Evaluation

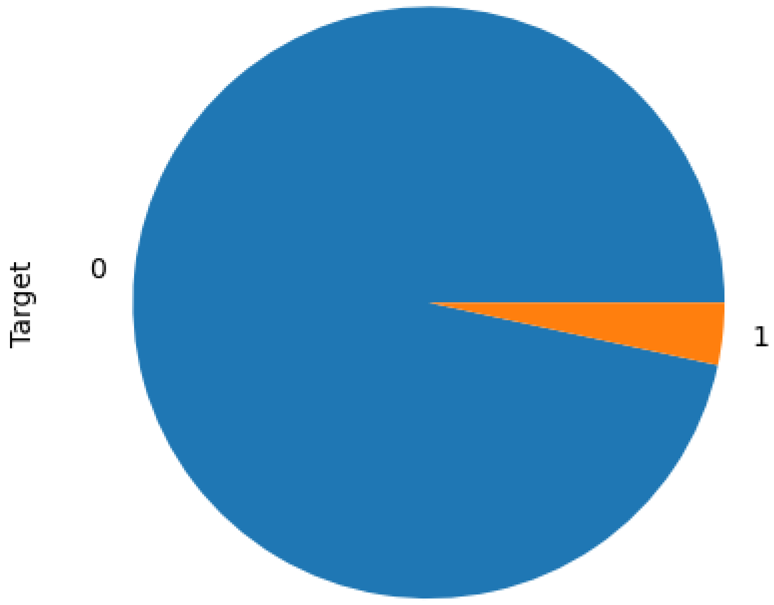
In [30]:
```
import pandas as pd
import seaborn as sns
from sklearn.preprocessing import OrdinalEncoder
import matplotlib.pyplot as plt
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import train_test_split
from sklearn import metrics
from sklearn import tree
```

Target split

In [25]:
```
maintenance = pd.read_csv("predictive_maintenance_prepared.csv")
```

In [26]:
```
maintenance['Target'].value_counts().plot(kind='pie')
```

Out[26]:
```
<AxesSubplot: ylabel='Target'>
```



As we can see in the pie chart above, we have way more Targets of value 0 than Targets of value 1. This means we have to split the data evenly into a test- and a training set. Due to the limited amount of Target 1s a validation set would reduce the data too much.

In [27]:
```
maintenance['Target'].value_counts()
```

Out[27]:
```
0    9661
1     339
Name: Target, dtype: int64
```

Splitting data

For demonstrative purposes, the data will not be split evenly at first.

In [28]:

```
maintenance.describe()
```

Out[28]:

	Id	Type	Air temperature [K]	Process temperature [K]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Ta
count	10000.00000	10000.000000	10000.000000	10000.000000	10000.000000	10000.000000	10000.000000	10000.00
mean	4999.50000	0.500300	300.004930	310.005560	1538.776100	39.986910	107.951000	0.03
std	2886.89568	0.671301	2.000259	1.483734	179.284096	9.968934	63.654147	0.18
min	0.00000	0.000000	295.300000	305.700000	1168.000000	3.800000	0.000000	0.00
25%	2499.75000	0.000000	298.300000	308.800000	1423.000000	33.200000	53.000000	0.00
50%	4999.50000	0.000000	300.100000	310.100000	1503.000000	40.100000	108.000000	0.00
75%	7499.25000	1.000000	301.500000	311.100000	1612.000000	46.800000	162.000000	0.00
max	9999.00000	2.000000	304.500000	313.800000	2886.000000	76.600000	253.000000	1.00

In [29]:

```
X = maintenance[['Type', 'Air temperature [K]', 'Process temperature [K]', 'Rotational speed [rp
y = maintenance['Target']

X_train, X_test, y_train, y_test = train_test_split(X,y,random_state=20)

dt_model = DecisionTreeClassifier()
dt_model.fit(X_train, y_train)

y_pred = dt_model.predict(X_test)

accuracy_score = metrics.accuracy_score(y_test, y_pred)
print('Accuracy: {:.2%}'.format(accuracy_score))
```

```
Accuracy: 97.84%
```

The accuracy is already at 97.84% without any adjustments. Let's take a look at the decision tree structure and the training data set.

