         …         …  ..   …  ..    …  ..  ..            …     …
939         0         7   7    1   6    4  73   6           24     1
940         0         7   5    2   6    6  50   6           24     1
941         0         3   6    2   7    5  43   6           24     1
942         0         6   6    2   5    6  46   7           24     1
943        18         7   4    2   6    3  61   7           24     1

[944 rows x 10 columns]
```

[3]:

```
df.head()
```

[3]:

```
   footfall  tempMode  AQ  USS  CS  VOC  RP  IP  Temperature  fail
0         0         7   7    1   6    6  36   3            1     1
1       190         1   3    3   5    1  20   4            1     0
2        31         7   2    2   6    1  24   6            1     0
3        83         4   3    4   5    1  28   6            1     0
4       640         7   5    6   4    0  68   6            1     0
```

[4]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 944 entries, 0 to 943
Data columns (total 10 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   footfall     944 non-null    int64
 1   tempMode     944 non-null    int64
 2   AQ           944 non-null    int64
 3   USS          944 non-null    int64
 4   CS           944 non-null    int64
 5   VOC          944 non-null    int64
 6   RP           944 non-null    int64
 7   IP           944 non-null    int64
 8   Temperature  944 non-null    int64
 9   fail         944 non-null    int64
dtypes: int64(10)
memory usage: 73.8 KB
```

[5]:

```python
df.shape
```

[5]:

```
(944, 10)
```

[6]:

```python
df.size
```

[6]:

```
9440
```

[7]:

```python
df = df.drop_duplicates()
df
```

[7]:

```
     footfall  tempMode  AQ  USS  CS  VOC  RP  IP  Temperature  fail
0           0         7   7    1   6    6  36   3            1     1
1         190         1   3    3   5    1  20   4            1     0
2          31         7   2    2   6    1  24   6            1     0
3          83         4   3    4   5    1  28   6            1     0
4         640         7   5    6   4    0  68   6            1     0
..        …         …  ..  …  ..  …  ..  ..          …   …
939         0         7   7    1   6    4  73   6           24     1
940         0         7   5    2   6    6  50   6           24     1
941         0         3   6    2   7    5  43   6           24     1
942         0         6   6    2   5    6  46   7           24     1
943        18         7   4    2   6    3  61   7           24     1

[943 rows x 10 columns]
```

[8]:

```python
from sklearn.preprocessing import LabelEncoder
import pandas as pd
enc = LabelEncoder()

for i in range(df.shape[1]):
    df.iloc[:, i] = enc.fit_transform(df.iloc[:, i])

df.head()
```

```
[8]:    footfall  tempMode  AQ  USS  CS  VOC  RP  IP  Temperature  fail
     0         0         7   6    0   5    6  17   2            0     1
     1        71         1   2    2   4    1   1   3            0     0
     2        29         7   1    1   5    1   5   5            0     0
     3        58         4   2    3   4    1   9   5            0     0
     4        90         7   4    5   3    0  49   5            0     0
```

```
[9]: df.describe()
```

```
[9]:           footfall    tempMode          AQ         USS          CS         VOC  \
     count  943.000000  943.000000  943.000000  943.000000  943.000000  943.000000
     mean    33.015907    3.726405    3.326617    1.939555    4.393425    2.844115
     std     33.012684    2.678334    1.438551    1.384458    1.269869    2.273751
     min      0.000000    0.000000    0.000000    0.000000    0.000000    0.000000
     25%      1.000000    1.000000    2.000000    1.000000    4.000000    1.000000
     50%     21.000000    3.000000    3.000000    2.000000    5.000000    2.000000
     75%     64.000000    7.000000    5.000000    3.000000    5.000000    5.000000
     max     98.000000    7.000000    6.000000    6.000000    6.000000    6.000000

                    RP          IP  Temperature        fail
     count  943.000000  943.000000   943.000000  943.000000
     mean    28.027572    3.564157    15.326617    0.416755
     std     16.394722    1.599452     5.976014    0.493283
     min      0.000000    0.000000     0.000000    0.000000
     25%     15.000000    2.000000    13.000000    0.000000
     50%     25.000000    3.000000    16.000000    0.000000
     75%     39.000000    5.000000    20.000000    1.000000
     max     70.000000    6.000000    23.000000    1.000000
```

1.2 Exploratory Data Analysis

```
[10]: df.corr()
```

```
[10]:              footfall  tempMode        AQ       USS        CS       VOC  \
      footfall     1.000000 -0.008931 -0.114961  0.106609  0.048040 -0.162860
      tempMode    -0.008931  1.000000 -0.010396  0.002120 -0.014200 -0.051985
      AQ          -0.114961 -0.010396  1.000000 -0.156912 -0.089594  0.618271
      USS          0.106609  0.002120 -0.156912  1.000000 -0.352980 -0.399579
      CS           0.048040 -0.014200 -0.089594 -0.352980  1.000000  0.048470
      VOC         -0.162860 -0.051985  0.618271 -0.399579  0.048470  1.000000
      RP          -0.051989  0.409347  0.094861 -0.032431 -0.027597  0.008146
      IP          -0.035615 -0.058593 -0.105083 -0.206546  0.185386  0.104480
      Temperature -0.100800 -0.062990  0.035119 -0.225232  0.143640  0.209769
      fail        -0.167747 -0.014043  0.582895 -0.466712  0.019292  0.797182
```

```
                   RP        IP  Temperature      fail
footfall    -0.051989 -0.035615    -0.100800 -0.167747
tempMode     0.409347 -0.058593    -0.062990 -0.014043
AQ           0.094861 -0.105083     0.035119  0.582895
USS         -0.032431 -0.206546    -0.225232 -0.466712
CS          -0.027597  0.185386     0.143640  0.019292
VOC          0.008146  0.104480     0.209769  0.797182
RP           1.000000 -0.158559    -0.077704  0.053840
IP          -0.158559  1.000000     0.372307  0.086497
Temperature -0.077704  0.372307     1.000000  0.191091
fail         0.053840  0.086497     0.191091  1.000000
```

[11]:

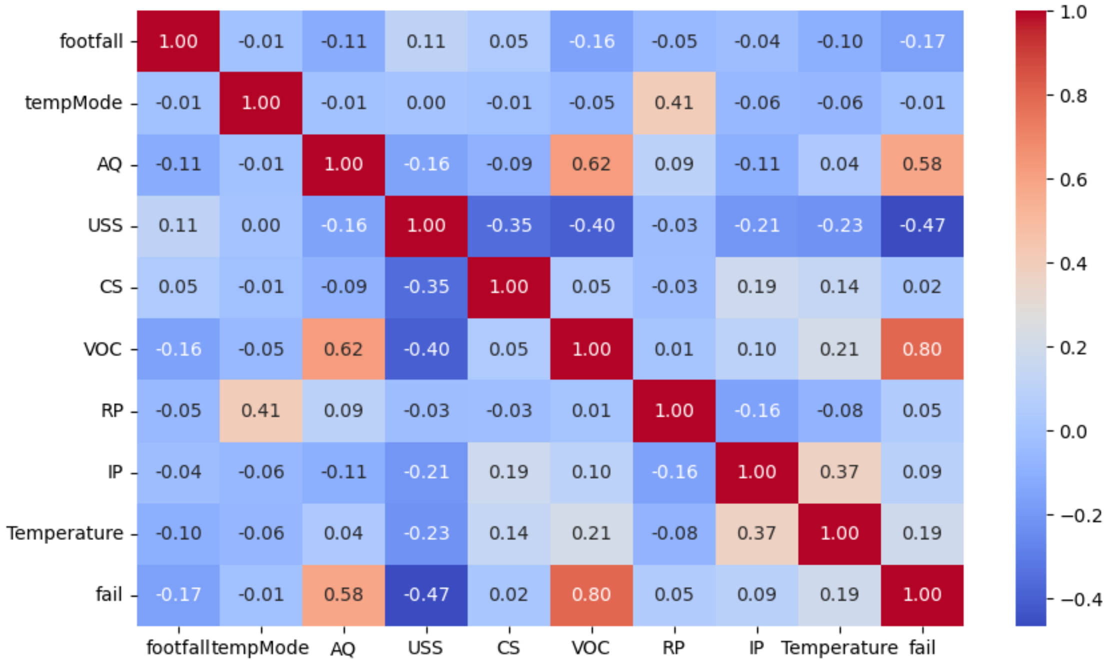
```python
import matplotlib.pyplot as plt
```

```
Matplotlib is building the font cache; this may take a moment.
```

[12]:

```python
%pip install seaborn
import seaborn as sns
import numpy as np

corr_matrix = df.corr()
plt.figure(figsize=(10, 6))
sns.heatmap(corr_matrix, annot=True, cmap="coolwarm", fmt=".2f")
plt.show()
```



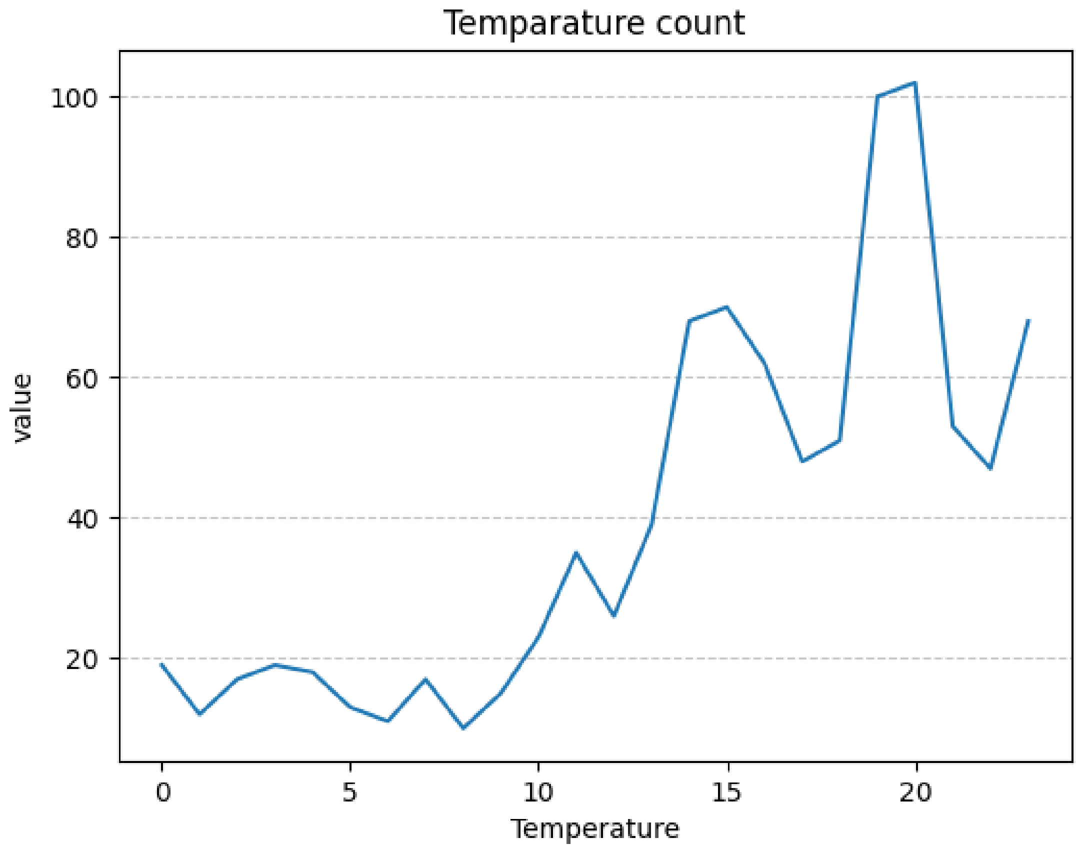
1. **The below analysis shows the count of value of each sensor data readings**

[13]:
```
temp = df['Temperature'].value_counts()
temp.sort_index(inplace = True)
temp
```

[13]:
```
Temperature
0      19
1      12
2      17
3      19
4      18
5      13
6      11
7      17
8      10
9      15
10     23
11     35
12     26
13     39
14     68
15     70
16     62
17     48
18     51
19    100
20    102
21     53
22     47
23     68
Name: count, dtype: int64
```

[14]:
```
plt.plot(temp)
plt.title("Temparature count")
plt.xlabel("Temperature")
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.ylabel("value")
```

[14]:
```
Text(0, 0.5, 'value')
```



[15]:

```
tmode = df['tempMode'].value_counts()
tmode.sort_index(inplace = True)
tmode
```

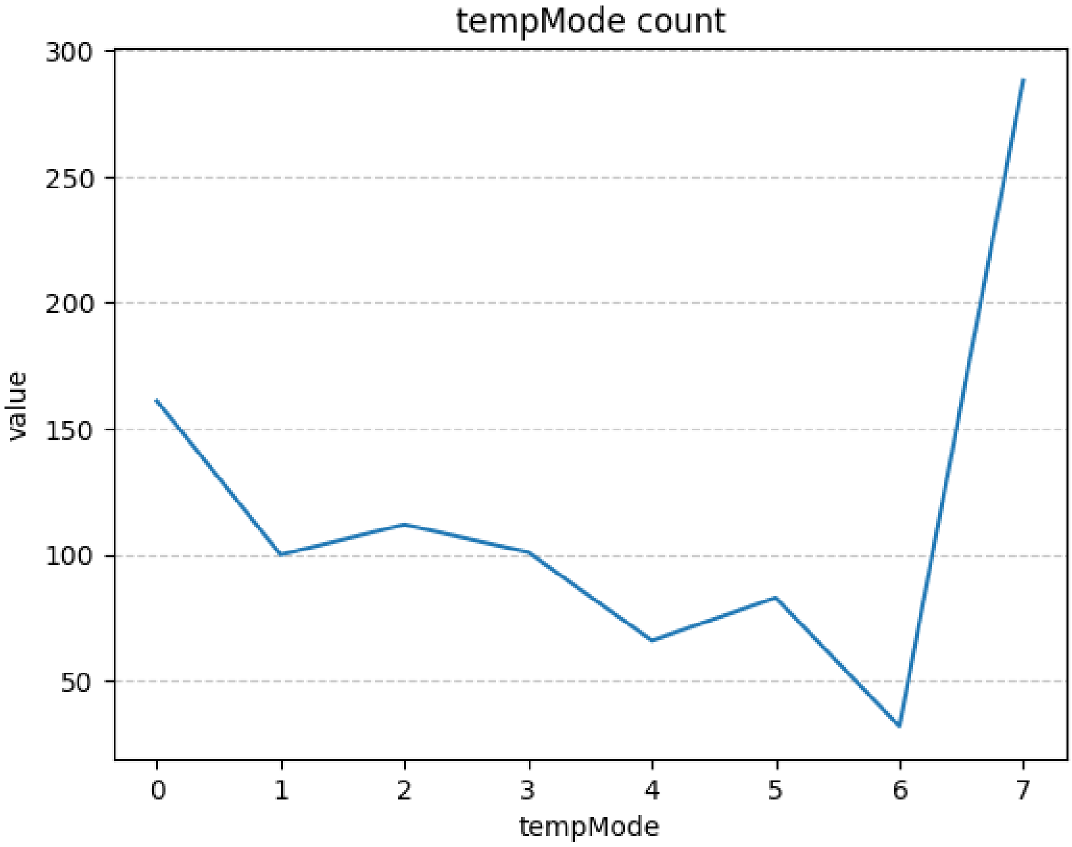
[15]:

```
tempMode
0    161
1    100
2    112
3    101
4     66
5     83
6     32
7    288
Name: count, dtype: int64
```

[16]:

```
plt.plot(tmode)
plt.title("tempMode count")
plt.xlabel("tempMode")
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.ylabel("value")
```

```
[16]: Text(0, 0.5, 'value')
```

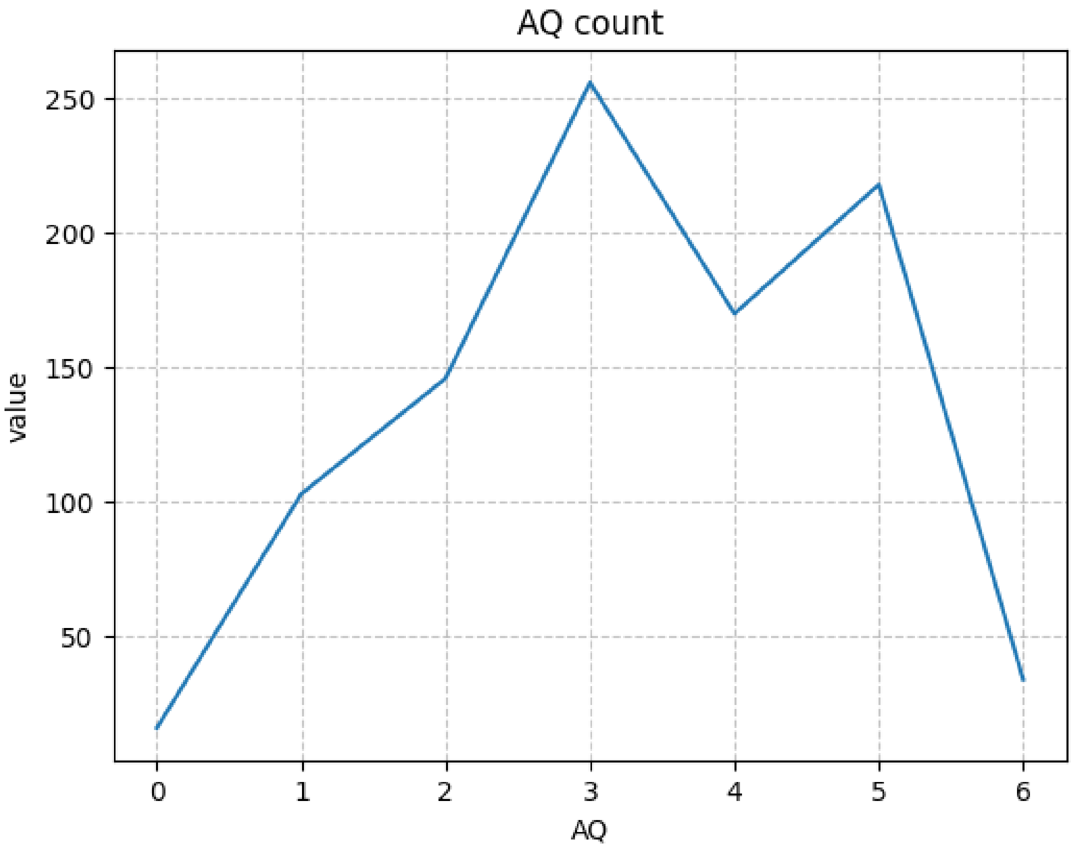


```
[17]: aq = df['AQ'].value_counts()
      aq.sort_index(inplace = True)
      aq
```

```
[17]: AQ
      0     16
      1    103
      2    146
      3    256
      4    170
      5    218
      6     34
      Name: count, dtype: int64
```

```
[18]: plt.plot(aq)
      plt.title("AQ count")
      plt.xlabel("AQ")
      plt.grid(axis='y', linestyle='--', alpha=0.7)
      plt.grid(axis='x', linestyle='--', alpha=0.7)
      plt.ylabel("value")
```

[18]:
```
Text(0, 0.5, 'value')
```



[19]:
```
uss = df['USS'].value_counts()
uss.sort_index(inplace = True)
uss
```

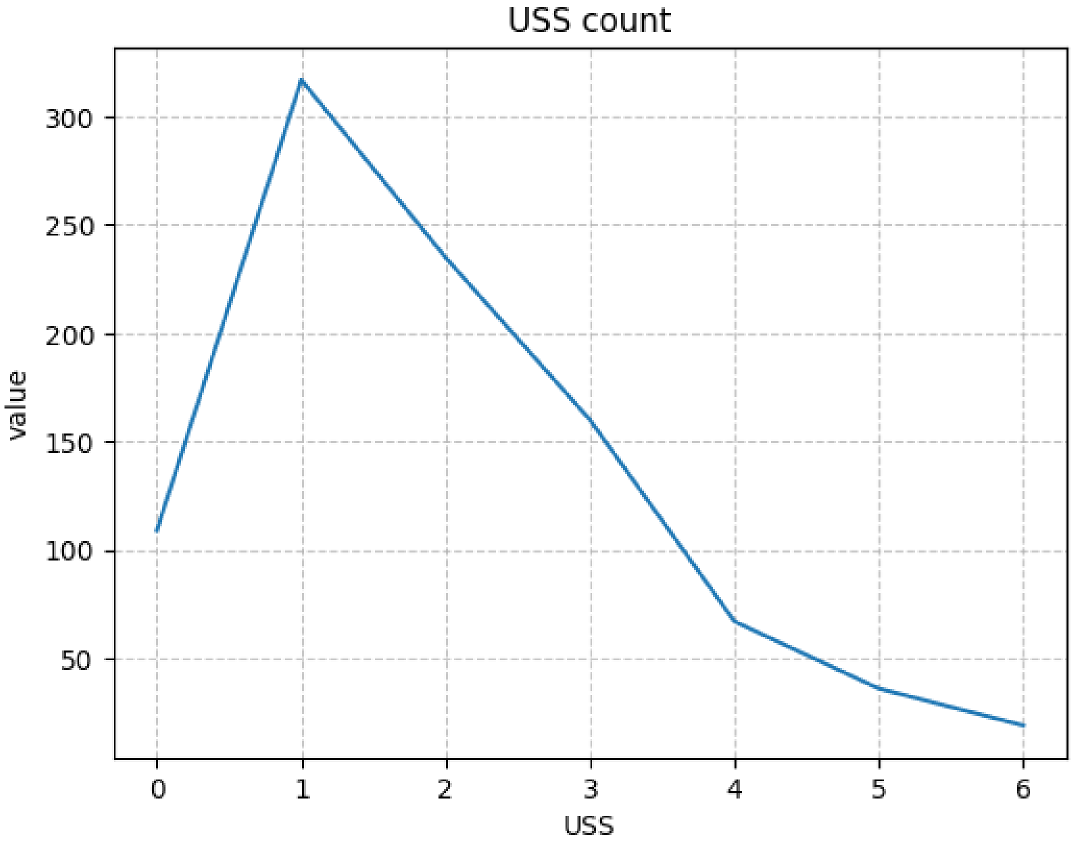
[19]:
```
USS
0    109
1    317
2    235
3    160
4     67
5     36
6     19
Name: count, dtype: int64
```

[20]:

```
plt.plot(uss)
plt.title("USS count")
plt.xlabel("USS")
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.grid(axis='x', linestyle='--', alpha=0.7)
plt.ylabel("value")
```

[20]:

```
Text(0, 0.5, 'value')
```



[21]:

```
cs = df['CS'].value_counts()
cs.sort_index(inplace = True)
cs
```

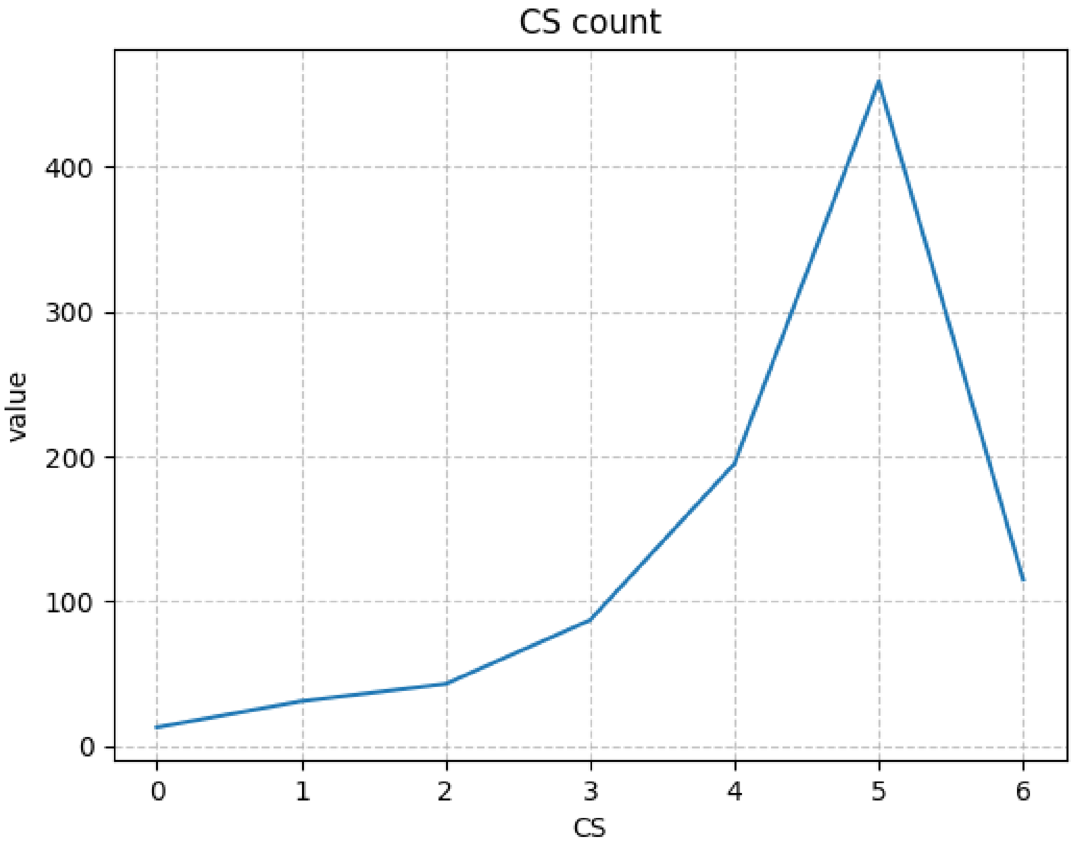
[21]:

```
CS
0      13
1      31
2      43
3      87
4     195
5     459
```

```
6    115
Name: count, dtype: int64
```

[22]:
```
plt.plot(cs)
plt.title("CS count")
plt.xlabel("CS")
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.grid(axis='x', linestyle='--', alpha=0.7)
plt.ylabel("value")
```

[22]:
```
Text(0, 0.5, 'value')
```



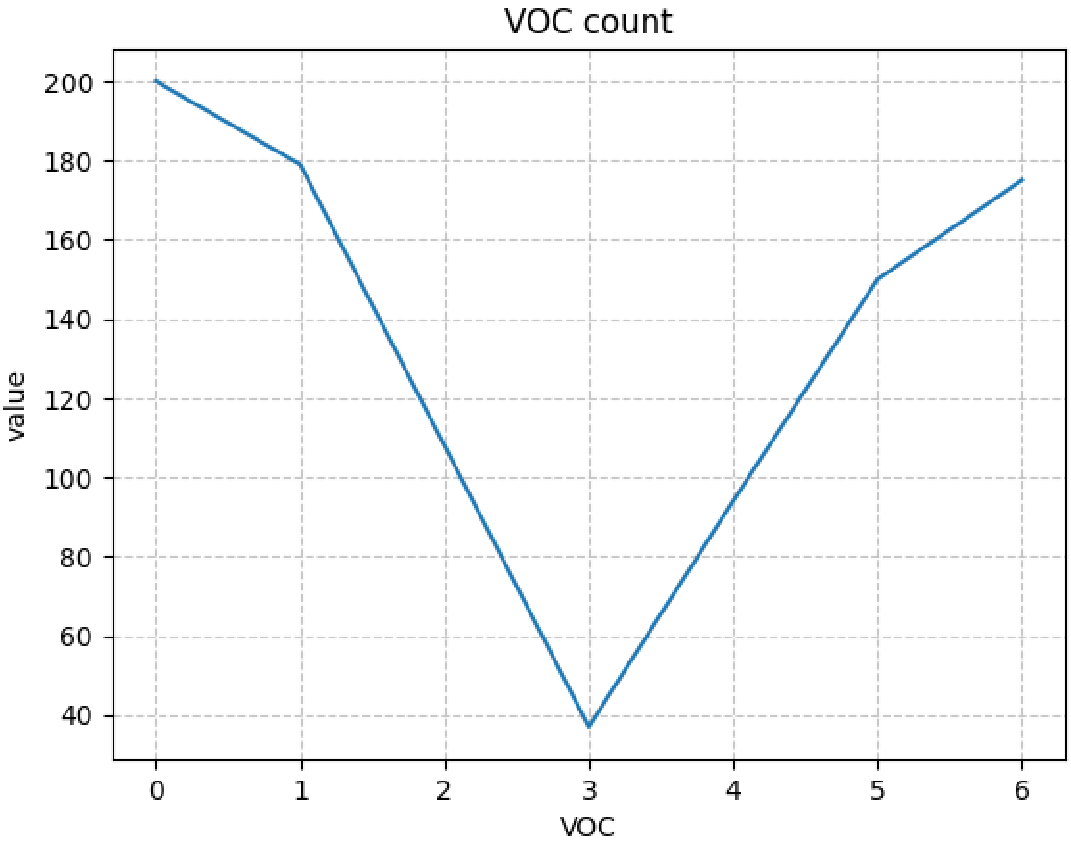
[23]:
```
voc = df['VOC'].value_counts()
voc.sort_index(inplace = True)
voc
```

[23]:
```
VOC
0    200
1    179
2    108
```

```
3     37
4     94
5    150
6    175
Name: count, dtype: int64
```

[24]:
```
plt.plot(voc)
plt.title("VOC count")
plt.xlabel("VOC")
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.grid(axis='x', linestyle='--', alpha=0.7)
plt.ylabel("value")
```

[24]:
```
Text(0, 0.5, 'value')
```

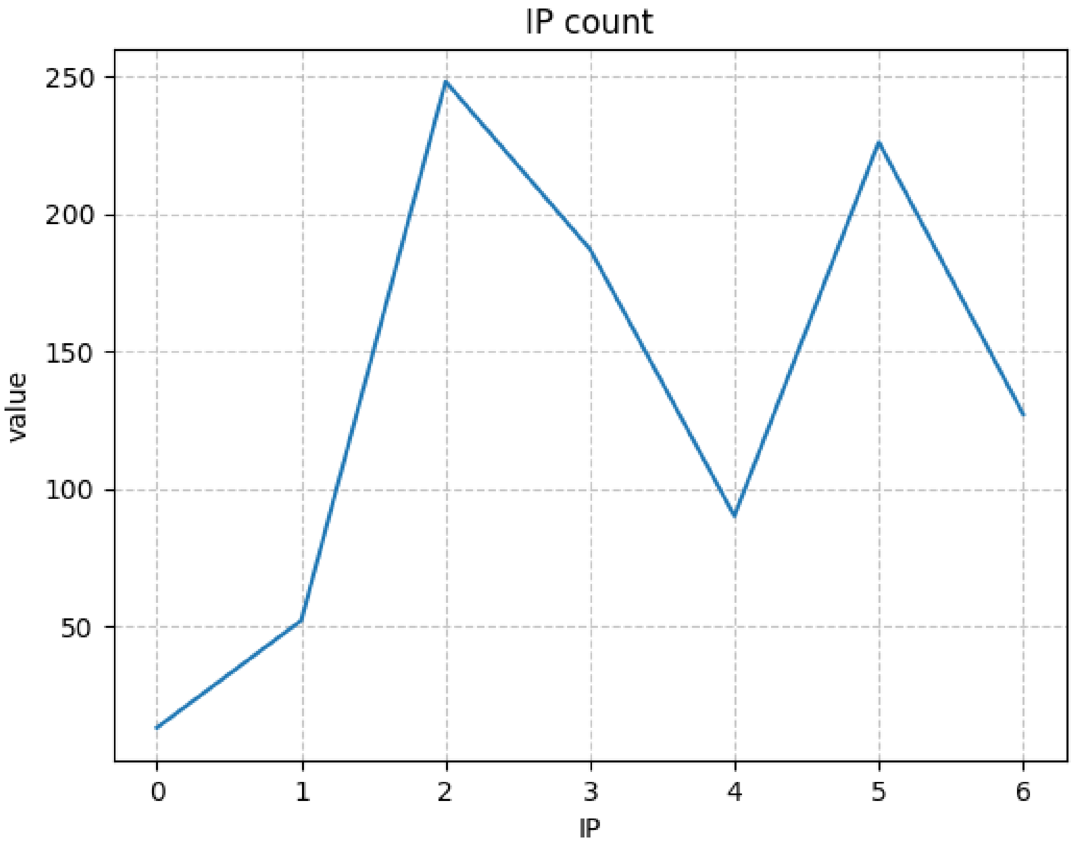


[25]:
```
ip = df['IP'].value_counts()
ip.sort_index(inplace = True)
ip
```

```
[25]: IP
      0     13
      1     52
      2    248
      3    187
      4     90
      5    226
      6    127
      Name: count, dtype: int64
```

```
[26]: plt.plot(ip)
      plt.title("IP count")
      plt.xlabel("IP")
      plt.grid(axis='y', linestyle='--', alpha=0.7)
      plt.grid(axis='x', linestyle='--', alpha=0.7)
      plt.ylabel("value")
```

```
[26]: Text(0, 0.5, 'value')
```



2) Below graphs shows the affect of each value or average of sensor data on the failure

of machines

[27]:

```
failure = df.groupby(by = 'Temperature')['fail'].value_counts()
```

[28]:

```
failure
```

[28]:

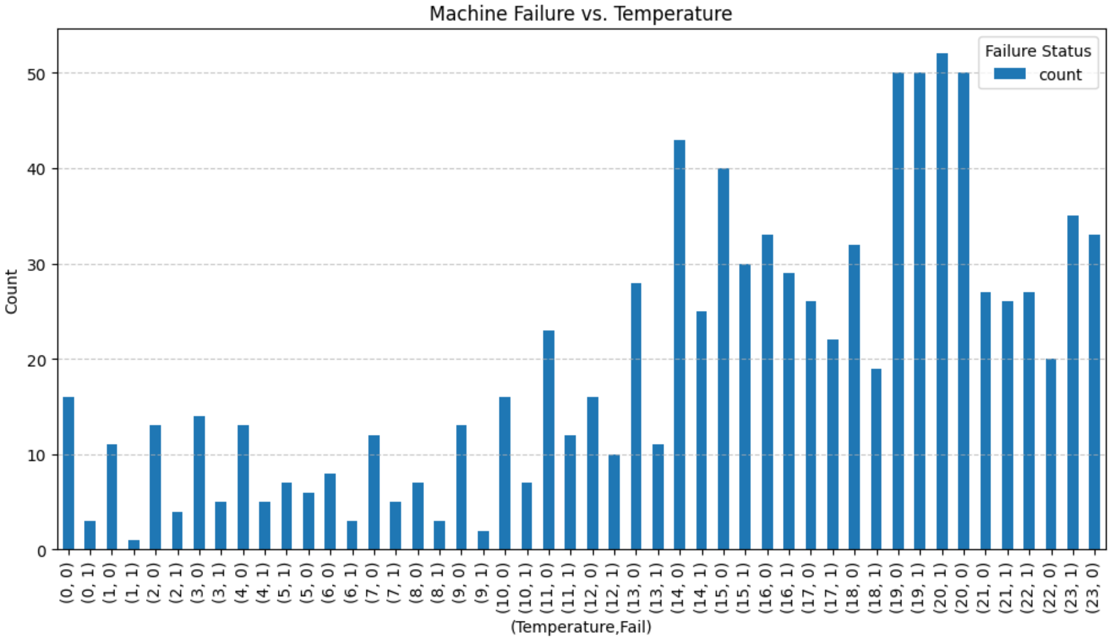
```
Temperature  fail
0            0       16
             1        3
1            0       11
             1        1
2            0       13
             1        4
3            0       14
             1        5
4            0       13
             1        5
5            1        7
             0        6
6            0        8
             1        3
7            0       12
             1        5
8            0        7
             1        3
9            0       13
             1        2
10           0       16
             1        7
11           0       23
             1       12
12           0       16
             1       10
13           0       28
             1       11
14           0       43
             1       25
15           0       40
             1       30
16           0       33
             1       29
17           0       26
             1       22
18           0       32
             1       19
19           0       50
             1       50
20           1       52
```

```
             0       50
21           0       27
             1       26
22           1       27
             0       20
23           1       35
             0       33
Name: count, dtype: int64
```

[29]:

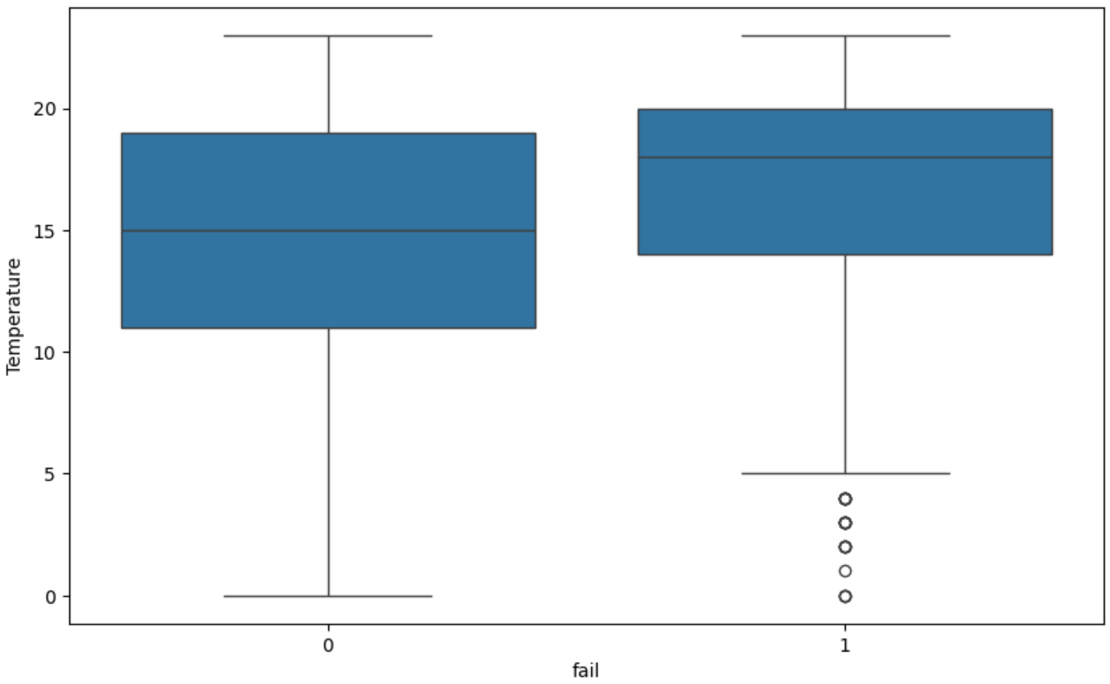
```
failure.plot(kind='bar', figsize=(12, 6))

plt.title("Machine Failure vs. Temperature")
plt.xlabel("(Temperature,Fail)")
plt.ylabel("Count")
plt.legend(title="Failure Status")
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.show()
```



[30]:

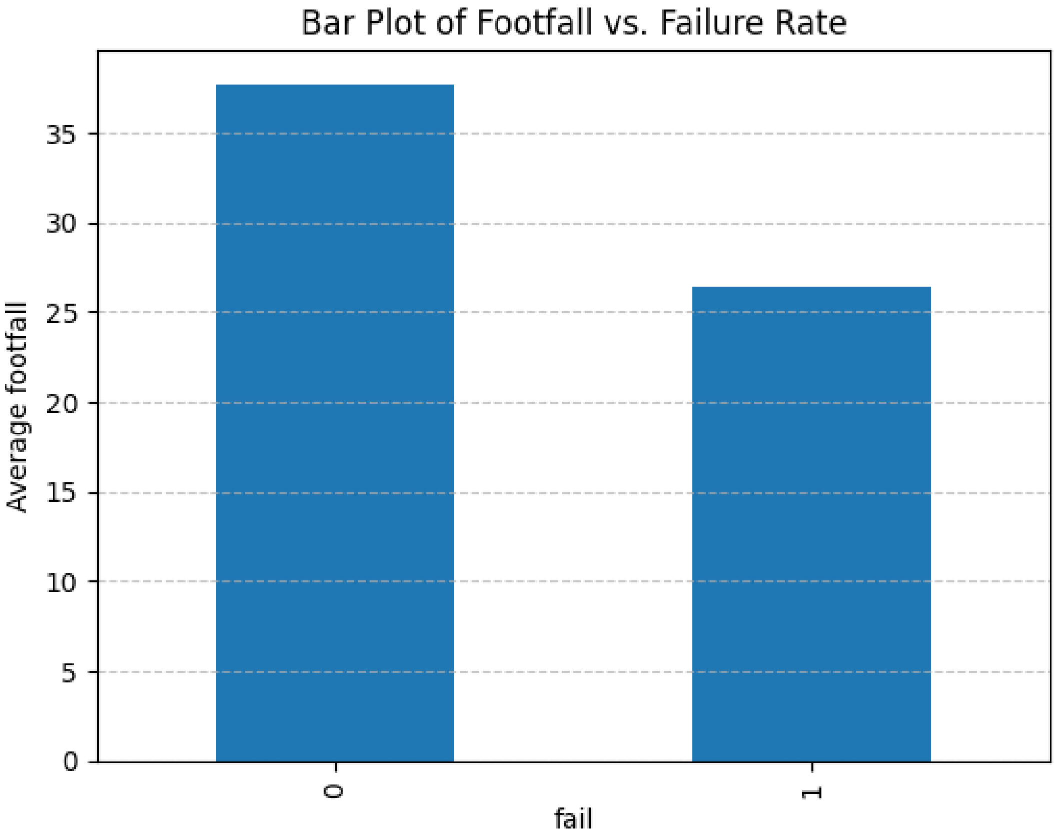
```
plt.figure(figsize=(10, 6))
sns.boxplot(x="fail", y="Temperature", data=df)
plt.show()
```



```
[31]: failure1 = df.groupby(by='fail')['footfall'].mean()
      failure1
```

```
[31]: fail
      0    37.694545
      1    26.468193
      Name: footfall, dtype: float64
```

```
[32]: failure1 = df.groupby(by='fail')['footfall'].mean().plot(kind="bar")
      plt.title("Bar Plot of Footfall vs. Failure Rate")
      plt.ylabel("Average footfall")
      plt.grid(axis="y", linestyle="--", alpha=0.7)
      plt.show()
```

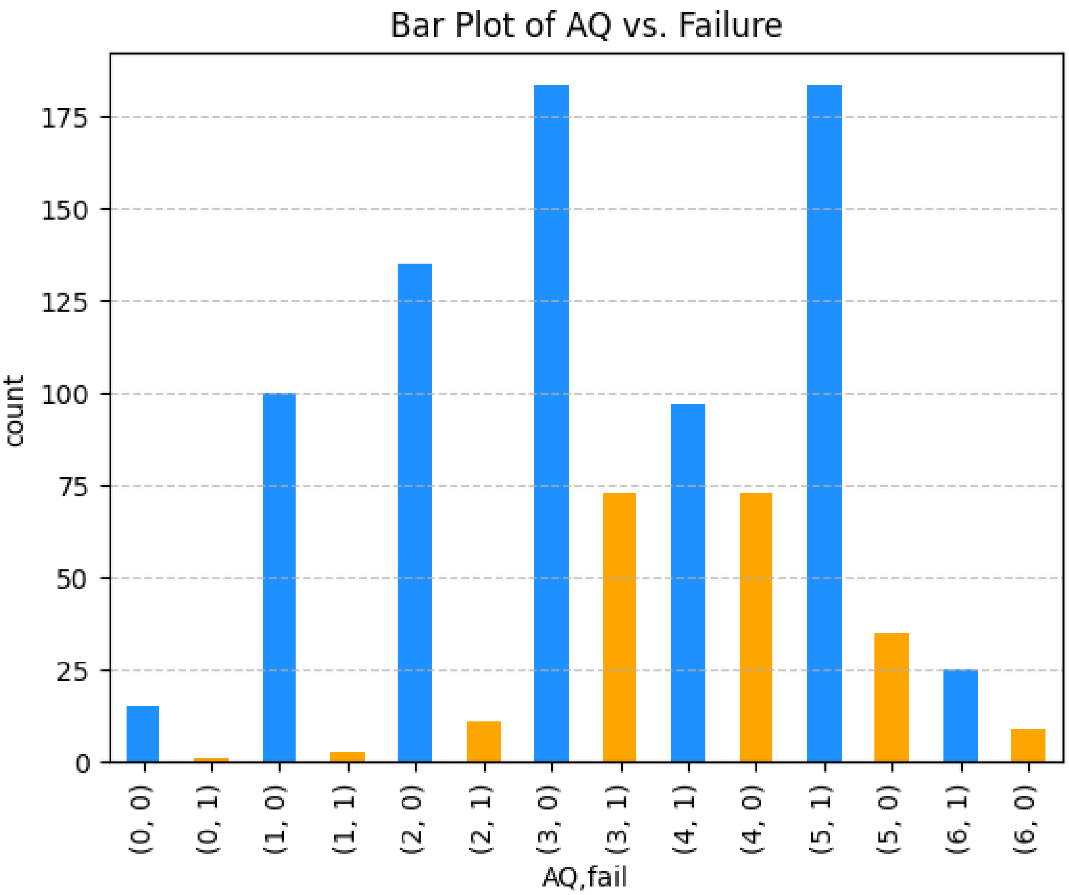


```
[33]: failure2 = df.groupby(by = 'AQ')['fail'].value_counts()
      failure2
```

```
[33]: AQ  fail
      0   0        15
          1         1
      1   0       100
          1         3
      2   0       135
          1        11
      3   0       183
          1        73
      4   1        97
          0        73
      5   1       183
          0        35
      6   1        25
          0         9
      Name: count, dtype: int64
```

[64]:

```
colors = ["dodgerblue", "orange"]
failure2.plot(kind="bar", color=[colors[i % 2] for i in range(len(failure2))])
plt.title("Bar Plot of AQ vs. Failure")
plt.ylabel("count")
plt.grid(axis="y", linestyle="--", alpha=0.7)
plt.show()
```



[59]:

```
failure3 = df.groupby(by = 'USS')['fail'].value_counts()
failure3
```

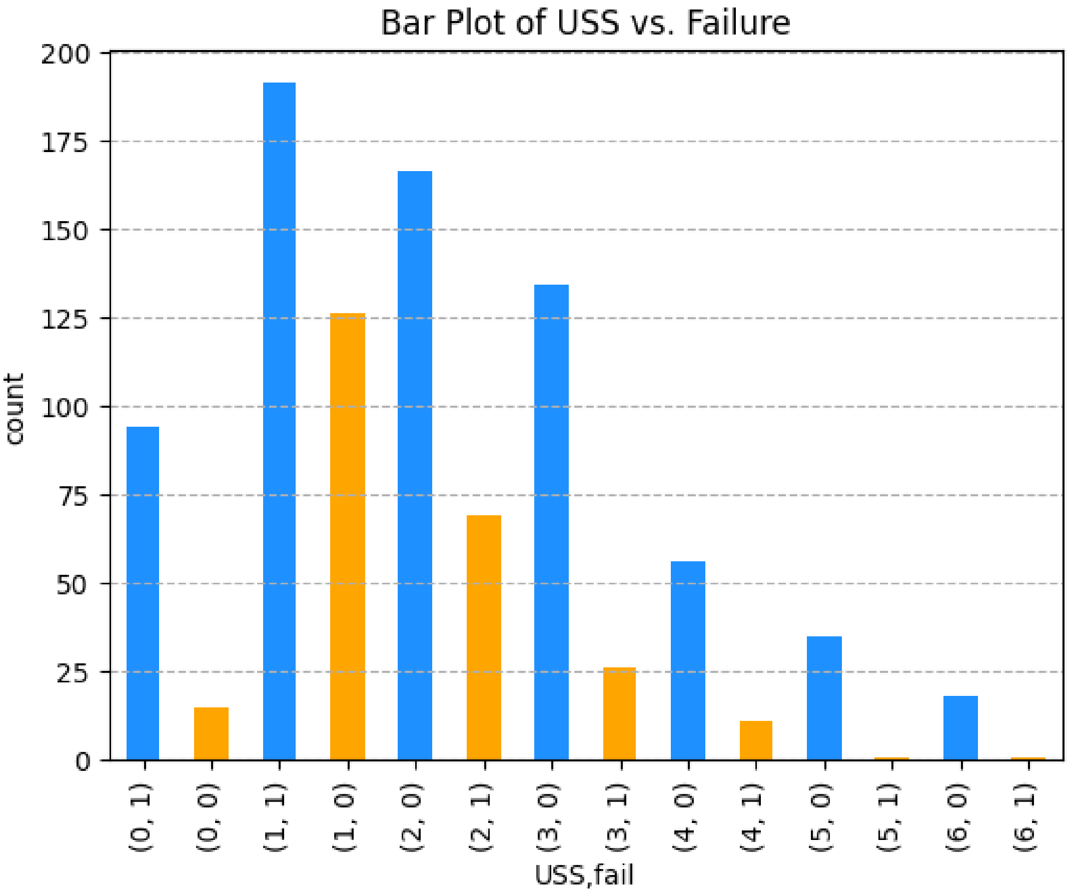
[59]:

```
USS  fail
0    1        94
     0        15
1    1       191
     0       126
2    0       166
     1        69
3    0       134
```

```
     1         26
4    0         56
     1         11
5    0         35
     1          1
6    0         18
     1          1
Name: count, dtype: int64
```

[65]:

```python
colors = ["dodgerblue", "orange"]
failure3.plot(kind="bar", color=[colors[i % 2] for i in range(len(failure3))])
plt.title("Bar Plot of USS vs. Failure")
plt.ylabel("count")
plt.grid(axis="y", linestyle="--")
plt.show()
```



[61]:

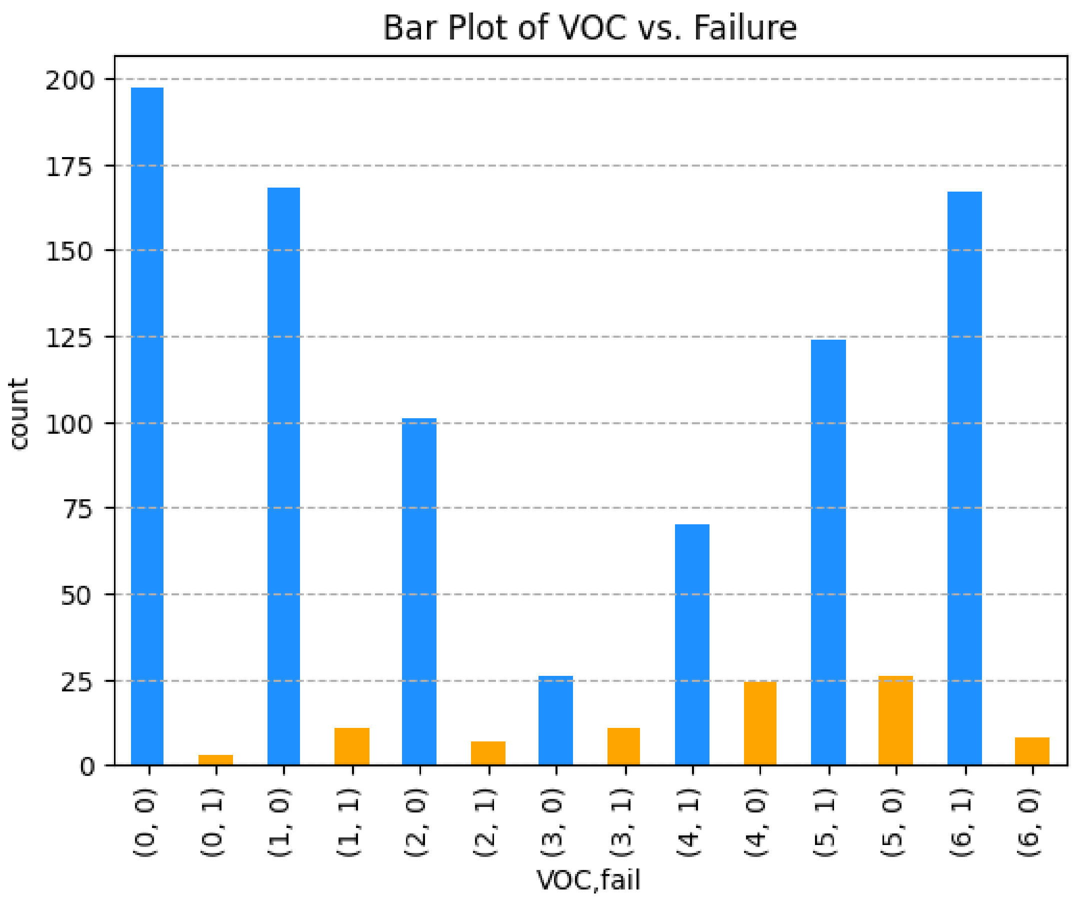
```python
failure4 = df.groupby(by = 'VOC')['fail'].value_counts()
failure4
```

[61]:

```
VOC  fail
0    0       197
     1         3
1    0       168
     1        11
2    0       101
     1         7
3    0        26
     1        11
4    1        70
     0        24
5    1       124
     0        26
6    1       167
     0         8
Name: count, dtype: int64
```

[66]:

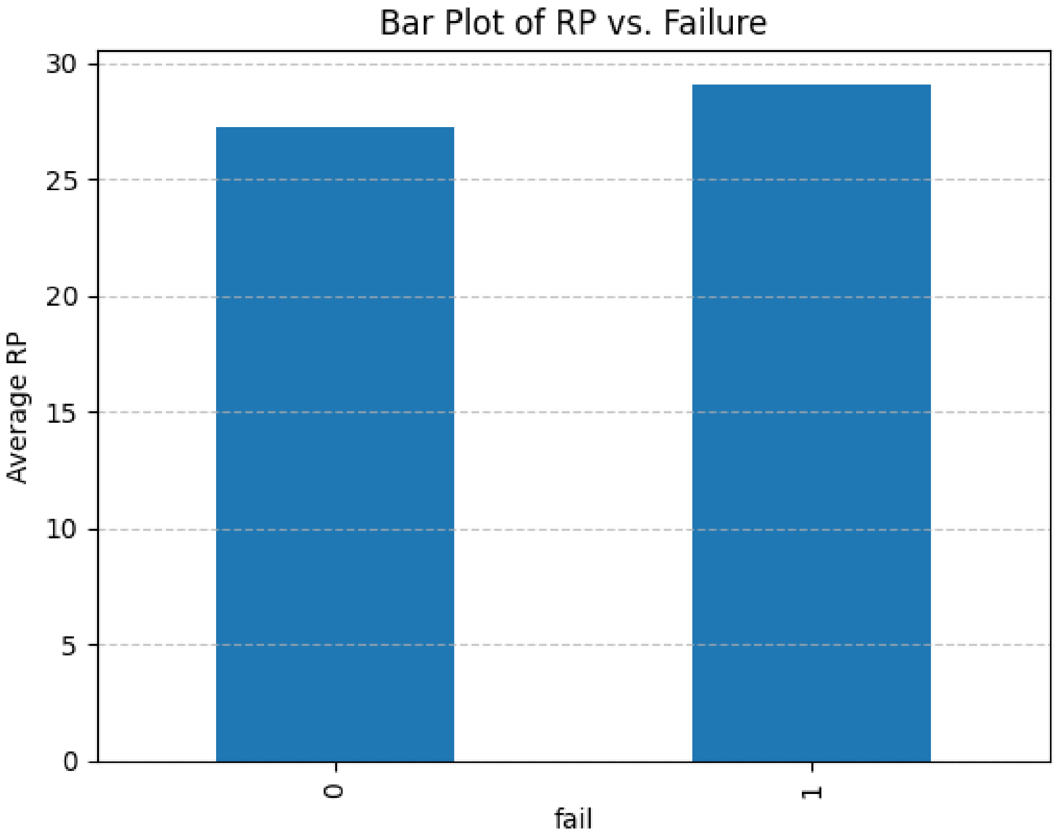
```
colors = ["dodgerblue", "orange"]
failure4.plot(kind="bar", color=[colors[i % 2] for i in range(len(failure4))])
plt.title("Bar Plot of VOC vs. Failure")
plt.ylabel("count")
plt.grid(axis="y", linestyle="--")
plt.show()
```



[39]:
```
failure5 = df.groupby(by='fail')['RP'].mean()
failure5
```

[39]:
```
fail
0    27.281818
1    29.071247
Name: RP, dtype: float64
```

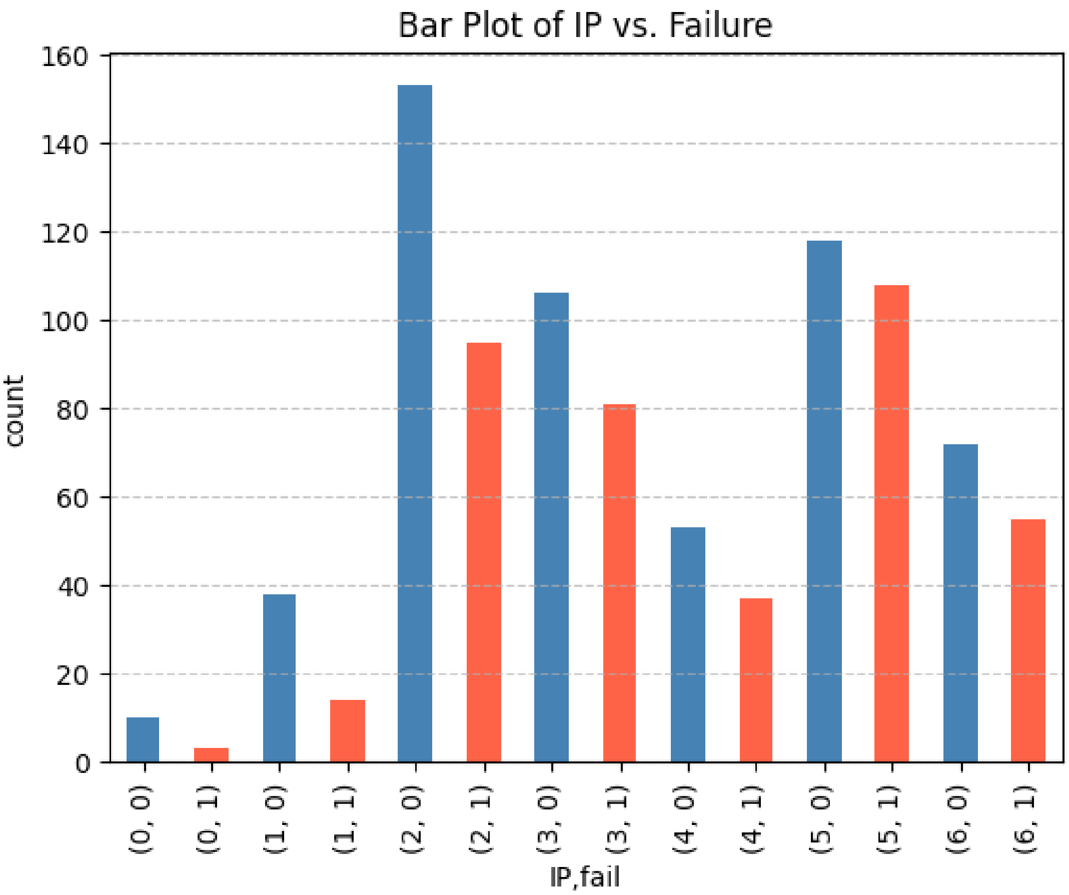
[67]:
```
failure5.plot(kind="bar")
plt.title("Bar Plot of RP vs. Failure")
plt.ylabel("Average RP")
plt.grid(axis="y", linestyle="--", alpha=0.7)
plt.show()
```



```
[41]: failure6 = df.groupby(by = 'IP')['fail'].value_counts()
      failure6
```

```
[41]: IP  fail
      0   0        10
          1         3
      1   0        38
          1        14
      2   0       153
          1        95
      3   0       106
          1        81
      4   0        53
          1        37
      5   0       118
          1       108
      6   0        72
          1        55
      Name: count, dtype: int64
```

[68]:
```
colors = ["steelblue", "tomato"]
failure6.plot(kind="bar", color=[colors[i % 2] for i in range(len(failure6))])
plt.title("Bar Plot of IP vs. Failure")
plt.ylabel("count")
plt.grid(axis="y", linestyle="--", alpha=0.7)
plt.show()
```



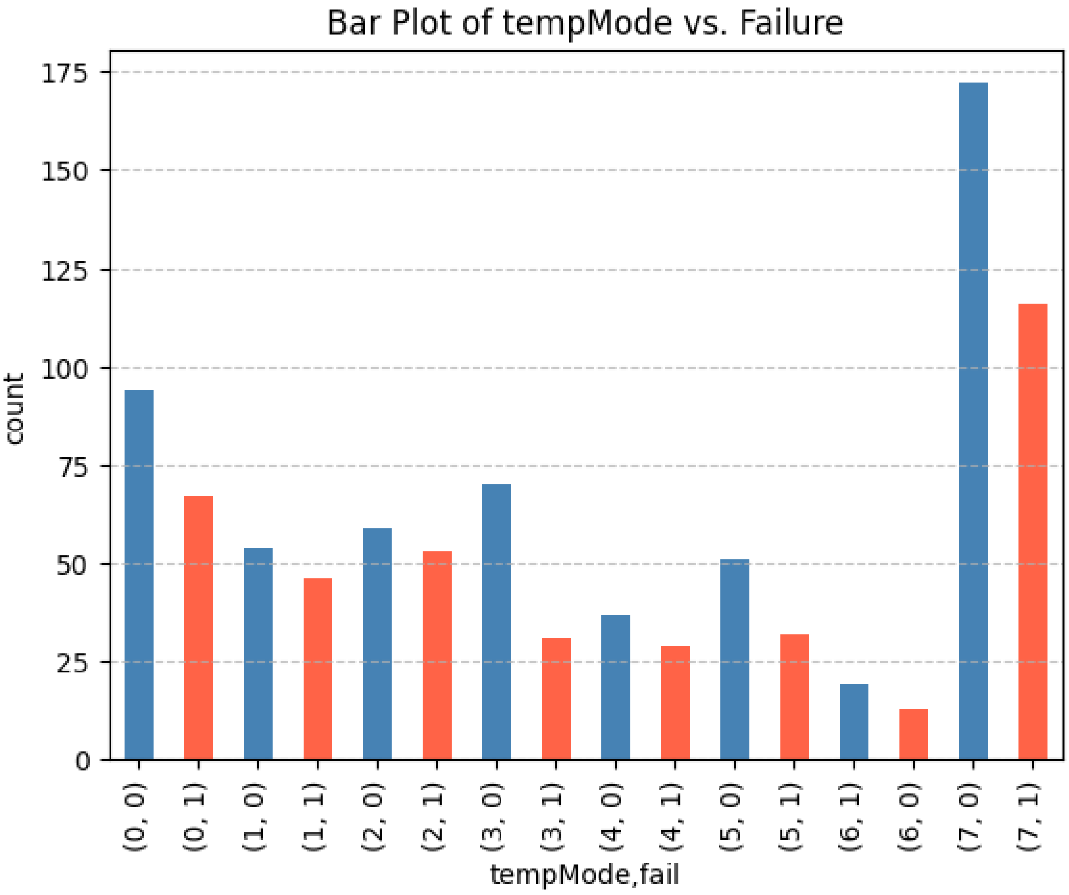
[43]:
```
failure7 = df.groupby(by = 'tempMode')['fail'].value_counts()
failure7
```

[43]:
```
tempMode  fail
0         0       94
          1       67
1         0       54
          1       46
2         0       59
          1       53
3         0       70
```

```
          1        31
4         0        37
          1        29
5         0        51
          1        32
6         1        19
          0        13
7         0       172
          1       116
Name: count, dtype: int64
```

[69]:

```
colors = ["steelblue", "tomato"]
failure7.plot(kind="bar", color=[colors[i % 2] for i in range(len(failure7))])
plt.title("Bar Plot of tempMode vs. Failure")
plt.ylabel("count")
plt.grid(axis="y", linestyle="--", alpha=0.7)
plt.show()
```



[45]:

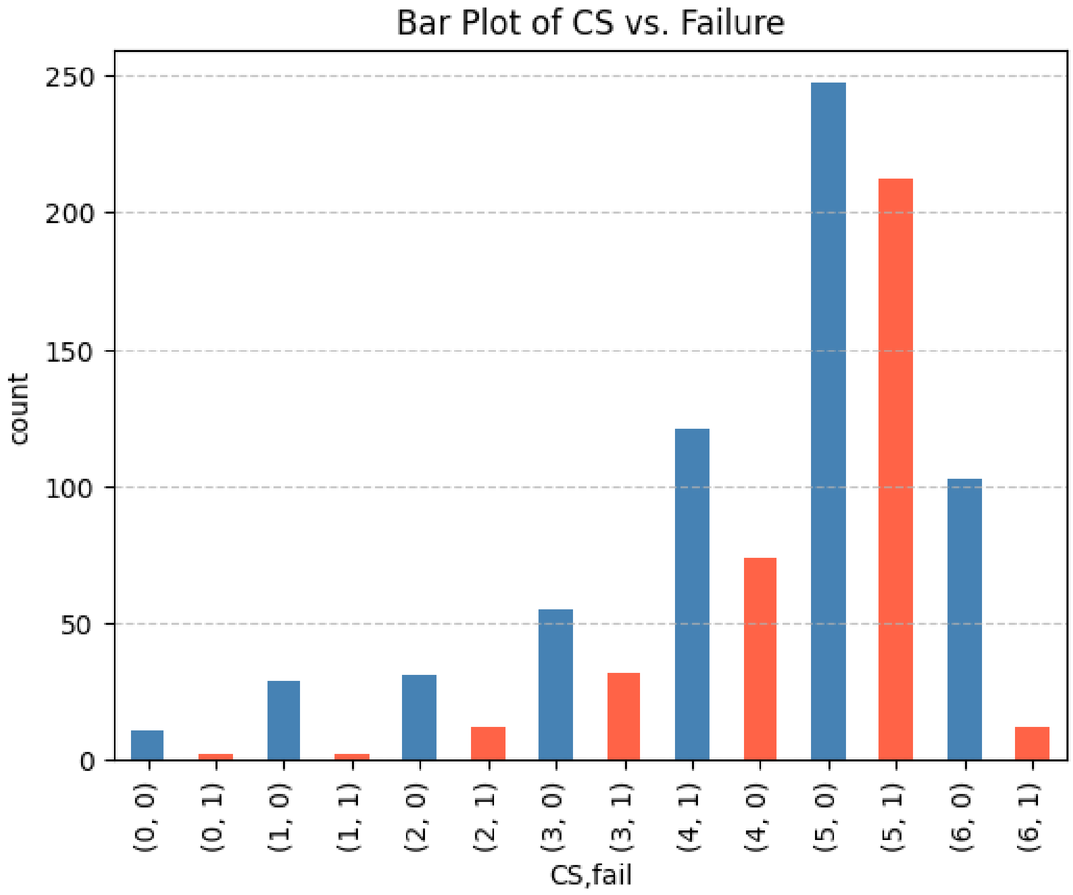
```
failure8 = df.groupby(by = 'CS')['fail'].value_counts()
failure8
```

[45]:

```
CS  fail
0   0        11
    1         2
1   0        29
    1         2
2   0        31
    1        12
3   0        55
    1        32
4   1       121
    0        74
5   0       247
    1       212
6   0       103
    1        12
Name: count, dtype: int64
```

[71]:

```
colors = ["steelblue", "tomato"]
failure8.plot(kind="bar", color=[colors[i % 2] for i in range(len(failure8))])
plt.title("Bar Plot of CS vs. Failure")
plt.ylabel("count")
plt.grid(axis="y", linestyle="--", alpha=0.7)
plt.show()
```

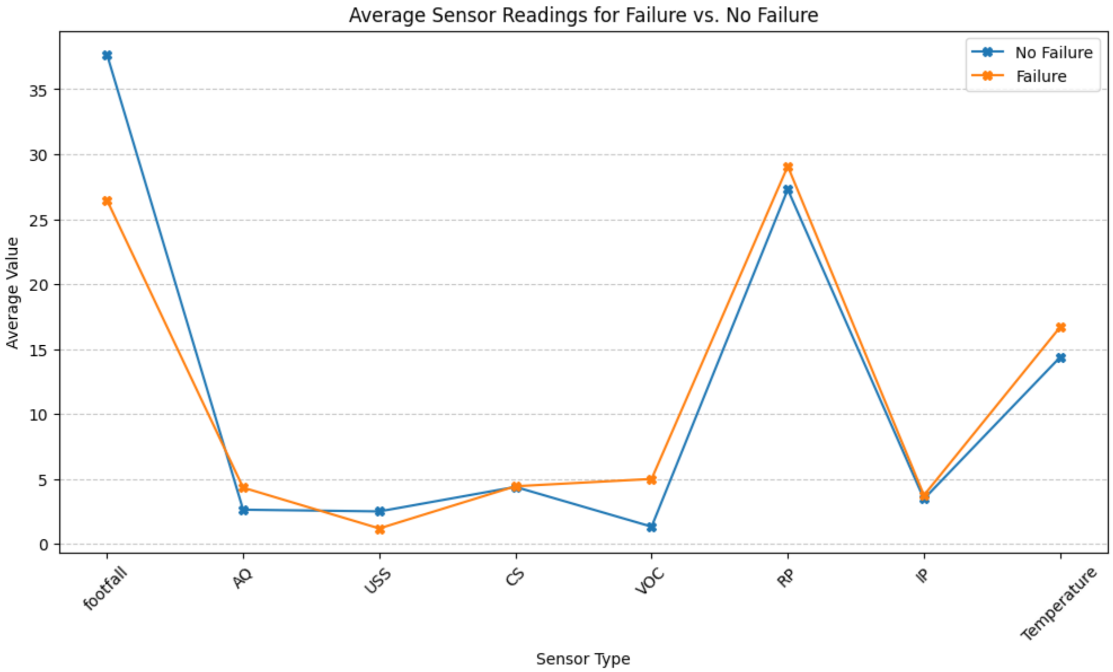


The below gives a comparitive analysis on how the average sensor readings of each sensor leads to either failure or no failure in machine

```
[47]: sensor_columns = ["footfall", "AQ", "USS", "CS", "VOC", "RP", "IP",␣
       ↪"Temperature"]
      df_grouped = df.groupby("fail")[sensor_columns].mean().T

      plt.figure(figsize=(12, 6))
      df_grouped.plot(kind="line", marker="X", figsize=(12, 6))
      plt.title("Average Sensor Readings for Failure vs. No Failure")
      plt.xlabel("Sensor Type")
      plt.ylabel("Average Value")
      plt.legend(["No Failure", "Failure"])
      plt.grid(axis="y", linestyle="--", alpha=0.7)
      plt.xticks(rotation=45)
      plt.show()
```

```
<Figure size 1200x600 with 0 Axes>
```



1.3 Model Training and evaluation

[48]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report
from sklearn.preprocessing import StandardScaler
```

[49]:
```
X = df.drop('fail', axis=1) # feature columns
y = df['fail']
```

[50]:
```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.
↪25,random_state=42)
```

[51]:
```
model = RandomForestClassifier(n_estimators=100, random_state=42)

# Train the model
model.fit(X_train, y_train)
```

[51]:
```
RandomForestClassifier(random_state=42)
```

[52]:
```
y_pred = model.predict(X_test)
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support
```

```
           0       0.90      0.90      0.90       127
           1       0.88      0.89      0.89       109

    accuracy                           0.89       236
   macro avg       0.89      0.89      0.89       236
weighted avg       0.89      0.89      0.89       236
```

[53]:

```
from sklearn.metrics import accuracy_score
print(f'Accuracy: {accuracy_score(y_test, y_pred)}')
```

```
Accuracy: 0.8940677966101694
```

[54]:

```
import pandas as pd
import numpy as np

input_values = pd.DataFrame({
    'footfall': [0],
    'tempMode': [7],
    'AQ': [7],
    'USS': [1],
    'CS': [6],
    'VOC': [6],
    'RP': [36],
    'IP': [3],
    'Temperature': [1]
})

prediction = model.predict(input_values)
if prediction[0] == 1:
    print("The machine is predicted to fail.")
else:
    print("The machine is predicted to not fail.")
```

```
The machine is predicted to fail.
```

[55]:

```
import pandas as pd
import numpy as np

input_values = pd.DataFrame({
    'footfall': [1600],
    'tempMode': [0],
    'AQ': [3],
    'USS': [2],
    'CS': [4],
    'VOC': [4],
    'RP': [26],
```

```python
    'IP': [2],
    'Temperature': [1]
})
prediction = model.predict(input_values)
if prediction[0] == 1:
    print("The machine is predicted to fail.")
else:
    print("The machine is predicted to not fail.")
```

```
The machine is predicted to not fail.
```

[ ]: