Maintenance EDA

In [1]:
```
##gerekli kütüphanelerin import edilmesi
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
```

In [2]:
```
#veri setinin yüklenmesi
df = pd.read_csv("predictive_maintenance.csv")
```

In [3]:
```
#veri setinin ilk 5 satırının yazdırılması
df.head()
```

Out[3]:

	UDI	Product ID	Type	Air temperature [K]	Process temperature [K]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target	Failure Type
0	1	M14860	M	298.1	308.6	1551	42.8	0	0	No Failure
1	2	L47181	L	298.2	308.7	1408	46.3	3	0	No Failure
2	3	L47182	L	298.1	308.5	1498	49.4	5	0	No Failure
3	4	L47183	L	298.2	308.6	1433	39.5	7	0	No Failure
4	5	L47184	L	298.2	308.7	1408	40.0	9	0	No Failure

In [4]:
```
#veri setinin son 5 satırının yazdırılması
df.tail()
```

Out[4]:

	UDI	Product ID	Type	Air temperature [K]	Process temperature [K]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target	Failure Type
9995	9996	M24855	M	298.8	308.4	1604	29.5	14	0	No Failure
9996	9997	H39410	H	298.9	308.4	1632	31.8	17	0	No Failure
9997	9998	M24857	M	299.0	308.6	1645	33.4	22	0	No Failure
9998	9999	H39412	H	299.0	308.7	1408	48.5	25	0	No Failure
9999	10000	M24859	M	299.0	308.7	1500	40.2	30	0	No Failure

In [5]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 10 columns):
 #   Column                   Non-Null Count  Dtype  
---  ------                   --------------  -----  
 0   UDI                      10000 non-null  int64  
 1   Product ID               10000 non-null  object 
 2   Type                     10000 non-null  object 
 3   Air temperature [K]      10000 non-null  float64
 4   Process temperature [K]  10000 non-null  float64
 5   Rotational speed [rpm]   10000 non-null  int64  
 6   Torque [Nm]              10000 non-null  float64
 7   Tool wear [min]          10000 non-null  int64  
 8   Target                   10000 non-null  int64  
 9   Failure Type             10000 non-null  object 
dtypes: float64(3), int64(4), object(3)
memory usage: 781.4+ KB
```

In [6]:

```
df.isnull().sum()
#veri setinde boş alan yoktur
```

Out[6]:

```
UDI                        0
Product ID                 0
Type                       0
Air temperature [K]        0
Process temperature [K]    0
Rotational speed [rpm]     0
Torque [Nm]                0
Tool wear [min]            0
Target                     0
Failure Type               0
dtype: int64
```

In [7]:

```
#kullanılmayacak UDI ve Product ID Satırlarının silinmesi
df.drop(['UDI','Product ID'], axis=1, inplace=True)
df.head()
```

Out[7]:

	Type	Air temperature [K]	Process temperature [K]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target	Failure Type
0	M	298.1	308.6	1551	42.8	0	0	No Failure
1	L	298.2	308.7	1408	46.3	3	0	No Failure
2	L	298.1	308.5	1498	49.4	5	0	No Failure
3	L	298.2	308.6	1433	39.5	7	0	No Failure
4	L	298.2	308.7	1408	40.0	9	0	No Failure

In [8]:

```
#Kelvin olarak verilen sıcaklığın celcius'a çevrimi
df["Air temperature [K]"] = df["Air temperature [K]"] - 272.15
df["Process temperature [K]"] = df["Process temperature [K]"] - 272.15
```

In [9]:

```
# Sütun adlarındaki Kelvinlerin (K) Centigrate(C) olarak değiştirilmesi
df.rename(columns={"Air temperature [K]" : "Air temperature [C]","Process temperature [K]"
```

In [10]:
```
df.head()
```

Out[10]:

	Type	Air temperature [C]	Process temperature [C]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target	Failure Type
0	M	25.95	36.45	1551	42.8	0	0	No Failure
1	L	26.05	36.55	1408	46.3	3	0	No Failure
2	L	25.95	36.35	1498	49.4	5	0	No Failure
3	L	26.05	36.45	1433	39.5	7	0	No Failure
4	L	26.05	36.55	1408	40.0	9	0	No Failure

In [11]:
```
df.info()
```

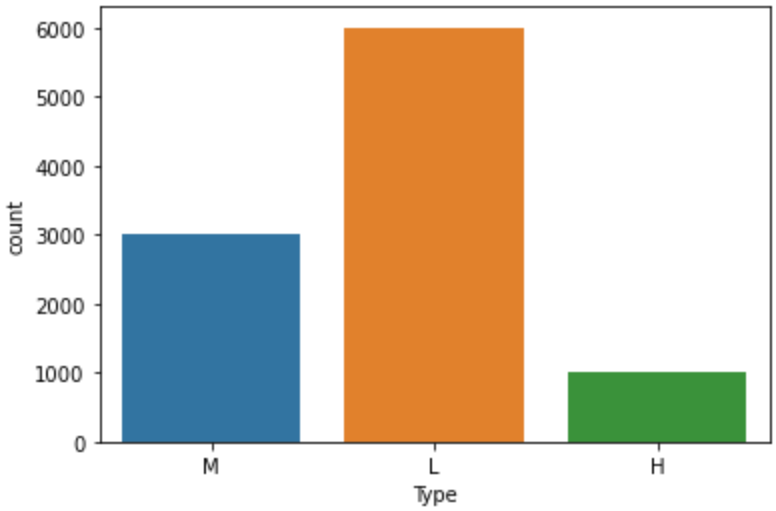
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 8 columns):
 #   Column                   Non-Null Count  Dtype  
---  ------                   --------------  -----  
 0   Type                     10000 non-null  object 
 1   Air temperature [C]      10000 non-null  float64
 2   Process temperature [C]  10000 non-null  float64
 3   Rotational speed [rpm]   10000 non-null  int64  
 4   Torque [Nm]              10000 non-null  float64
 5   Tool wear [min]          10000 non-null  int64  
 6   Target                   10000 non-null  int64  
 7   Failure Type             10000 non-null  object 
dtypes: float64(3), int64(3), object(2)
memory usage: 625.1+ KB
```