Analysing the data and the first decision tree

In [42]:

```
tree_as_text = tree.export_text(dt_model, feature_names=list(maintenance.columns[1:-1]))
print(tree_as_text)
```

```
|--- Torque [Nm] <= 65.05
|   |--- Torque [Nm] <= 13.15
|   |   |--- Process temperature [K] <= 313.30
|   |   |   |--- Type <= 1.50
|   |   |   |   |--- class: 1
|   |   |   |--- Type >  1.50
|   |   |   |   |--- Process temperature [K] <= 309.00
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- Process temperature [K] >  309.00
|   |   |   |   |   |--- class: 1
|   |   |--- Process temperature [K] >  313.30
|   |   |   |--- class: 0
|   |--- Torque [Nm] >  13.15
|   |   |--- Rotational speed [rpm] <= 1380.50
|   |   |   |--- Air temperature [K] <= 301.55
|   |   |   |   |--- Tool wear [min] <= 199.50
|   |   |   |   |   |--- Torque [Nm] <= 60.65
|   |   |   |   |   |   |--- Tool wear [min] <= 188.50
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- Tool wear [min] >  188.50
|   |   |   |   |   |   |   |--- Process temperature [K] <= 311.70
|   |   |   |   |   |   |   |   |--- Rotational speed [rpm] <= 1281.00
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Rotational speed [rpm] >  1281.00
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Process temperature [K] >  311.70
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- Torque [Nm] >  60.65
|   |   |   |   |   |   |--- Tool wear [min] <= 180.00
|   |   |   |   |   |   |   |--- Air temperature [K] <= 300.75
|   |   |   |   |   |   |   |   |--- Rotational speed [rpm] <= 1371.00
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Rotational speed [rpm] >  1371.00
|   |   |   |   |   |   |   |   |   |--- Torque [Nm] <= 62.95
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Torque [Nm] >  62.95
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Air temperature [K] >  300.75
|   |   |   |   |   |   |   |   |--- Torque [Nm] <= 61.90
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Torque [Nm] >  61.90
|   |   |   |   |   |   |   |   |   |--- Process temperature [K] <= 311.35
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Process temperature [K] >  311.35
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- Tool wear [min] >  180.00
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |--- Tool wear [min] >  199.50
|   |   |   |   |   |--- Torque [Nm] <= 52.45
|   |   |   |   |   |   |--- Tool wear [min] <= 224.00
|   |   |   |   |   |   |   |--- Process temperature [K] <= 308.65
|   |   |   |   |   |   |   |   |--- Process temperature [K] <= 308.30
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Process temperature [K] >  308.30
|   |   |   |   |   |   |   |   |   |--- Air temperature [K] <= 297.80
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Air temperature [K] >  297.80
|   |   |   |   |   |   |   |   |   |   |--- Torque [Nm] <= 49.90
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- Torque [Nm] >  49.90
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Process temperature [K] >  308.65
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- Tool wear [min] >  224.00
|   |   |   |   |   |   |   |--- Torque [Nm] <= 49.75
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Torque [Nm] >  49.75
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- Torque [Nm] >  52.45
|   |   |   |   |   |   |--- Type <= 0.50
|   |   |   |   |   |   |   |--- Air temperature [K] <= 300.65
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Air temperature [K] >  300.65
|   |   |   |   |   |   |   |   |--- Torque [Nm] <= 54.95
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Torque [Nm] >  54.95
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Type >  0.50
|   |   |   |   |   |   |   |--- Torque [Nm] <= 60.35
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Torque [Nm] >  60.35
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |--- Air temperature [K] >  301.55
|   |   |   |   |--- Process temperature [K] <= 310.55
|   |   |   |   |   |--- Air temperature [K] <= 301.75
|   |   |   |   |   |   |--- Process temperature [K] <= 310.30
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Process temperature [K] >  310.30
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- Air temperature [K] >  301.75
|   |   |   |   |   |   |--- class: 1
|   |   |   |   |--- Process temperature [K] >  310.55
|   |   |   |   |   |--- Tool wear [min] <= 206.50
|   |   |   |   |   |   |--- Process temperature [K] <= 312.15
|   |   |   |   |   |   |   |--- Air temperature [K] <= 302.65
|   |   |   |   |   |   |   |   |--- Process temperature [K] <= 310.95
|   |   |   |   |   |   |   |   |   |--- Air temperature [K] <= 302.05
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Air temperature [K] >  302.05
|   |   |   |   |   |   |   |   |   |   |--- Tool wear [min] <= 82.00
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |--- Tool wear [min] >  82.00
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Process temperature [K] >  310.95
|   |   |   |   |   |   |   |   |   |--- Air temperature [K] <= 302.55
|   |   |   |   |   |   |   |   |   |   |--- Process temperature [K] <= 311.75
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- Process temperature [K] >  311.75
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |--- Air temperature [K] >  302.55
|   |   |   |   |   |   |   |   |   |   |--- Process temperature [K] <= 311.30
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- Process temperature [K] >  311.30
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Air temperature [K] >  302.65
|   |   |   |   |   |   |   |   |--- Process temperature [K] <= 312.05
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Process temperature [K] >  312.05
|   |   |   |   |   |   |   |   |   |--- Air temperature [K] <= 303.30
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Air temperature [K] >  303.30
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Process temperature [K] >  312.15
|   |   |   |   |   |   |   |--- Tool wear [min] <= 203.50
|   |   |   |   |   |   |   |   |--- Tool wear [min] <= 193.50
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Tool wear [min] >  193.50
|   |   |   |   |   |   |   |   |   |--- Tool wear [min] <= 195.50
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Tool wear [min] >  195.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Tool wear [min] >  203.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- Tool wear [min] >  206.50
|   |   |   |   |   |   |--- Process temperature [K] <= 312.05
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Process temperature [K] >  312.05
|   |   |   |   |   |   |   |--- class: 0
|   |   |--- Rotational speed [rpm] >  1380.50
|   |   |   |--- Torque [Nm] <= 59.05
|   |   |   |   |--- Tool wear [min] <= 204.50
|   |   |   |   |   |--- Torque [Nm] <= 13.45
|   |   |   |   |   |   |--- Type <= 1.00
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Type >  1.00
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- Torque [Nm] >  13.45
|   |   |   |   |   |   |--- Torque [Nm] <= 15.35
|   |   |   |   |   |   |   |--- Air temperature [K] <= 296.45
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Air temperature [K] >  296.45
|   |   |   |   |   |   |   |   |--- Torque [Nm] <= 15.25
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Torque [Nm] >  15.25
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Torque [Nm] >  15.35
|   |   |   |   |   |   |   |--- Tool wear [min] <= 201.50
|   |   |   |   |   |   |   |   |--- Rotational speed [rpm] <= 1439.50
|   |   |   |   |   |   |   |   |   |--- Rotational speed [rpm] <= 1437.50
|   |   |   |   |   |   |   |   |   |   |--- Air temperature [K] <= 303.55
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 4
|   |   |   |   |   |   |   |   |   |   |--- Air temperature [K] >  303.55
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |--- Rotational speed [rpm] >  1437.50
|   |   |   |   |   |   |   |   |   |   |--- Torque [Nm] <= 45.05
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- Torque [Nm] >  45.05
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 4
|   |   |   |   |   |   |   |   |--- Rotational speed [rpm] >  1439.50
|   |   |   |   |   |   |   |   |   |--- Torque [Nm] <= 29.15
|   |   |   |   |   |   |   |   |   |   |--- Torque [Nm] <= 29.05
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 4
|   |   |   |   |   |   |   |   |   |   |--- Torque [Nm] >  29.05
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |--- Torque [Nm] >  29.15
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Tool wear [min] >  201.50
|   |   |   |   |   |   |   |   |--- Torque [Nm] <= 54.90
|   |   |   |   |   |   |   |   |   |--- Rotational speed [rpm] <= 1973.00
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Rotational speed [rpm] >  1973.00
|   |   |   |   |   |   |   |   |   |   |--- Rotational speed [rpm] <= 2103.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- Rotational speed [rpm] >  2103.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Torque [Nm] >  54.90
|   |   |   |   |   |   |   |   |   |--- Process temperature [K] <= 308.55
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Process temperature [K] >  308.55
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- Tool wear [min] >  204.50
|   |   |   |   |   |--- Torque [Nm] <= 52.10
|   |   |   |   |   |   |--- Tool wear [min] <= 224.50
|   |   |   |   |   |   |   |--- Air temperature [K] <= 304.20
|   |   |   |   |   |   |   |   |--- Rotational speed [rpm] <= 1405.50
|   |   |   |   |   |   |   |   |   |--- Air temperature [K] <= 299.60
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Air temperature [K] >  299.60
|   |   |   |   |   |   |   |   |   |   |--- Air temperature [K] <= 300.80
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |   |--- Air temperature [K] >  300.80
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |--- Rotational speed [rpm] >  1405.50
|   |   |   |   |   |   |   |   |   |--- Rotational speed [rpm] <= 2270.00
|   |   |   |   |   |   |   |   |   |   |--- Process temperature [K] <= 313.10
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 10
|   |   |   |   |   |   |   |   |   |   |--- Process temperature [K] >  313.10
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |--- Rotational speed [rpm] >  2270.00
|   |   |   |   |   |   |   |   |   |   |--- Rotational speed [rpm] <= 2443.00
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- Rotational speed [rpm] >  2443.00
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Air temperature [K] >  304.20
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Tool wear [min] >  224.50
|   |   |   |   |   |   |   |--- Torque [Nm] <= 45.40
|   |   |   |   |   |   |   |   |--- Rotational speed [rpm] <= 1593.50
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Rotational speed [rpm] >  1593.50
|   |   |   |   |   |   |   |   |   |--- Tool wear [min] <= 225.50
|   |   |   |   |   |   |   |   |   |   |--- Air temperature [K] <= 301.05
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- Air temperature [K] >  301.05
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Tool wear [min] >  225.50
|   |   |   |   |   |   |   |   |   |   |--- Type <= 0.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |   |--- Type >  0.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |--- Torque [Nm] >  45.40
|   |   |   |   |   |   |   |   |--- Tool wear [min] <= 227.00
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Tool wear [min] >  227.00
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- Torque [Nm] >  52.10
|   |   |   |   |   |   |--- Rotational speed [rpm] <= 1436.00
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Rotational speed [rpm] >  1436.00
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |--- Torque [Nm] >  59.05
|   |   |   |   |--- Rotational speed [rpm] <= 1418.50
|   |   |   |   |   |--- Torque [Nm] <= 61.10
|   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- Torque [Nm] >  61.10
|   |   |   |   |   |   |--- Tool wear [min] <= 82.00
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- Tool wear [min] >  82.00
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |--- Rotational speed [rpm] >  1418.50
|   |   |   |   |   |--- class: 1
|--- Torque [Nm] >  65.05
|   |--- Rotational speed [rpm] <= 1228.50
|   |   |--- Process temperature [K] <= 311.25
|   |   |   |--- class: 0
|   |   |--- Process temperature [K] >  311.25
|   |   |   |--- class: 1
|   |--- Rotational speed [rpm] >  1228.50
|   |   |--- Torque [Nm] <= 67.40
|   |   |   |--- Rotational speed [rpm] <= 1294.00
|   |   |   |   |--- Tool wear [min] <= 184.00
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- Tool wear [min] >  184.00
|   |   |   |   |   |--- class: 1
|   |   |   |--- Rotational speed [rpm] >  1294.00
|   |   |   |   |--- class: 1
|   |   |--- Torque [Nm] >  67.40
|   |   |   |--- class: 1
```

In [37]:

```
X_train.info()
print('-----------')
y_train.info()
print('Unique values')
y_train.value_counts()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 7500 entries, 2294 to 4367
Data columns (total 6 columns):
 #   Column                   Non-Null Count  Dtype  
---  ------                   --------------  -----  
 0   Type                     7500 non-null   float64
 1   Air temperature [K]      7500 non-null   float64
 2   Process temperature [K]  7500 non-null   float64
 3   Rotational speed [rpm]   7500 non-null   int64  
 4   Torque [Nm]              7500 non-null   float64
 5   Tool wear [min]          7500 non-null   int64  
dtypes: float64(4), int64(2)
memory usage: 410.2 KB
-----------
<class 'pandas.core.series.Series'>
Int64Index: 7500 entries, 2294 to 4367
Series name: Target
Non-Null Count  Dtype
--------------  -----
7500 non-null   int64
dtypes: int64(1)
memory usage: 117.2 KB
Unique values
```

Out[37]:

```
0    7243
1     257
Name: Target, dtype: int64
```

In [44]:

```
X_test.info()
print('-----------')
y_test.info()
print('Unique values')
y_test.value_counts()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 2500 entries, 9957 to 6961
Data columns (total 6 columns):
 #   Column                   Non-Null Count  Dtype  
---  ------                   --------------  -----  
 0   Type                     2500 non-null   float64
 1   Air temperature [K]      2500 non-null   float64
 2   Process temperature [K]  2500 non-null   float64
 3   Rotational speed [rpm]   2500 non-null   int64  
 4   Torque [Nm]              2500 non-null   float64
 5   Tool wear [min]          2500 non-null   int64  
dtypes: float64(4), int64(2)
memory usage: 136.7 KB
-----------
<class 'pandas.core.series.Series'>
Int64Index: 2500 entries, 9957 to 6961
Series name: Target
Non-Null Count  Dtype
--------------  -----
2500 non-null   int64
dtypes: int64(1)
memory usage: 39.1 KB
Unique values
```

Out[44]:

```
0    2418
1      82
Name: Target, dtype: int64
```

As we can see and have predicted, the ratio between Target 1 and Target 0 is totally imbalanced between the test and training set. So let's split it evenly.

Splitting the data evenly

In [52]:

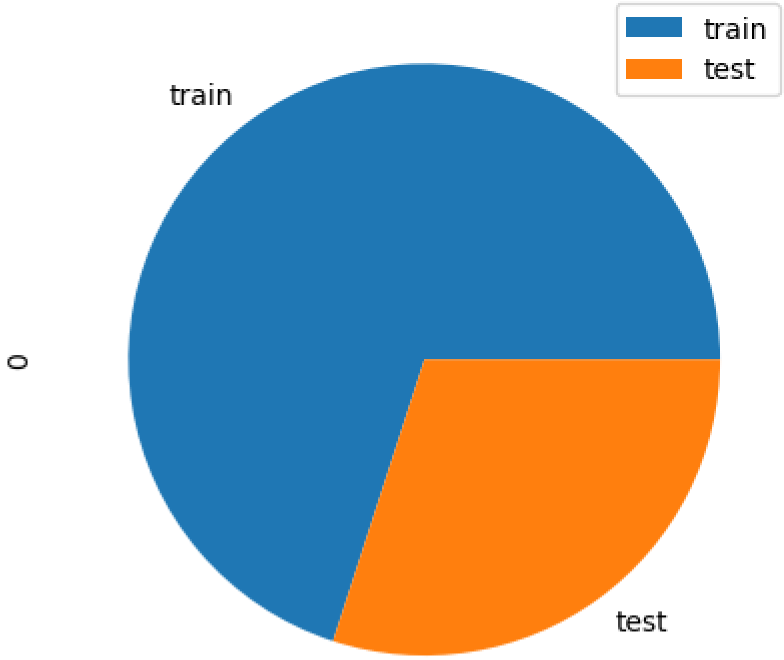
```
X = maintenance[maintenance.columns[1:-1]]
y = maintenance['Target']

X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=20, test_size=0.3, strati
```

In [53]:

```
pd.DataFrame([len(y_train), len(y_test)], index=['train', 'test']).plot(kind='pie', subplots=Tru
```

Out[53]:

```
array([<AxesSubplot: ylabel='0'>], dtype=object)
```

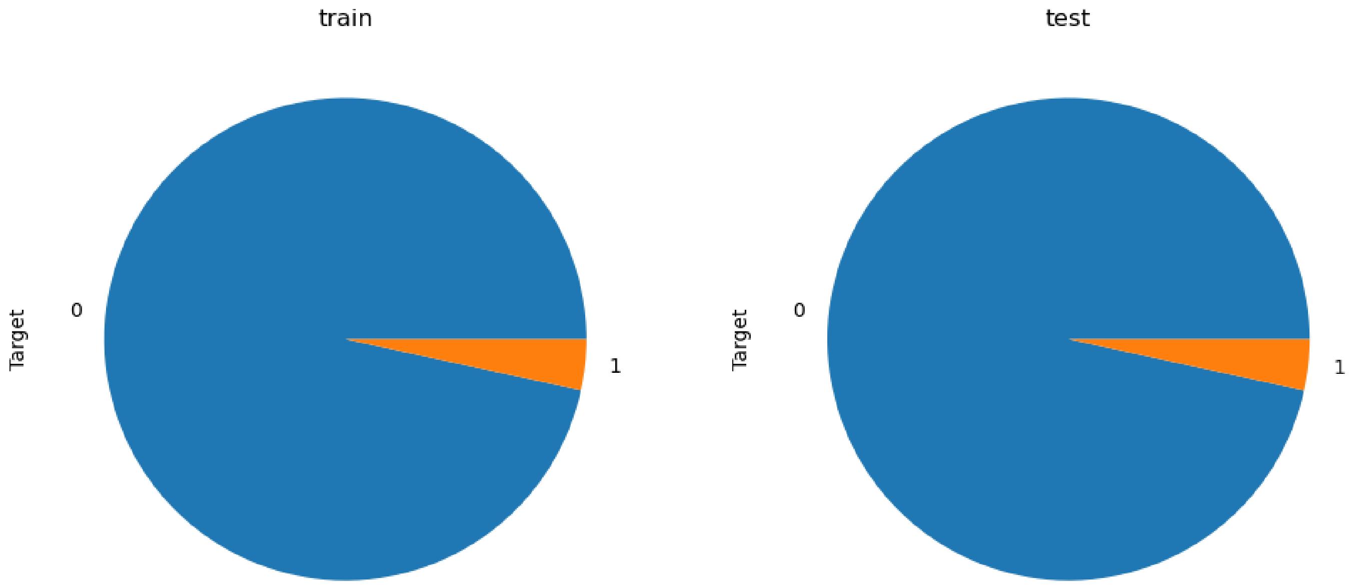


In [54]:

```
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(12,6))
y_train.value_counts().plot(kind='pie', ax=ax1, title='train')
y_test.value_counts().plot(kind='pie', ax=ax2, title='test')
```

Out[54]:

```
<AxesSubplot: title={'center': 'test'}, ylabel='Target'>
```



In [58]:

```
print('Train dataset target amount: ')
y_train.value_counts()
```

```
Train dataset target amount:
```

Out[58]:

```
0    6763
1     237
Name: Target, dtype: int64
```

In [59]:

```
print('Test dataset target amount: ')
y_test.value_counts()
```

```
Test dataset target amount:
```

Out[59]:

```
0    2898
1     102
Name: Target, dtype: int64
```

Making a new decision tree with balanced data

In [60]:

```
dt_model = DecisionTreeClassifier()
dt_model.fit(X_train, y_train)

y_pred = dt_model.predict(X_test)

accuracy_score = metrics.accuracy_score(y_test, y_pred)
print('Accuracy: {:.2%}'.format(accuracy_score))
```

```
Accuracy: 98.13%
```

With the balanced data the accuracy got even higher.

In [66]:

```
def train_and_find_best_depth(X_train, X_val, y_train, y_val, do_print):
    result = None
    accuracy_max = -1

    for curr_max_depth in range(1, 20):
        dt_model = DecisionTreeClassifier(max_depth=curr_max_depth, random_state=20)
        dt_model.fit(X_train, y_train)
        y_pred = dt_model.predict(X_val)

        accuracy_score = metrics.accuracy_score(y_val, y_pred)

        if accuracy_score >= accuracy_max:
            accuracy_max = accuracy_score
            result = curr_max_depth

        if do_print:
            print('max depth {}: {:.2%} accuracy on test set.'.format(curr_max_depth, accuracy_s
    if do_print:
        print('-' * 20)
        print('best max depth {} has {:.2%} accuracy.'.format(result,accuracy_max))

    return result
```

In [67]:

```
best_max_depth = train_and_find_best_depth(X_train ,X_test, y_train, y_test, True)
```

```
max depth 1: 97.00% accuracy on test set.
max depth 2: 97.17% accuracy on test set.
max depth 3: 97.20% accuracy on test set.
max depth 4: 97.40% accuracy on test set.
max depth 5: 97.60% accuracy on test set.
max depth 6: 97.87% accuracy on test set.
max depth 7: 98.43% accuracy on test set.
max depth 8: 98.40% accuracy on test set.
max depth 9: 98.43% accuracy on test set.
max depth 10: 98.43% accuracy on test set.
max depth 11: 98.43% accuracy on test set.
max depth 12: 98.43% accuracy on test set.
max depth 13: 98.43% accuracy on test set.
max depth 14: 98.43% accuracy on test set.
max depth 15: 98.43% accuracy on test set.
max depth 16: 98.30% accuracy on test set.
max depth 17: 98.23% accuracy on test set.
max depth 18: 98.23% accuracy on test set.
max depth 19: 98.27% accuracy on test set.
--------------------
best max depth 15 has 98.43% accuracy.
```

According to the output the best depth ist 15, although about the same accuracy can be achieved with only a depth of 7.