In [12]:
```
df.describe()
```

Out[12]:

	Air temperature [C]	Process temperature [C]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target
count	10000.000000	10000.000000	10000.000000	10000.000000	10000.000000	10000.000000
mean	27.854930	37.855560	1538.776100	39.986910	107.951000	0.033900
std	2.000259	1.483734	179.284096	9.968934	63.654147	0.180981
min	23.150000	33.550000	1168.000000	3.800000	0.000000	0.000000
25%	26.150000	36.650000	1423.000000	33.200000	53.000000	0.000000
50%	27.950000	37.950000	1503.000000	40.100000	108.000000	0.000000
75%	29.350000	38.950000	1612.000000	46.800000	162.000000	0.000000
max	32.350000	41.650000	2886.000000	76.600000	253.000000	1.000000

In [13]:
```
#ürün türüne göre dağılım
ax = sns.countplot(x="Type", data=df)
```



In [14]:
```
#sıcaklık farkı isimli yeni bir sütun oluşturulması ve ilk 5 satırın yazdırılması
# temp_diff = Process temperature - Process temperature
df['temp_diff'] = pd.DataFrame(df['Process temperature [C]']-df['Air temperature [C]'])
df.head()
```

Out[14]:

	Type	Air temperature [C]	Process temperature [C]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target	Failure Type	temp_diff
0	M	25.95	36.45	1551	42.8	0	0	No Failure	10.5
1	L	26.05	36.55	1408	46.3	3	0	No Failure	10.5
2	L	25.95	36.35	1498	49.4	5	0	No Failure	10.4
3	L	26.05	36.45	1433	39.5	7	0	No Failure	10.4
4	L	26.05	36.55	1408	40.0	9	0	No Failure	10.5

In [15]:
```
##indeksin resetlenerek sütun haline getirilmesi
#df.reset_index()
```

In [16]:
```
df.sample(5)
```

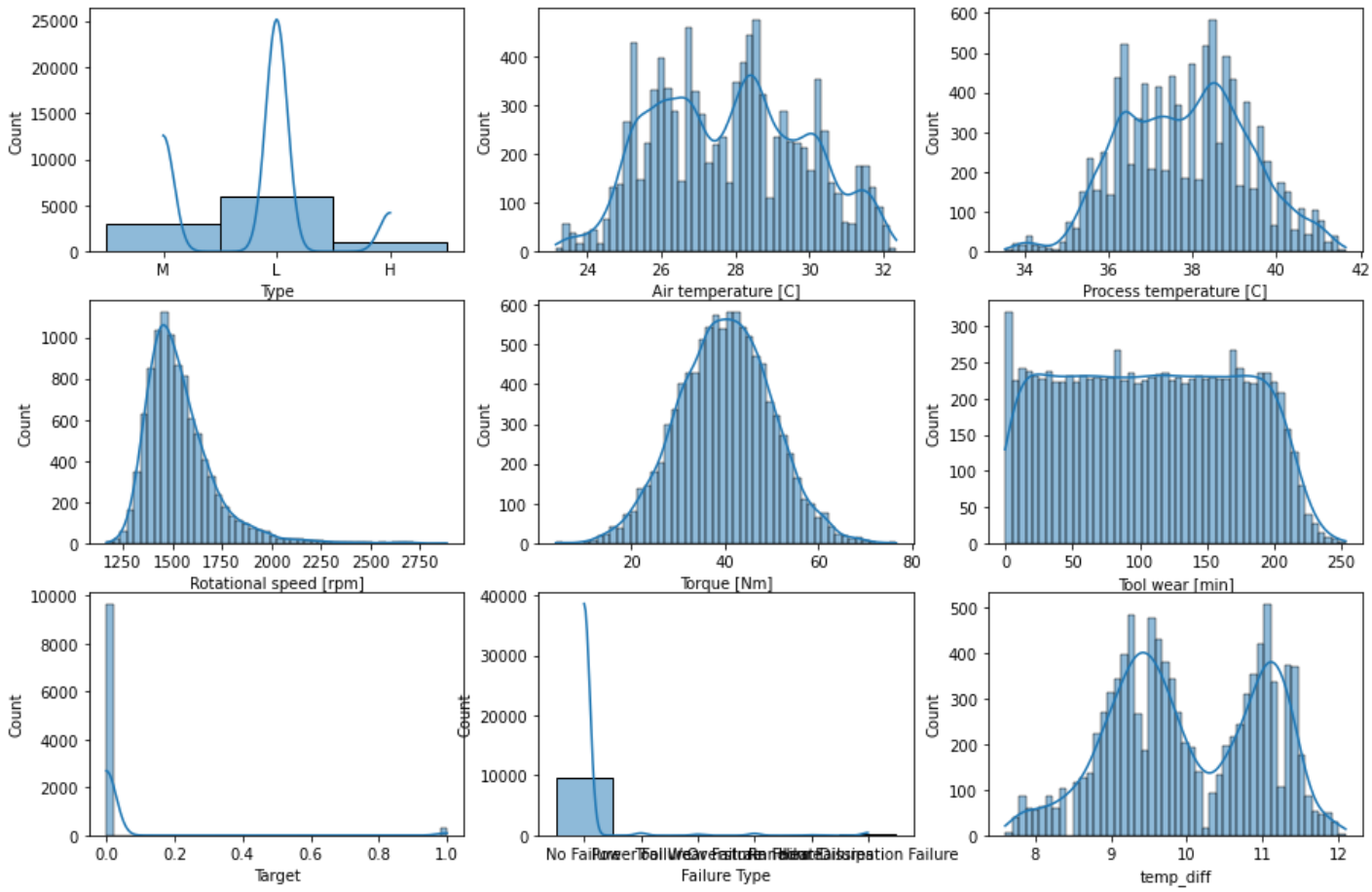
Out[16]:

	Type	Air temperature [C]	Process temperature [C]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target	Failure Type	temp_diff
5868	L	29.35	38.95	1731	27.9	101	0	No Failure	9.6
4073	M	29.75	38.45	1412	46.5	89	0	No Failure	8.7
2251	H	26.95	36.15	1424	43.4	16	0	No Failure	9.2
5164	M	32.15	41.25	1624	32.1	53	0	No Failure	9.1

	Type	Air temperature [C]	Process temperature [C]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target	Failure Type	temp_diff
6466	L	28.25	37.55	1740	31.1	113	0	No Failure	9.3

In [17]:

```
#veri setindeki tüm değişkenlerin histogram dağılımının yapılması
plt.figure(figsize=(15,10))
for i,col in enumerate(df.columns,1):
    plt.subplot(3,3,i)
    sns.histplot(df[col],kde=True, bins=50)
```



In [18]:

```
import math
import numpy as np
from scipy.stats import shapiro

import math
import numpy as np
from scipy.stats import kstest
from scipy.stats import lognorm
df_num=df.select_dtypes(["float64","int64"])
for col in df_num:
    print(col)
    plt.figure()
#      ks,p =kstest(df_num[col],'norm')
#      print(ks,p)

    shapiro(df_num)
```

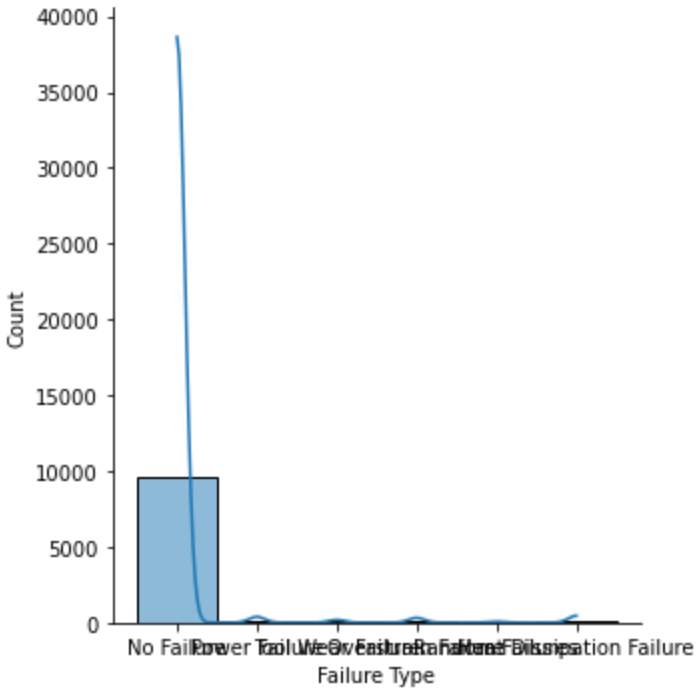
```
Air temperature [C]
Process temperature [C]
Rotational speed [rpm]
Torque [Nm]
Tool wear [min]
Target
temp_diff
C:\ProgramData\Anaconda3\lib\site-packages\scipy\stats\morestats.py:1760: UserWarning: p-value may not be accurate for N > 5000.
  warnings.warn("p-value may not be accurate for N > 5000.")
<Figure size 432x288 with 0 Axes>
<Figure size 432x288 with 0 Axes>
<Figure size 432x288 with 0 Axes>
<Figure size 432x288 with 0 Axes>
<Figure size 432x288 with 0 Axes>
<Figure size 432x288 with 0 Axes>
<Figure size 432x288 with 0 Axes>
```

In [19]:
```
#Hangi tür arıza tipleri olduğunu görmek için
df['Failure Type'].unique()
```

Out[19]:
```
array(['No Failure', 'Power Failure', 'Tool Wear Failure',
       'Overstrain Failure', 'Random Failures',
       'Heat Dissipation Failure'], dtype=object)
```

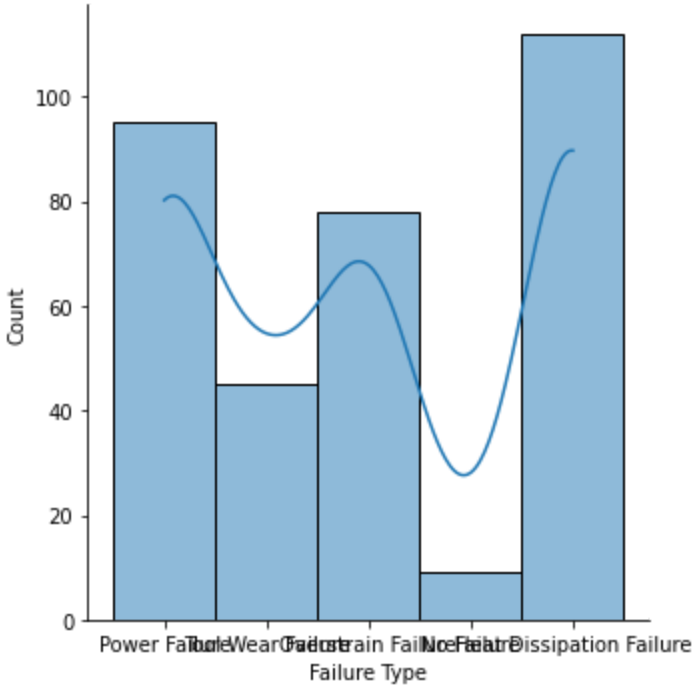
In [20]:
```
#seçilen tek değişkenin dağılımının basılması
sns.displot(data=df, x="Failure Type", kde=True)
```

Out[20]:
```
<seaborn.axisgrid.FacetGrid at 0x1b804731a90>
```



In [21]:
```
#seçilen tek değişkenin dağılımının basılması
#(sadece arıza olduğu durumda yani Target=1'ken)
sns.displot(data=df[df['Target'] == 1], x="Failure Type", kde=True)
```

Out[21]:
```
<seaborn.axisgrid.FacetGrid at 0x1b805608d90>
```



In [22]:
```
#4 tip arıza beklerken 5 tip basılmış,
#dolayısıyla Arıza türlerinin incelenmesi gerekmektedir
df1=df[df['Target'] == 1]
df1['Failure Type'].value_counts()
```

Out[22]:
```
Heat Dissipation Failure    112
Power Failure                95
Overstrain Failure           78
Tool Wear Failure            45
No Failure                    9
Name: Failure Type, dtype: int64
```

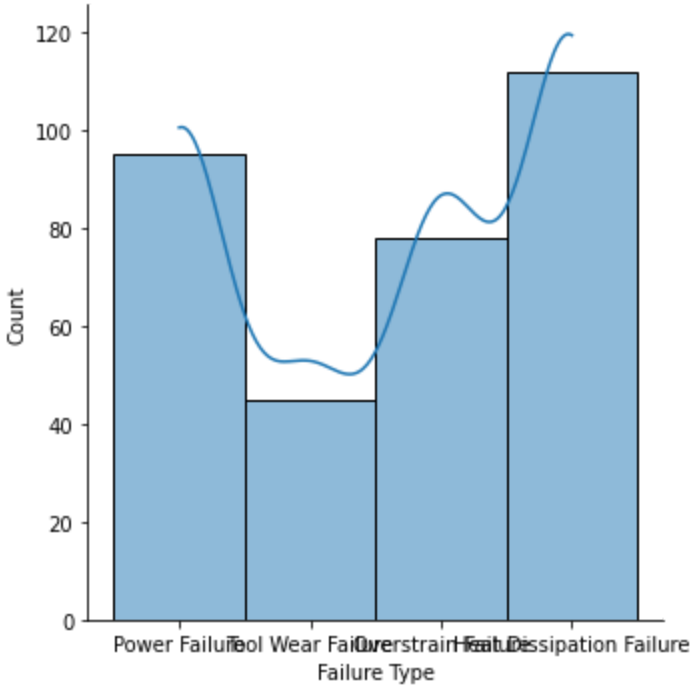
In [23]:
```
#Target =1 ken yani arıza var ise arıza tipinde no failure olmamalı. Bu veriler yanlış işa
#yanlış işaretlenen verilerin silinmesi
indexNames = df[(df['Target'] == 1) & (df['Failure Type'] == 'No Failure')].index
df.drop(indexNames , inplace=True)
```

In [24]:
```
##yanlış işaretlenen verilerin silinmesinin kontrolü
df2=df[df['Target'] == 1]
df2['Failure Type'].value_counts()
```

Out[24]:
```
Heat Dissipation Failure    112
Power Failure                95
Overstrain Failure           78
Tool Wear Failure            45
Name: Failure Type, dtype: int64
```

In [25]:
```
#seçilen tek değişkenin dağılımının basılması
plt.figure(figsize = (10, 8))
sns.displot(data=df[df['Target'] == 1], x="Failure Type", kde=True)
```

Out[25]:
```
<seaborn.axisgrid.FacetGrid at 0x1b805176100>

<Figure size 720x576 with 0 Axes>
```



In [26]:

```
##veri setinin arıza türü bazında gruplanması ve değerlerin ortalaması
arizaturu = df.groupby('Failure Type').mean()
arizaturu
```

Out[26]:

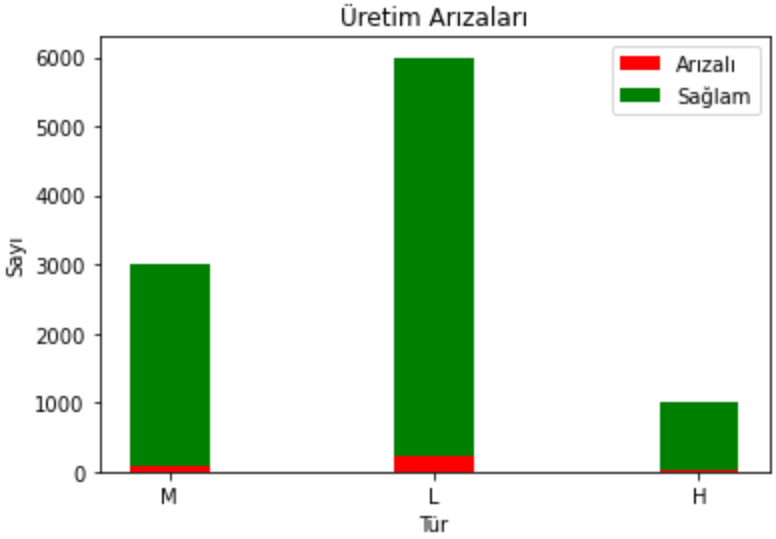
Failure Type	Air temperature [C]	Process temperature [C]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target	temp_diff
Heat Dissipation Failure	30.417857	38.649107	1337.964286	52.778571	107.339286	1.0	8.231250
No Failure	27.822519	37.844151	1540.354869	39.622389	106.669086	0.0	10.021632
Overstrain Failure	27.717949	37.901282	1354.243590	56.878205	208.217949	1.0	10.183333
Power Failure	27.925789	37.804737	1763.968421	48.514737	101.884211	1.0	9.878947
Random Failures	28.616667	38.605556	1489.444444	43.522222	119.888889	0.0	9.988889
Tool Wear Failure	28.138889	38.014444	1570.666667	37.226667	216.555556	1.0	9.875556

In [27]:

```
labels_Failed = ["M", "L", "H"]
#türlere göre arızaların ayrılması
M_Failed = sum(df.loc[df['Type']=='M'].Target)
L_Failed = sum(df.loc[df['Type']=='L'].Target)
H_Failed = sum(df.loc[df['Type']=='H'].Target)
Failed=[M_Failed, L_Failed, H_Failed]

#Kalite türlerine göre toplam ürün sayıları
M_Tot = len(df.loc[df['Type']=='M'].Target)
L_Tot = len(df.loc[df['Type']=='L'].Target)
H_Tot = len(df.loc[df['Type']=='H'].Target)

#türlere göre sorunsuz olanların ayrılması
M_NF = M_Tot-M_Failed
L_NF = L_Tot-L_Failed
H_NF = H_Tot-H_Failed
```

```
NFail = [M_NF, L_NF, H_NF]

fig, ax = plt.subplots(1,1)
width = 0.3
ax.bar(labels_Failed, Failed, width, label='Arızalı',color='Red')
ax.bar(labels_Failed, NFail, width, bottom=Failed,label='Sağlam',color='green')
ax.set_xlabel('Tür')
ax.set_ylabel('Sayı')
ax.set_title('Üretim Arızaları')
ax.legend()
```

Out[27]:
```
<matplotlib.legend.Legend at 0x1b8052c1c70>
```



In [28]:
```
#hata yüzdelerinin basılması
print('Sağlam ürünler:',round((M_NF+L_NF+H_NF)*100/(M_Tot+L_Tot+H_Tot),1),'%')
print('Arızalı ürünler:',round((M_Failed+L_Failed+H_Failed)*100/(M_Tot+L_Tot+H_Tot),1),'%'
```

```
Sağlam ürünler: 96.7 %
Arızalı ürünler: 3.3 %
```

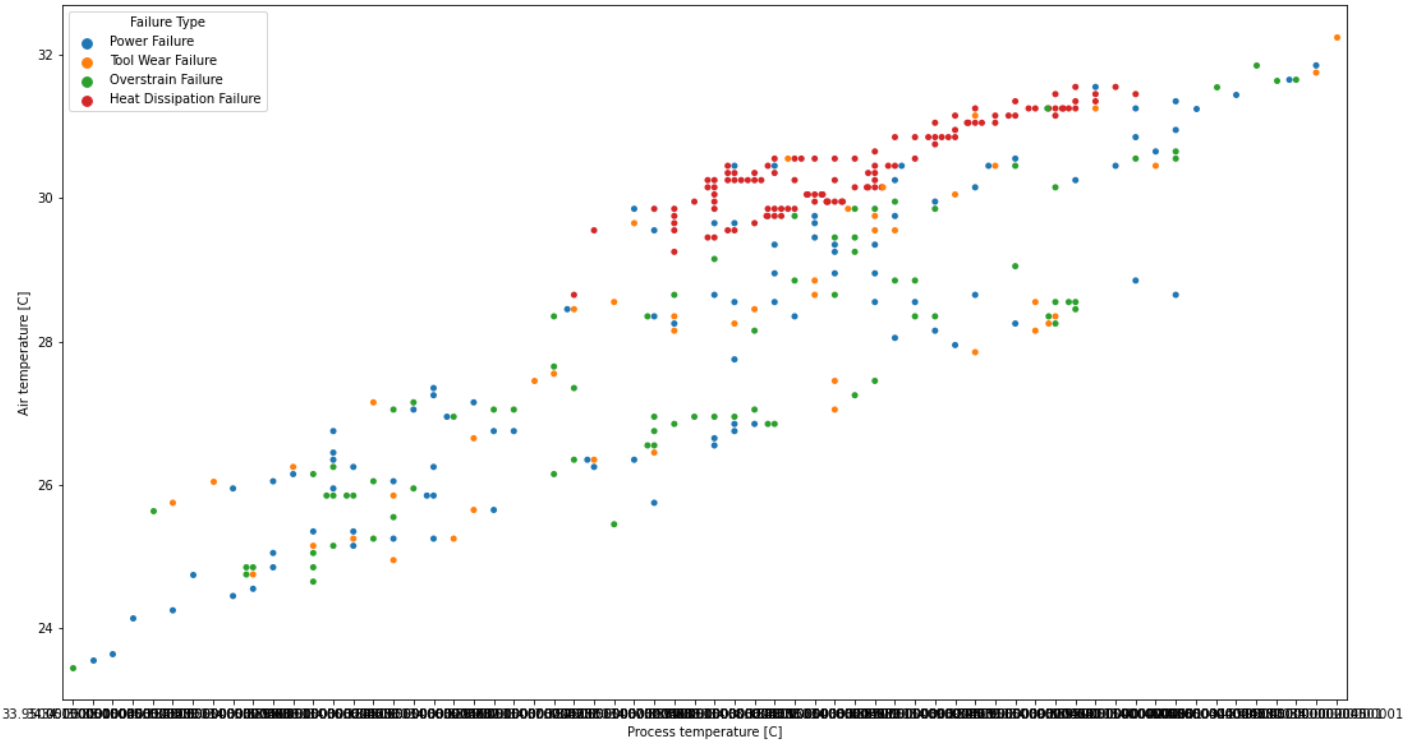
In [29]:
```
#Sıcaklık eksenlerine göre sürü grafiği
plt.figure(figsize=(18,10))
sns.swarmplot(data=df[df['Target'] == 1],x="Process temperature [C]",y='Air temperature [C
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\categorical.py:1296: UserWarning: 6.2%
of the points cannot be placed; you may want to decrease the size of the markers or use st
ripplot.
  warnings.warn(msg, UserWarning)
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\categorical.py:1296: UserWarning: 16.7%
of the points cannot be placed; you may want to decrease the size of the markers or use st
ripplot.
  warnings.warn(msg, UserWarning)
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\categorical.py:1296: UserWarning: 20.0%
of the points cannot be placed; you may want to decrease the size of the markers or use st
ripplot.
  warnings.warn(msg, UserWarning)
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\categorical.py:1296: UserWarning: 11.8%
of the points cannot be placed; you may want to decrease the size of the markers or use st
ripplot.
  warnings.warn(msg, UserWarning)
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\categorical.py:1296: UserWarning: 11.1%
of the points cannot be placed; you may want to decrease the size of the markers or use st
ripplot.
  warnings.warn(msg, UserWarning)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\categorical.py:1296: UserWarning: 15.4%
of the points cannot be placed; you may want to decrease the size of the markers or use st
ripplot.
  warnings.warn(msg, UserWarning)
```

Out[29]:

```
<AxesSubplot:xlabel='Process temperature [C]', ylabel='Air temperature [C]'>
```

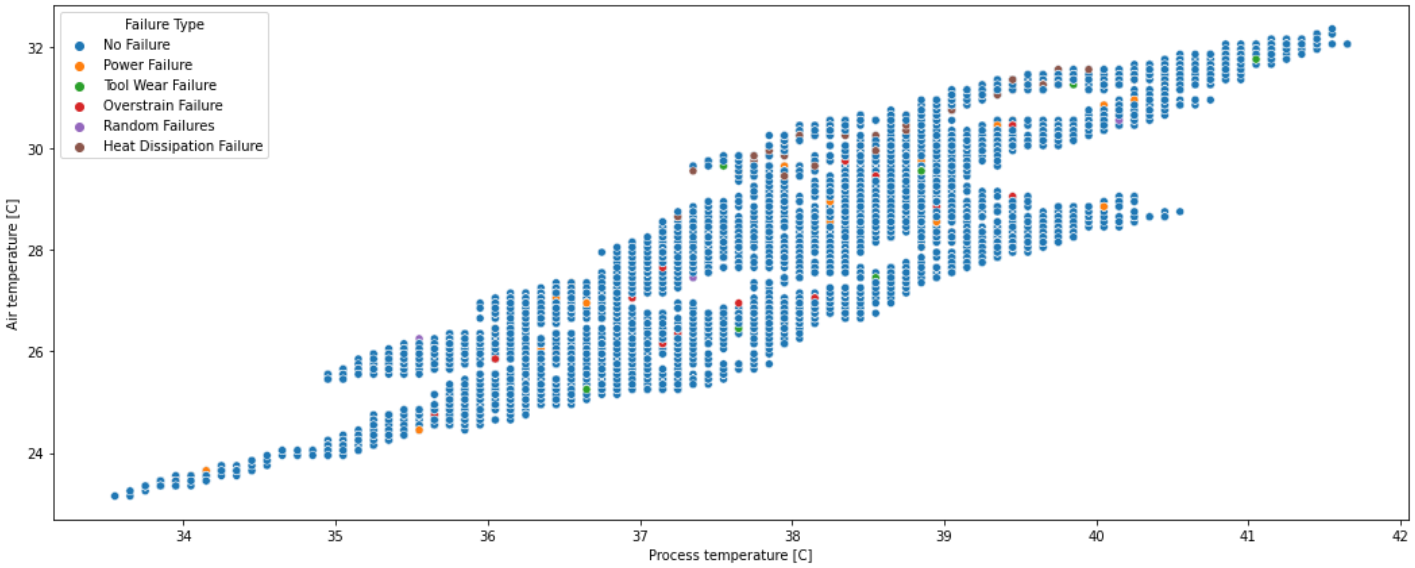


In [30]:

```
#Sürü grafiği farklı kategorik değişkenlerin görselleştirilmesine yardımcı olur.
#benzer şekilde scatter plot (serpilme grafiği) de 2 tür verinin incelendiği durumda kulla
#bu veri analizi için sürü grafiğine göre daha hızlı sonuç alınmıştır.
```

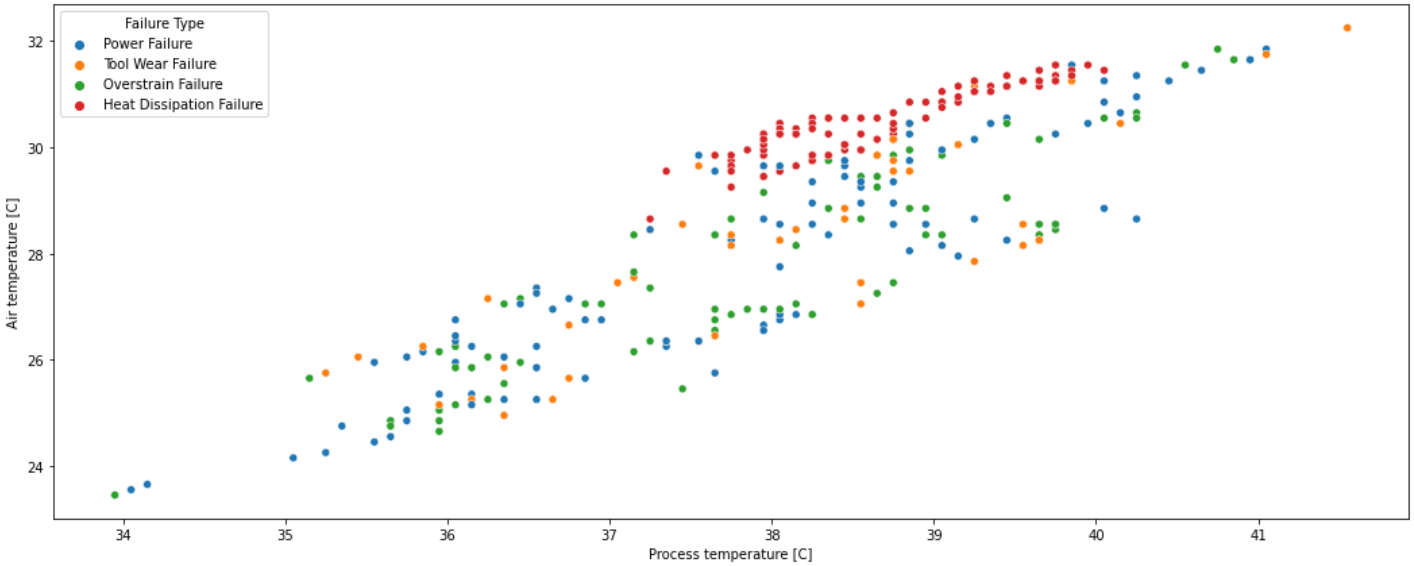
In [31]:

```
#farklı değişkenlere göre arızaların oluşmasının gözlemlenmesi (arıza olmayan durumlar ha
plt.figure(figsize=(18,7))
sns.scatterplot(data=df, x="Process temperature [C]", y="Air temperature [C]", hue="Failu
```



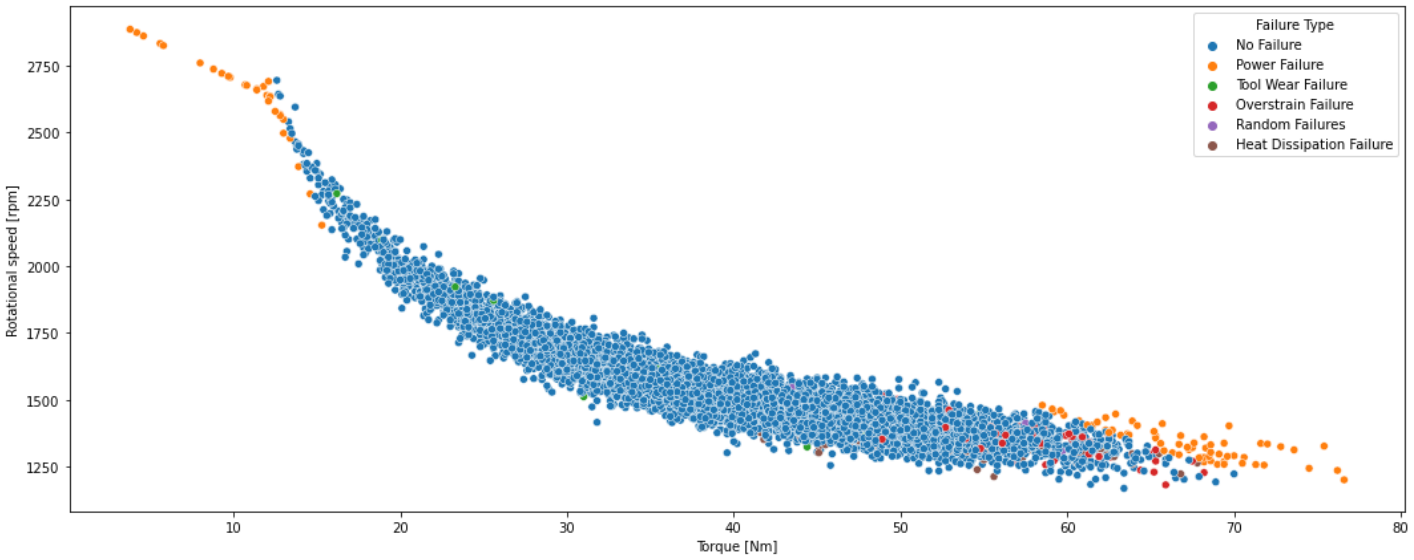
In [32]:

```
#farklı değişkenlere göre arızaların oluşmasının gözlemlenmesi (arızalı olduğu durumda ya
plt.figure(figsize=(18,7))
sns.scatterplot(data=df[df['Target'] == 1], x="Process temperature [C]", y="Air temperatu
```

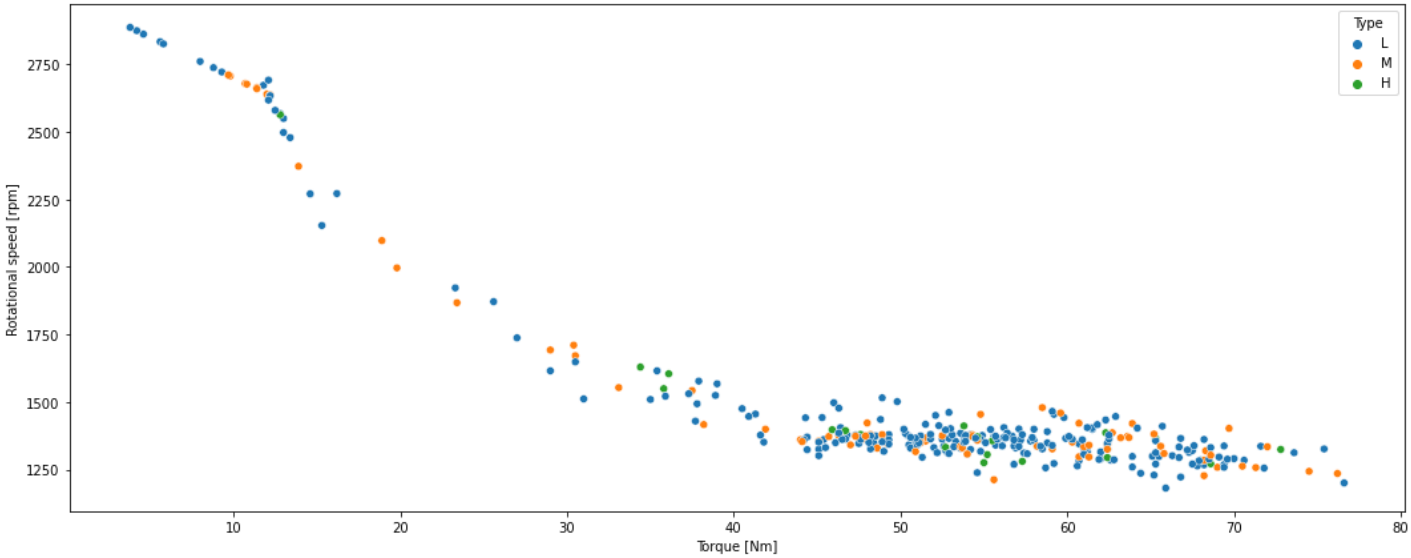


In [33]:
```
#bazı durumlarda verilerin belirli bir kısmının analiz edilmesi daha anlaşılır sonuçlar su
#bazılarında tüm verinin değerlendirilmesi daha açıklayıcı olabilir.
```

In [34]:
```
#farklı değişkenlere göre arızaların oluşmasının gözlemlenmesi (arıza olmayan durumlar hai
plt.figure(figsize=(18,7))
sns.scatterplot(data=df, x="Torque [Nm]", y="Rotational speed [rpm]", hue="Failure Type");
```



In [35]:
```
# Torque ve rotational speed değerlerine göre arıza olan durumda (Target = 1 iken) ürün ti
plt.figure(figsize=(18,7))
sns.scatterplot(data=df[df['Target'] == 1], x="Torque [Nm]", y="Rotational speed [rpm]", h
```


Type
L
M
H
Rotational speed [rpm]
2750
2500
2250
2000
1750
1500
1250
10
20
30
40
50
60
70
80
Torque [Nm]

In [ ]: