Arcing_Issue_Case_Random_Forest-20221109

November 9, 2022

1 Arcing Issue

[117]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

1.1 import data

[118]:

```
dataset=r'C:\Users\pj007\exercises\JMP_Case\dataset\Arcing Issue_195.csv'
data=pd.read_csv(dataset)
data
```

[118]:

```
   Glass ID Arcing Classification  1PC_ITEMP_AVG  1PC_ITEMP_MAX  \
0        G1                     Y          339.7          340.0
1        G2                     N          341.4          341.6
2        G4                     N          340.8          341.0
3        G5                     Y          339.4          339.6
4        G6                     N          340.9          341.0
5       G10                     N          339.0          339.0
6       G11                     N          341.9          342.1
7       G14                     Y          339.5          339.7
8       G15                     Y          340.7          340.8
9       G16                     Y          339.1          339.5
10      G19                     Y          340.5          340.7
11      G20                     N          341.1          341.3
12      G21                     Y          338.4          338.6
13      G23                     Y          339.4          339.7
14      G24                     N          339.2          339.5
15      G25                     N          340.7          341.0
16      G26                     Y          339.2          339.3
17      G27                     N          340.6          340.6
18      G28                     Y          338.6          338.8
19      G30                     Y          339.4          339.6
20      G36                     Y          339.8          340.2
21      G37                     Y          340.7          340.8
22      G38                     Y          339.6          339.7
23      G39                     N          341.2          341.3
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24       G3                     Y          339.1          339.5
25       G7                     Y          339.3          339.7
26      G13                     Y          341.8          342.0
27      G17                     N          340.9          341.0
28      G18                     Y          339.1          339.3
29      G22                     N          340.4          340.6
30      G33                     N          339.7          339.8
31      G34                     N          340.8          341.0
32       G8                     N          341.0          341.0
33       G9                     Y          339.0          339.2
34      G12                     Y          339.9          340.2
35      G29                     Y          341.6          342.0
36      G31                     Y          338.6          338.8
37      G32                     N          341.7          342.0
38      G35                     Y          340.4          340.7
39      G40                     Y          339.0          339.2

    1PC_ITEMP_MIN  1PC_OTEMP2_AVG  1PC_OTEMP2_MAX  1PC_OTEMP2_MIN  \
0           339.5           360.1           360.2           359.9
1           341.3           360.2           360.2           360.2
2           340.7           360.2           360.3           360.2
3           339.1           360.2           360.3           360.0
4           340.7           359.8           360.2           359.4
5           339.0           359.8           360.2           359.5
6           341.8           359.9           360.4           359.7
7           339.2           359.6           359.8           359.5
8           340.7           359.6           359.9           359.3
9           338.8           360.0           360.2           359.9
10          340.5           359.8           360.0           359.4
11          341.0           359.9           360.0           359.8
12          338.2           359.6           359.9           359.3
13          339.2           359.8           360.0           359.5
14          339.0           360.1           360.3           359.9
15          340.7           360.1           360.3           359.8
16          339.0           360.2           360.3           360.2
17          340.5           360.2           360.3           359.9
18          338.3           360.2           360.2           360.2
19          339.2           359.6           359.7           359.5
20          339.6           359.5           359.7           359.4
21          340.5           360.0           360.3           359.7
22          339.3           359.6           359.7           359.5
23          341.1           360.0           360.0           360.0
24          338.8           360.1           360.2           359.9
25          339.2           359.7           359.9           359.3
26          341.6           359.8           359.9           359.7
27          340.8           359.5           360.0           359.3
28          338.8           359.7           360.0           359.4
```

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29         340.3           359.6           360.0           359.4
30         339.6           359.7           359.8           359.7
31         340.6           359.7           360.0           359.5
32         341.0           359.7           359.9           359.5
33         338.7           359.6           360.0           359.4
34         339.7           359.7           360.2           359.4
35         341.5           359.5           359.8           359.4
36         338.3           359.9           360.3           359.5
37         341.6           359.8           360.0           359.7
38         340.2           360.2           360.3           360.0
39         338.7           360.2           360.4           359.9

    1PC_OTEMP_AVG  1PC_OTEMP_MAX  …  6RF_VDC_MAX  6RF_VDC_MIN  6RF_VPP_AVG  \
0           359.6          360.0  …         20.9         20.8       1767.2
1           359.6          359.9  …         20.8         20.6       1768.4
2           359.6          360.0  …         20.8         20.8       1756.6
3           359.6          360.0  …         20.8         20.8       1750.9
4           359.6          359.9  …         20.8         20.7       1759.1
5           359.9          359.9  …         21.0         21.0       1769.7
6           359.7          359.8  …         21.0         20.9       1766.5
7           360.0          360.4  …         20.9         20.8       1759.1
8           359.7          360.0  …         20.9         20.9       1750.3
9           360.2          360.2  …         20.9         20.8       1747.2
10          359.6          359.8  …         21.0         20.9       1739.1
11          360.2          360.3  …         20.7         20.7       1749.1
12          359.4          359.5  …         20.9         20.8       1763.4
13          359.6          359.9  …         20.8         20.8       1754.1
14          360.0          360.3  …         20.9         20.9       1754.7
15          359.8          360.0  …         20.8         20.8       1751.6
16          359.6          359.8  …         20.8         20.8       1746.0
17          359.5          359.9  …         21.0         20.8       1742.8
18          359.8          360.2  …         20.8         20.8       1764.7
19          359.9          360.0  …         20.8         20.8       1756.6
20          360.3          360.4  …         20.9         20.9       1775.9
21          359.6          359.9  …         21.0         20.9       1752.8
22          360.1          360.2  …         20.9         20.8       1760.3
23          359.4          359.4  …         20.9         20.9       1760.3
24          359.5          359.7  …         20.9         20.7       1762.2
25          359.5          359.7  …         21.0         20.8       1755.9
26          360.2          360.3  …         20.9         20.7       1761.6
27          359.5          359.7  …         20.9         20.8       1746.6
28          359.6          359.7  …         21.0         20.9       1745.3
29          359.6          360.0  …         21.0         20.9       1747.2
30          360.2          360.4  …         20.9         20.8       1755.9
31          359.7          360.2  …         21.1         21.0       1754.1
32          359.5          359.7  …         20.9         20.9       1750.3
33          359.5          359.8  …         20.8         20.8       1749.1
```

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34          359.7          359.9  …          20.8          20.8        1766.5
35          360.1          360.3  …          20.8          20.8        1761.6
36          359.7          360.2  …          20.9          20.9        1771.5
37          360.2          360.3  …          20.9          20.8        1767.8
38          359.8          360.2  …          21.1          21.1        1770.9
39          359.6          359.9  …          20.9          20.9        1755.9

    6RF_VPP_MAX  6RF_VPP_MIN  6TH_VALVE_AVG  6TH_VALVE_MAX  6TH_VALVE_MIN  \
0        1778.4       1759.7           14.4           16.2           12.2
1        1782.1       1755.9           15.1           16.8           13.2
2        1765.3       1748.4           12.8           15.5            9.6
3        1761.6       1742.8           14.2           15.8           12.0
4        1772.8       1746.6           15.1           16.3           13.8
5        1778.4       1763.4           15.1           20.2            9.7
6        1774.7       1759.7           13.8           16.5            9.6
7        1770.9       1750.3           15.4           16.9           13.9
8        1759.7       1742.8           14.8           16.5           13.0
9        1757.8       1737.2           13.8           15.7           11.9
10       1748.4       1731.6           14.5           16.1           12.6
11       1761.6       1737.2           15.4           16.7           14.3
12       1770.9       1757.8           15.0           17.2           12.2
13       1767.2       1742.8           15.1           15.9           14.7
14       1767.2       1744.7           13.3           15.9           10.0
15       1763.4       1742.8           15.8           17.9           13.8
16       1755.9       1737.2           14.3           16.0           12.6
17       1754.1       1731.6           14.2           15.3           12.1
18       1776.5       1755.9           14.4           16.1           11.8
19       1767.2       1746.6           15.2           17.4           13.3
20       1785.9       1767.2           14.8           16.1           13.2
21       1763.4       1742.8           13.2           15.7            9.8
22       1770.9       1750.3           15.0           16.4           13.4
23       1770.9       1752.2           15.5           16.7           14.0
24       1772.8       1754.1           14.8           16.3           12.9
25       1765.3       1746.6           15.0           16.5           14.0
26       1772.8       1754.1           15.1           16.4           13.6
27       1757.8       1737.2           15.1           16.5           13.6
28       1757.8       1735.3           14.5           15.9           12.0
29       1755.9       1741.0           13.1           15.1            9.5
30       1765.3       1746.6           13.4           16.2            9.2
31       1765.3       1744.7           14.7           16.2           12.9
32       1763.4       1739.1           15.2           16.5           13.3
33       1761.6       1739.1           15.4           17.1           13.2
34       1778.4       1755.9           15.2           16.0           14.4
35       1772.8       1752.2           14.2           16.3           12.0
36       1782.1       1763.4           14.3           17.3           10.4
37       1778.4       1759.7           14.5           16.4           12.1
38       1782.1       1761.6           14.8           16.2           13.0
```

```
39       1765.3       1748.4             14.6              16.3              12.7

    6WFS_PM
0       1.0
1       2.0
2       4.0
3       5.0
4       4.0
5       1.0
6       2.0
7       3.0
8       4.0
9       5.0
10      8.0
11      8.0
12      1.0
13      5.0
14      5.0
15      6.0
16      7.0
17      8.0
18      1.0
19      3.0
20      2.0
21      5.0
22      6.0
23      7.0
24      3.0
25      5.0
26      2.0
27      6.0
28      7.0
29      4.0
30      3.0
31      4.0
32      6.0
33      7.0
34      3.0
35      2.0
36      1.0
37      2.0
38      1.0
39      8.0

[40 rows x 198 columns]
```

1.1.1 train_set

[119]:

```
train_data=data.iloc[0:32,2:-1]
train_data
```

[119]:

```
    1PC_ITEMP_AVG  1PC_ITEMP_MAX  1PC_ITEMP_MIN  1PC_OTEMP2_AVG  \
0           339.7          340.0          339.5           360.1
1           341.4          341.6          341.3           360.2
2           340.8          341.0          340.7           360.2
3           339.4          339.6          339.1           360.2
4           340.9          341.0          340.7           359.8
5           339.0          339.0          339.0           359.8
6           341.9          342.1          341.8           359.9
7           339.5          339.7          339.2           359.6
8           340.7          340.8          340.7           359.6
9           339.1          339.5          338.8           360.0
10          340.5          340.7          340.5           359.8
11          341.1          341.3          341.0           359.9
12          338.4          338.6          338.2           359.6
13          339.4          339.7          339.2           359.8
14          339.2          339.5          339.0           360.1
15          340.7          341.0          340.7           360.1
16          339.2          339.3          339.0           360.2
17          340.6          340.6          340.5           360.2
18          338.6          338.8          338.3           360.2
19          339.4          339.6          339.2           359.6
20          339.8          340.2          339.6           359.5
21          340.7          340.8          340.5           360.0
22          339.6          339.7          339.3           359.6
23          341.2          341.3          341.1           360.0
24          339.1          339.5          338.8           360.1
25          339.3          339.7          339.2           359.7
26          341.8          342.0          341.6           359.8
27          340.9          341.0          340.8           359.5
28          339.1          339.3          338.8           359.7
29          340.4          340.6          340.3           359.6
30          339.7          339.8          339.6           359.7
31          340.8          341.0          340.6           359.7

    1PC_OTEMP2_MAX  1PC_OTEMP2_MIN  1PC_OTEMP_AVG  1PC_OTEMP_MAX  \
0            360.2           359.9          359.6          360.0
1            360.2           360.2          359.6          359.9
2            360.3           360.2          359.6          360.0
3            360.3           360.0          359.6          360.0
4            360.2           359.4          359.6          359.9
5            360.2           359.5          359.9          359.9
6            360.4           359.7          359.7          359.8
```

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7            359.8           359.5          360.0          360.4
8            359.9           359.3          359.7          360.0
9            360.2           359.9          360.2          360.2
10           360.0           359.4          359.6          359.8
11           360.0           359.8          360.2          360.3
12           359.9           359.3          359.4          359.5
13           360.0           359.5          359.6          359.9
14           360.3           359.9          360.0          360.3
15           360.3           359.8          359.8          360.0
16           360.3           360.2          359.6          359.8
17           360.3           359.9          359.5          359.9
18           360.2           360.2          359.8          360.2
19           359.7           359.5          359.9          360.0
20           359.7           359.4          360.3          360.4
21           360.3           359.7          359.6          359.9
22           359.7           359.5          360.1          360.2
23           360.0           360.0          359.4          359.4
24           360.2           359.9          359.5          359.7
25           359.9           359.3          359.5          359.7
26           359.9           359.7          360.2          360.3
27           360.0           359.3          359.5          359.7
28           360.0           359.4          359.6          359.7
29           360.0           359.4          359.6          360.0
30           359.8           359.7          360.2          360.4
31           360.0           359.5          359.7          360.2

    1PC_OTEMP_MIN  1PRESSURE_AVG  …  6RF_VDC_AVG  6RF_VDC_MAX  6RF_VDC_MIN  \
0           359.3            7.8  …         20.9         20.9         20.8
1           359.5            8.7  …         20.7         20.8         20.6
2           359.4            7.8  …         20.8         20.8         20.8
3           359.4            7.8  …         20.8         20.8         20.8
4           359.3            8.3  …         20.8         20.8         20.7
5           359.8            8.8  …         21.0         21.0         21.0
6           359.5            8.5  …         21.0         21.0         20.9
7           359.7            9.3  …         20.8         20.9         20.8
8           359.3            8.7  …         20.9         20.9         20.9
9           360.0            8.5  …         20.9         20.9         20.8
10          359.3            8.5  …         21.0         21.0         20.9
11          359.9            8.2  …         20.7         20.7         20.7
12          359.3            8.6  …         20.8         20.9         20.8
13          359.4            8.6  …         20.8         20.8         20.8
14          359.7            8.5  …         20.9         20.9         20.9
15          359.4            8.3  …         20.8         20.8         20.8
16          359.4            8.5  …         20.8         20.8         20.8
17          359.4            8.3  …         20.9         21.0         20.8
18          359.4            9.0  …         20.8         20.8         20.8
19          359.7            9.0  …         20.8         20.8         20.8
```

```
20          359.9            5.8  …         20.9         20.9         20.9
21          359.4            5.2  …         20.9         21.0         20.9
22          359.9            5.0  …         20.9         20.9         20.8
23          359.3            4.8  …         20.9         20.9         20.9
24          359.3            8.1  …         20.8         20.9         20.7
25          359.4            8.5  …         20.8         21.0         20.8
26          360.2            8.5  …         20.9         20.9         20.7
27          359.4            8.7  …         20.9         20.9         20.8
28          359.4            8.3  …         21.0         21.0         20.9
29          359.4            8.7  …         20.9         21.0         20.9
30          359.9            8.7  …         20.9         20.9         20.8
31          359.5            8.4  …         21.0         21.1         21.0

    6RF_VPP_AVG  6RF_VPP_MAX  6RF_VPP_MIN  6TH_VALVE_AVG  6TH_VALVE_MAX  \
0        1767.2       1778.4       1759.7           14.4           16.2  
1        1768.4       1782.1       1755.9           15.1           16.8  
2        1756.6       1765.3       1748.4           12.8           15.5  
3        1750.9       1761.6       1742.8           14.2           15.8  
4        1759.1       1772.8       1746.6           15.1           16.3  
5        1769.7       1778.4       1763.4           15.1           20.2  
6        1766.5       1774.7       1759.7           13.8           16.5  
7        1759.1       1770.9       1750.3           15.4           16.9  
8        1750.3       1759.7       1742.8           14.8           16.5  
9        1747.2       1757.8       1737.2           13.8           15.7  
10       1739.1       1748.4       1731.6           14.5           16.1  
11       1749.1       1761.6       1737.2           15.4           16.7  
12       1763.4       1770.9       1757.8           15.0           17.2  
13       1754.1       1767.2       1742.8           15.1           15.9  
14       1754.7       1767.2       1744.7           13.3           15.9  
15       1751.6       1763.4       1742.8           15.8           17.9  
16       1746.0       1755.9       1737.2           14.3           16.0  
17       1742.8       1754.1       1731.6           14.2           15.3  
18       1764.7       1776.5       1755.9           14.4           16.1  
19       1756.6       1767.2       1746.6           15.2           17.4  
20       1775.9       1785.9       1767.2           14.8           16.1  
21       1752.8       1763.4       1742.8           13.2           15.7  
22       1760.3       1770.9       1750.3           15.0           16.4  
23       1760.3       1770.9       1752.2           15.5           16.7  
24       1762.2       1772.8       1754.1           14.8           16.3  
25       1755.9       1765.3       1746.6           15.0           16.5  
26       1761.6       1772.8       1754.1           15.1           16.4  
27       1746.6       1757.8       1737.2           15.1           16.5  
28       1745.3       1757.8       1735.3           14.5           15.9  
29       1747.2       1755.9       1741.0           13.1           15.1  
30       1755.9       1765.3       1746.6           13.4           16.2  
31       1754.1       1765.3       1744.7           14.7           16.2  
```

```
    6TH_VALVE_MIN  6WFS_PM
0            12.2      1.0
1            13.2      2.0
2             9.6      4.0
3            12.0      5.0
4            13.8      4.0
5             9.7      1.0
6             9.6      2.0
7            13.9      3.0
8            13.0      4.0
9            11.9      5.0
10           12.6      8.0
11           14.3      8.0
12           12.2      1.0
13           14.7      5.0
14           10.0      5.0
15           13.8      6.0
16           12.6      7.0
17           12.1      8.0
18           11.8      1.0
19           13.3      3.0
20           13.2      2.0
21            9.8      5.0
22           13.4      6.0
23           14.0      7.0
24           12.9      3.0
25           14.0      5.0
26           13.6      2.0
27           13.6      6.0
28           12.0      7.0
29            9.5      4.0
30            9.2      3.0
31           12.9      4.0

[32 rows x 195 columns]
```

[120]:
```
train_labels=data.iloc[0:32,1]
train_labels
```

[120]:
```
0     Y
1     N
2     N
3     Y
4     N
5     N
6     N
7     Y
```

```
8     Y
9     Y
10    Y
11    N
12    Y
13    Y
14    N
15    N
16    Y
17    N
18    Y
19    Y
20    Y
21    Y
22    Y
23    N
24    Y
25    Y
26    Y
27    N
28    Y
29    N
30    N
31    N
Name: Arcing Classification, dtype: object
```

1.1.2 test_set

[121]:

```
test_data=data.iloc[32:,2:-1]
test_data
```

[121]:

```
    1PC_ITEMP_AVG  1PC_ITEMP_MAX  1PC_ITEMP_MIN  1PC_OTEMP2_AVG  \
32          341.0          341.0          341.0           359.7
33          339.0          339.2          338.7           359.6
34          339.9          340.2          339.7           359.7
35          341.6          342.0          341.5           359.5
36          338.6          338.8          338.3           359.9
37          341.7          342.0          341.6           359.8
38          340.4          340.7          340.2           360.2
39          339.0          339.2          338.7           360.2

    1PC_OTEMP2_MAX  1PC_OTEMP2_MIN  1PC_OTEMP_AVG  1PC_OTEMP_MAX  \
32           359.9           359.5          359.5          359.7
33           360.0           359.4          359.5          359.8
34           360.2           359.4          359.7          359.9
35           359.8           359.4          360.1          360.3
36           360.3           359.5          359.7          360.2
```

```
37           360.0           359.7          360.2          360.3
38           360.3           360.0          359.8          360.2
39           360.4           359.9          359.6          359.9

    1PC_OTEMP_MIN  1PRESSURE_AVG  ...  6RF_VDC_AVG  6RF_VDC_MAX  6RF_VDC_MIN  \
32          359.4            8.1  ...         20.9         20.9         20.9
33          359.4            7.9  ...         20.8         20.8         20.8
34          359.7            8.6  ...         20.8         20.8         20.8
35          359.8            8.5  ...         20.8         20.8         20.8
36          359.4            8.5  ...         20.9         20.9         20.9
37          360.0            8.1  ...         20.9         20.9         20.8
38          359.5            5.8  ...         21.1         21.1         21.1
39          359.5            5.5  ...         20.9         20.9         20.9

    6RF_VPP_AVG  6RF_VPP_MAX  6RF_VPP_MIN  6TH_VALVE_AVG  6TH_VALVE_MAX  \
32       1750.3       1763.4       1739.1           15.2           16.5
33       1749.1       1761.6       1739.1           15.4           17.1
34       1766.5       1778.4       1755.9           15.2           16.0
35       1761.6       1772.8       1752.2           14.2           16.3
36       1771.5       1782.1       1763.4           14.3           17.3
37       1767.8       1778.4       1759.7           14.5           16.4
38       1770.9       1782.1       1761.6           14.8           16.2
39       1755.9       1765.3       1748.4           14.6           16.3

    6TH_VALVE_MIN  6WFS_PM
32           13.3      6.0
33           13.2      7.0
34           14.4      3.0
35           12.0      2.0
36           10.4      1.0
37           12.1      2.0
38           13.0      1.0
39           12.7      8.0

[8 rows x 195 columns]
```

[122]:
```
test_labels=data.iloc[32:,1]
test_labels
```

[122]:
```
32    N
33    Y
34    Y
35    Y
36    Y
37    N
38    Y
39    Y
```

```
Name: Arcing Classification, dtype: object
```

1.2 export standard dataset

[123]:
```
from sklearn import datasets, preprocessing
#from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
scaler=preprocessing.StandardScaler().fit(train_data)
train_data=scaler.transform(train_data)
test_data=scaler.transform(test_data)
```

[124]:
```
Arcing_Issue_standard1=data.iloc[:,0:2]
#Arcing_Issue_standard1
```

[125]:
```
train_data_df=pd.DataFrame(train_data)
#train_data_df
```

[126]:
```
test_data_df=pd.DataFrame(test_data)
#test_data_df
```

[127]:
```
Arcing_Issue_standard2=pd.concat([train_data_df,test_data_df]).
 ↪reset_index(drop=True)
#Arcing_Issue_standard2
```

[128]:
```
Arcing_Issue_standard3=data.iloc[:,-1:]
#Arcing_Issue_standard3
```

[129]:
```
cols=list(data.columns)
#cols
```

[130]:
```
Arcing_Issue_standard=pd.
 ↪concat([Arcing_Issue_standard1,Arcing_Issue_standard2,Arcing_Issue_standard3],axis=1)
#Arcing_Issue_standard
```

[131]:
```
Arcing_Issue_standard.columns=cols
Arcing_Issue_standard
```

[131]:
```
   Glass ID Arcing Classification  1PC_ITEMP_AVG  1PC_ITEMP_MAX  \
0        G1                     Y      -0.384757      -0.284609
1        G2                     N       1.435313       1.471051
2        G4                     N       0.792935       0.812679
3        G5                     Y      -0.705946      -0.723524
4        G6                     N       0.899998       0.812679
5       G10                     N      -1.134198      -1.381897
6       G11                     N       1.970627       2.019695
7       G14                     Y      -0.598883      -0.613795
```

```
8       G15                     Y        0.685872       0.593221
9       G16                     Y       -1.027135      -0.833253
10      G19                     Y        0.471746       0.483492
11      G20                     N        1.114124       1.141865
12      G21                     Y       -1.776576      -1.820812
13      G23                     Y       -0.705946      -0.613795
14      G24                     N       -0.920072      -0.833253
15      G25                     N        0.685872       0.812679
16      G26                     Y       -0.920072      -1.052710
17      G27                     N        0.578809       0.373764
18      G28                     Y       -1.562450      -1.601354
19      G30                     Y       -0.705946      -0.723524
20      G36                     Y       -0.277694      -0.065151
21      G37                     Y        0.685872       0.593221
22      G38                     Y       -0.491820      -0.613795
23      G39                     N        1.221187       1.141865
24       G3                     Y       -1.027135      -0.833253
25       G7                     Y       -0.813009      -0.613795
26      G13                     Y        1.863564       1.909966
27      G17                     N        0.899998       0.812679
28      G18                     Y       -1.027135      -1.052710
29      G22                     N        0.364683       0.373764
30      G33                     N       -0.384757      -0.504067
31      G34                     N        0.792935       0.812679
32       G8                     N        1.007061       0.812679
33       G9                     Y       -1.134198      -1.162439
34      G12                     Y       -0.170632      -0.065151
35      G29                     Y        1.649438       1.909966
36      G31                     Y       -1.562450      -1.601354
37      G32                     N        1.756501       1.909966
38      G35                     Y        0.364683       0.483492
39      G40                     Y       -1.134198      -1.162439

    1PC_ITEMP_MIN  1PC_OTEMP2_AVG  1PC_OTEMP2_MAX  1PC_OTEMP2_MIN  \
0       -0.399929        0.983611        0.649002        0.739290
1        1.428320        1.408957        0.649002        1.767868
2        0.818903        1.408957        1.143480        1.767868
3       -0.806207        1.408957        1.143480        1.082150
4        0.818903       -0.292425        0.649002       -0.975006
5       -0.907776       -0.292425        0.649002       -0.632147
6        1.936166        0.132920        1.637957        0.053572
7       -0.704638       -1.143116       -1.328909       -0.632147
8        0.818903       -1.143116       -0.834431       -1.317866
9       -1.110915        0.558266        0.649002        0.739290
10       0.615764       -0.292425       -0.339953       -0.975006
11       1.123611        0.132920       -0.339953        0.396431
12      -1.720332       -1.143116       -0.834431       -1.317866
```

```
13      -0.704638       -0.292425       -0.339953       -0.632147
14      -0.907776        0.983611        1.143480        0.739290
15       0.818903        0.983611        1.143480        0.396431
16      -0.907776        1.408957        1.143480        1.767868
17       0.615764        1.408957        1.143480        0.739290
18      -1.618762        1.408957        0.649002        1.767868
19      -0.704638       -1.143116       -1.823386       -0.632147
20      -0.298360       -1.568461       -1.823386       -0.975006
21       0.615764        0.558266        1.143480        0.053572
22      -0.603068       -1.143116       -1.823386       -0.632147
23       1.225181        0.558266       -0.339953        1.082150
24      -1.110915        0.983611        0.649002        0.739290
25      -0.704638       -0.717770       -0.834431       -1.317866
26       1.733028       -0.292425       -0.834431        0.053572
27       0.920473       -1.568461       -0.339953       -1.317866
28      -1.110915       -0.717770       -0.339953       -0.975006
29       0.412626       -1.143116       -0.339953       -0.975006
30      -0.298360       -0.717770       -1.328909        0.053572
31       0.717334       -0.717770       -0.339953       -0.632147
32       1.123611       -0.717770       -0.834431       -0.632147
33      -1.212485       -1.143116       -0.339953       -0.975006
34      -0.196791       -0.717770        0.649002       -0.975006
35       1.631458       -1.568461       -1.328909       -0.975006
36      -1.618762        0.132920        1.143480       -0.632147
37       1.733028       -0.292425       -0.339953        0.053572
38       0.311056        1.408957        1.143480        1.082150
39      -1.212485        1.408957        1.637957        0.739290

    1PC_OTEMP_AVG  1PC_OTEMP_MAX  …  6RF_VDC_MAX  6RF_VDC_MIN  6RF_VPP_AVG  \
0       -0.589421       0.074102  …     0.035377    -0.255434     1.311505
1       -0.589421      -0.321110  …    -1.096701    -2.590827     1.453289
2       -0.589421       0.074102  …    -1.096701    -0.255434     0.059077
3       -0.589421       0.074102  …    -1.096701    -0.255434    -0.614399
4       -0.589421      -0.321110  …    -1.096701    -1.423130     0.354461
5        0.565363      -0.321110  …     1.167456     2.079960     1.606889
6       -0.204493      -0.716322  …     1.167456     0.912263     1.228797
7        0.950291       1.654952  …     0.035377    -0.255434     0.354461
8       -0.204493       0.074102  …     0.035377     0.912263    -0.685291
9        1.720147       0.864527  …     0.035377    -0.255434    -1.051567
10      -0.589421      -0.716322  …     1.167456     0.912263    -2.008611
11       1.720147       1.259739  …    -2.228780    -1.423130    -0.827075
12      -1.359277      -1.901959  …     0.035377    -0.255434     0.862521
13      -0.589421      -0.321110  …    -1.096701    -0.255434    -0.236307
14       0.950291       1.259739  …     0.035377     0.912263    -0.165415
15       0.180435       0.074102  …    -1.096701    -0.255434    -0.531691
16      -0.589421      -0.716322  …    -1.096701    -0.255434    -1.193351
17      -0.974349      -0.321110  …     1.167456    -0.255434    -1.571442
```

```
18     0.180435      0.864527  …    -1.096701     -0.255434      1.016121
19     0.565363      0.074102  …    -1.096701     -0.255434      0.059077
20     2.105075      1.654952  …     0.035377      0.912263      2.339441
21    -0.589421     -0.321110  …     1.167456      0.912263     -0.389907
22     1.335219      0.864527  …     0.035377     -0.255434      0.496245
23    -1.359277     -2.297172  …     0.035377      0.912263      0.496245
24    -0.974349     -1.111535  …     0.035377     -1.423130      0.720737
25    -0.974349     -1.111535  …     1.167456     -0.255434     -0.023631
26     1.720147      1.259739  …     0.035377     -1.423130      0.649845
27    -0.974349     -1.111535  …     0.035377     -0.255434     -1.122459
28    -0.589421     -1.111535  …     1.167456      0.912263     -1.276059
29    -0.589421      0.074102  …     1.167456      0.912263     -1.051567
30     1.720147      1.654952  …     0.035377     -0.255434     -0.023631
31    -0.204493      0.864527  …     2.299535      2.079960     -0.236307
32    -0.974349     -1.111535  …     0.035377      0.912263     -0.685291
33    -0.974349     -0.716322  …    -1.096701     -0.255434     -0.827075
34    -0.204493     -0.321110  …    -1.096701     -0.255434      1.228797
35     1.335219      1.259739  …    -1.096701     -0.255434      0.649845
36    -0.204493      0.864527  …     0.035377      0.912263      1.819565
37     1.720147      1.259739  …     0.035377     -0.255434      1.382397
38     0.180435      0.864527  …     2.299535      3.247656      1.748673
39    -0.589421     -0.321110  …     0.035377      0.912263     -0.023631

    6RF_VPP_MAX  6RF_VPP_MIN  6TH_VALVE_AVG  6TH_VALVE_MAX  6TH_VALVE_MIN  \
0      1.360938     1.409973      -0.210652      -0.228309      -0.078011
1      1.795734     0.984849       0.714565       0.446081       0.546076
2     -0.178472     0.145787      -2.325434      -1.015098      -1.700636
3     -0.613267    -0.480712      -0.475000      -0.677903      -0.202828
4      0.702870    -0.055588       0.714565      -0.115911       0.920528
5      1.360938     1.823910       0.714565       4.267626      -1.638227
6      0.926143     1.409973      -1.003695       0.108886      -1.700636
7      0.479597     0.358349       1.111087       0.558479       0.982936
8     -0.836540    -0.480712       0.318043       0.108886       0.421258
9     -1.059813    -1.107212      -1.003695      -0.790301      -0.265237
10    -2.164428    -1.733711      -0.078478      -0.340708       0.171624
11    -0.613267    -1.107212       1.111087       0.333683       1.232571
12     0.479597     1.197411       0.582391       0.895675      -0.078011
13     0.044802    -0.480712       0.714565      -0.565504       1.482205
14     0.044802    -0.268150      -1.664565      -0.565504      -1.451001
15    -0.401745    -0.480712       1.639782       1.682463       0.920528
16    -1.283087    -1.107212      -0.342826      -0.453106       0.171624
17    -1.494609    -1.733711      -0.475000      -1.239895      -0.140419
18     1.137665     0.984849      -0.210652      -0.340708      -0.327645
19     0.044802    -0.055588       0.846739       1.120471       0.608484
20     2.242280     2.249035       0.318043      -0.340708       0.546076
21    -0.401745    -0.480712      -1.796738      -0.790301      -1.575818
22     0.479597     0.358349       0.582391      -0.003512       0.670893
```

```
23     0.479597     0.570911        1.243260        0.333683        1.045345
24     0.702870     0.783474        0.318043       -0.115911        0.358850
25    -0.178472    -0.055588        0.582391        0.108886        1.045345
26     0.702870     0.783474        0.714565       -0.003512        0.795710
27    -1.059813    -1.107212        0.714565        0.108886        0.795710
28    -1.059813    -1.319774       -0.078478       -0.565504       -0.202828
29    -1.283087    -0.682087       -1.928912       -1.464691       -1.763044
30    -0.178472    -0.055588       -1.532391       -0.228309       -1.950270
31    -0.178472    -0.268150        0.185869       -0.228309        0.358850
32    -0.401745    -0.894649        0.846739        0.108886        0.608484
33    -0.613267    -0.894649        1.111087        0.783276        0.546076
34     1.360938     0.984849        0.846739       -0.453106        1.294979
35     0.702870     0.570911       -0.475000       -0.115911       -0.202828
36     1.795734     1.823910       -0.342826        1.008073       -1.201366
37     1.360938     1.409973       -0.078478       -0.003512       -0.140419
38     1.795734     1.622535        0.318043       -0.228309        0.421258
39    -0.178472     0.145787        0.053696       -0.115911        0.234032

     6WFS_PM
0  -1.533705
1  -1.066290
2  -0.131460
3   0.335954
4  -0.131460
5  -1.533705
6  -1.066290
7  -0.598875
8  -0.131460
9   0.335954
10  1.738199
11  1.738199
12 -1.533705
13  0.335954
14  0.335954
15  0.803369
16  1.270784
17  1.738199
18 -1.533705
19 -0.598875
20 -1.066290
21  0.335954
22  0.803369
23  1.270784
24 -0.598875
25  0.335954
26 -1.066290
27  0.803369
```

```
28  1.270784
29 -0.131460
30 -0.598875
31 -0.131460
32  0.803369
33  1.270784
34 -0.598875
35 -1.066290
36 -1.533705
37 -1.066290
38 -1.533705
39  1.738199

[40 rows x 198 columns]
```

```
[132]: Arcing_Issue_standard.to_csv('Arcing_Issue_standard_195.csv')
```

1.3 train data with RF

```
[ ]: from sklearn.ensemble import RandomForestClassifier

     rnd_clf = RandomForestClassifier(n_estimators=100, min_samples_split=10,␣
      ↪min_samples_leaf=3, max_features=143, n_jobs=-1, random_state=42)
     rnd_clf.fit(train_data, train_labels)
     test_pred = rnd_clf.predict(test_data)
```

1.3.1 accuracy

```
[134]: from sklearn.metrics import accuracy_score
       accuracy_score(test_labels, test_pred)
```

```
[134]: 0.75
```

1.3.2 feature importances

```
[135]: importances_0=rnd_clf.feature_importances_
```

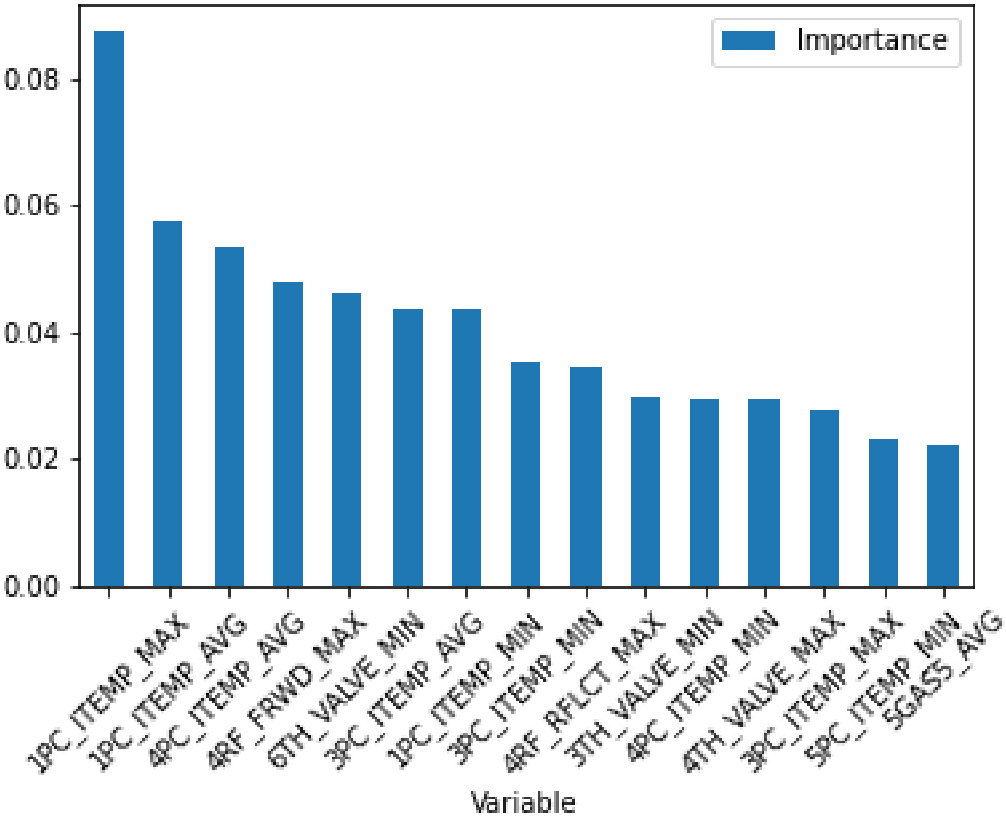
```
[136]: cols_0=data.columns[2:-1]
       df_importances_0=pd.DataFrame({'Variable':cols_0,'Importance':importances_0})
       df_importances_0=df_importances_0.sort_values(by='Importance',ascending=False).
        ↪head(20)
       df_importances_0
```

```
[136]:          Variable  Importance
       1    1PC_ITEMP_MAX    0.087206
       0    1PC_ITEMP_AVG    0.057342
```

```
75    4PC_ITEMP_AVG    0.053386
94     4RF_FRWD_MAX    0.047932
193   6TH_VALVE_MIN    0.046300
44    3PC_ITEMP_AVG    0.043738
2     1PC_ITEMP_MIN    0.043642
46    3PC_ITEMP_MIN    0.035109
100   4RF_RFLCT_MAX    0.034225
64    3TH_VALVE_MIN    0.029806
77    4PC_ITEMP_MIN    0.029430
109   4TH_VALVE_MAX    0.029139
45    3PC_ITEMP_MAX    0.027485
123   5PC_ITEMP_MIN    0.023096
118       5GAS5_AVG    0.022334
167   6PRESSURE_AVG    0.021672
168   6PRESSURE_MAX    0.021636
144     5RF_LOAD_MIN    0.021457
62    3TH_VALVE_AVG    0.019791
36       2RF_VDC_MIN    0.019090
```

[137]:
```python
df_importances_0.head(15).plot(kind='bar',x='Variable', y='Importance', rot=45)
```

[137]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1bb27d6f888>
```



```
[138]: Arcing_Issue_standard.loc[:, df_importances_0.iloc[:15,0]].head()
```

```
[138]:    1PC_ITEMP_MAX  1PC_ITEMP_AVG  4PC_ITEMP_AVG  4RF_FRWD_MAX  6TH_VALVE_MIN  \
       0      -0.284609      -0.384757       0.990137     -0.477036      -0.078011
       1       1.471051       1.435313       0.751010      1.000237       0.546076
       2       0.812679       0.792935       1.109701     -0.723248      -1.700636
       3      -0.723524      -0.705946      -1.162010     -0.230824      -0.202828
       4       0.812679       0.899998       0.870573      1.000237       0.920528

          3PC_ITEMP_AVG  1PC_ITEMP_MIN  3PC_ITEMP_MIN  4RF_RFLCT_MAX  3TH_VALVE_MIN  \
       0       0.131372      -0.399929      -0.221346      -0.797009       -0.26968
       1       1.086804       1.428320       1.066484       1.420755        0.26968
       2       1.086804       0.818903       1.066484      -1.536264        1.34840
       3      -1.015147      -0.806207      -0.773273      -0.797009        1.34840
       4       0.991261       0.818903       1.066484       0.681501       -1.34840

          4PC_ITEMP_MIN  4TH_VALVE_MAX  3PC_ITEMP_MAX  5PC_ITEMP_MIN  5GAS5_AVG
       0       0.792619      -1.664790       0.561551       1.039797  -1.068525
       1       0.792619       0.418523       1.167268       0.643684  -0.031560
       2       1.023199      -0.871147       1.066315       1.039797  -0.130748
       3      -1.282602      -1.367174      -1.255602      -1.072806   0.752927
       4       0.907909      -1.069558       0.965362       0.775721   0.013526
```

1.4 GridSearchCV

```
[139]: '''
       RandomForestClassifier(
           n_estimators='warn',
           criterion='gini',
           max_depth=None,
           min_samples_split=2,
           min_samples_leaf=1,
           min_weight_fraction_leaf=0.0,
           max_features='auto',
           max_leaf_nodes=None,
           min_impurity_decrease=0.0,
           min_impurity_split=None,
           bootstrap=True,
           oob_score=False,
           n_jobs=None,
           random_state=None,
           verbose=0,
           warm_start=False,
           class_weight=None,
)
'''
```

```
[139]: "\nRandomForestClassifier(\n    n_estimators='warn',\n    criterion='gini',\n
       max_depth=None,\n    min_samples_split=2,\n    min_samples_leaf=1,\n
       min_weight_fraction_leaf=0.0,\n    max_features='auto',\n
       max_leaf_nodes=None,\n    min_impurity_decrease=0.0,\n
       min_impurity_split=None,\n    bootstrap=True,\n    oob_score=False,\n
       n_jobs=None,\n    random_state=None,\n    verbose=0,\n    warm_start=False,\n
       class_weight=None,\n)\n"
```

rnd_clf = RandomForestClassifier(n_estimators=100, min_samples_split=10, min_samples_leaf=3, max_features=143, n_jobs=-1, random_state=42)

0.75

```
[140]: from sklearn.ensemble import RandomForestClassifier

       rnd_clf_grid = RandomForestClassifier(n_jobs=-1, random_state=42)
```

```
[ ]: from sklearn.model_selection import GridSearchCV

     param_distributions = {"n_estimators": [100,200], "max_features":
      ↪[120,130],"min_samples_split": [3,5],"min_samples_leaf": [1,3,5,7]}
     grid_search_cv = GridSearchCV(rnd_clf_grid, param_distributions, cv=4,␣
      ↪verbose=2, scoring='accuracy') # 4-fold
     grid_search_cv.fit(train_data, train_labels)
```

```
[142]: grid_search_cv_best=grid_search_cv.best_estimator_
       grid_search_cv_best
```

```
[142]: RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
                              max_depth=None, max_features=120, max_leaf_nodes=None,
                              min_impurity_decrease=0.0, min_impurity_split=None,
                              min_samples_leaf=7, min_samples_split=3,
                              min_weight_fraction_leaf=0.0, n_estimators=100,
                              n_jobs=-1, oob_score=False, random_state=42, verbose=0,
                              warm_start=False)
```

```
[143]: grid_search_cv.best_score_
```

```
[143]: 0.75
```

```
[ ]: grid_search_cv_best.fit(train_data, train_labels)
```

```
[145]: train_pred = grid_search_cv_best.predict(train_data)
       accuracy_score(train_labels, train_pred)
```

```
C:\Users\pj007\Anaconda3\lib\site-packages\sklearn\ensemble\base.py:158:
DeprecationWarning: `np.int` is a deprecated alias for the builtin `int`. To
silence this warning, use `int` by itself. Doing this will not modify any
behavior and is safe. When replacing `np.int`, you may wish to use e.g.
`np.int64` or `np.int32` to specify the precision. If you wish to review your
current use, check the release note link for additional information.
Deprecated in NumPy 1.20; for more details and guidance:
https://numpy.org/devdocs/release/1.20.0-notes.html#deprecations
  dtype=np.int)
```

```
[145]: 0.84375
```

1.5 use RF model to predict labels of test set

```
[146]: test_pred = grid_search_cv_best.predict(test_data)
       test_pred
```

```
C:\Users\pj007\Anaconda3\lib\site-packages\sklearn\ensemble\base.py:158:
DeprecationWarning: `np.int` is a deprecated alias for the builtin `int`. To
silence this warning, use `int` by itself. Doing this will not modify any
behavior and is safe. When replacing `np.int`, you may wish to use e.g.
`np.int64` or `np.int32` to specify the precision. If you wish to review your
current use, check the release note link for additional information.
Deprecated in NumPy 1.20; for more details and guidance:
https://numpy.org/devdocs/release/1.20.0-notes.html#deprecations
  dtype=np.int)
```

```
[146]: array(['N', 'Y', 'Y', 'N', 'Y', 'N', 'Y', 'Y'], dtype=object)
```

1.6 model evaluation

1.6.1 classification_report

```
[147]: df=pd.DataFrame({'test_label':test_labels,'test_pred':test_pred})
       df
```

```
[147]:    test_label test_pred
       32          N         N
       33          Y         Y
       34          Y         Y
       35          Y         N
       36          Y         Y
       37          N         N
       38          Y         Y
       39          Y         Y
```

[148]:

```
import sklearn.metrics as sm
cr = sm.classification_report(test_labels,test_pred)
print(cr)
```

```
              precision    recall  f1-score   support

           N       0.67      1.00      0.80         2
           Y       1.00      0.83      0.91         6

    accuracy                           0.88         8
   macro avg       0.83      0.92      0.85         8
weighted avg       0.92      0.88      0.88         8
```

1.6.2 confusion matrix

[149]:

```
from sklearn.metrics import confusion_matrix
confusion_matrix(test_labels,test_pred)
```

[149]:

```
array([[2, 0],
       [1, 5]], dtype=int64)
```

[150]:

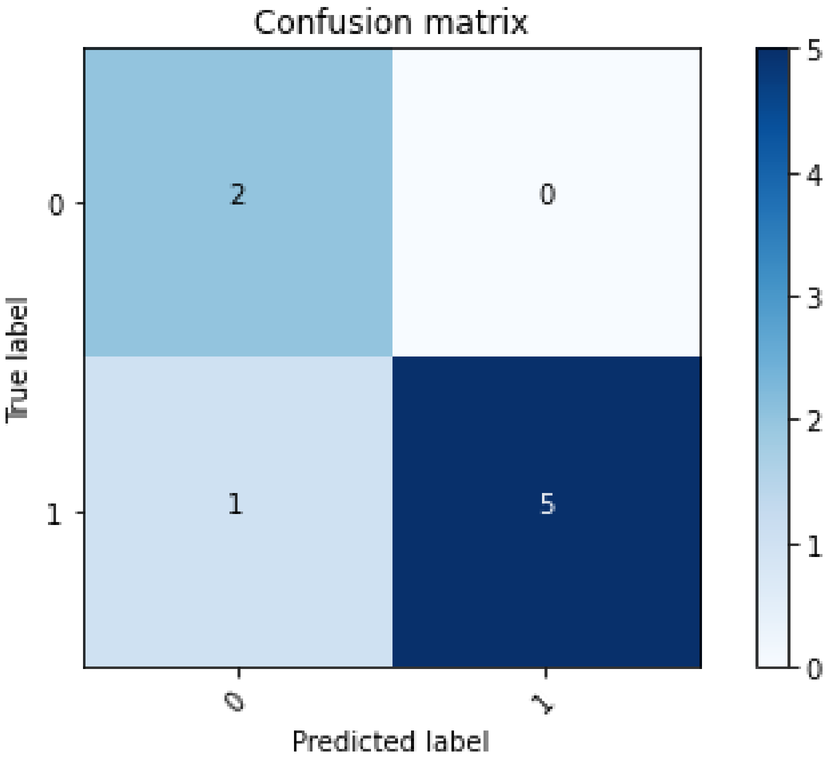
```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import KFold, cross_val_score
from sklearn.metrics import confusion_matrix, recall_score,␣
 ↪classification_report
```

[151]:

```
def plot_confusion_matrix(cm, classes,normalize=False,title='Confusion␣
 ↪matrix',cmap=plt.cm.Blues):
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        print("Normalized confusion matrix")
    else:
        print('Confusion matrix, without normalization')
    print(cm)
    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=45)
    plt.yticks(tick_marks, classes)
    fmt = '.2f' if normalize else 'd'
    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, format(cm[i, j], fmt),
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")
    plt.tight_layout()
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
```

[152]:
```
import itertools
cnf_matrix = confusion_matrix(test_labels,test_pred) #
class_names = [0,1]
plt.figure()
plot_confusion_matrix(cnf_matrix, classes = class_names, title = 'Confusion␣
 ↪matrix')  #
np.set_printoptions(precision=2)
print('Accuracy:', (cnf_matrix[1,1]+cnf_matrix[0,0])/
 ↪(cnf_matrix[1,1]+cnf_matrix[0,1]+cnf_matrix[0,0]+cnf_matrix[1,0]))
print('Recall:', cnf_matrix[1,1]/(cnf_matrix[1,1]+cnf_matrix[1,0]))
print('Precision:', cnf_matrix[1,1]/(cnf_matrix[1,1]+cnf_matrix[0,1]))
print('Specificity:', cnf_matrix[0,0]/(cnf_matrix[0,1]+cnf_matrix[0,0]))
plt.show()
```

```
Confusion matrix, without normalization
[[2 0]
 [1 5]]
Accuracy: 0.875
Recall: 0.8333333333333334
Precision: 1.0
Specificity: 1.0
```



1.6.3 ROC curve

[153]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import sklearn.metrics as metrics

def plot_ROC(labels,preds):
    """
    Args:
        labels : ground truth
        preds : model prediction
        savepath : save path
    """
    fpr1, tpr1, threshold1 = metrics.roc_curve(labels, preds)  #

    roc_auc1 = metrics.auc(fpr1, tpr1)  # auc  auc
    plt.figure()
    lw = 2
    plt.figure(figsize=(10, 10))
    plt.plot(fpr1, tpr1, color='darkorange',
            lw=lw, label='AUC = %0.2f' % roc_auc1)  #
    plt.plot([0, 1], [0, 1], color='navy', lw=lw, linestyle='--')
    plt.xlim([-0.05, 1.05])
    plt.ylim([-0.05, 1.05])
    plt.xlabel('1 - Specificity')
    plt.ylabel('Sensitivity')
    # plt.title('ROCs for Densenet')
    plt.legend(loc="lower right")
    # plt.show()
```

[154]:

```
test_labels_1=np.array(test_labels)
test_labels_1=[1 if x=='Y' else 0 for x in test_labels_1 ]
test_labels_1
```

[154]:

```
[0, 1, 1, 1, 1, 0, 1, 1]
```

[155]:

```
test_pred_1=np.array(test_pred)
test_pred_1=[1 if x=='Y' else 0 for x in test_pred_1 ]
test_pred_1
```

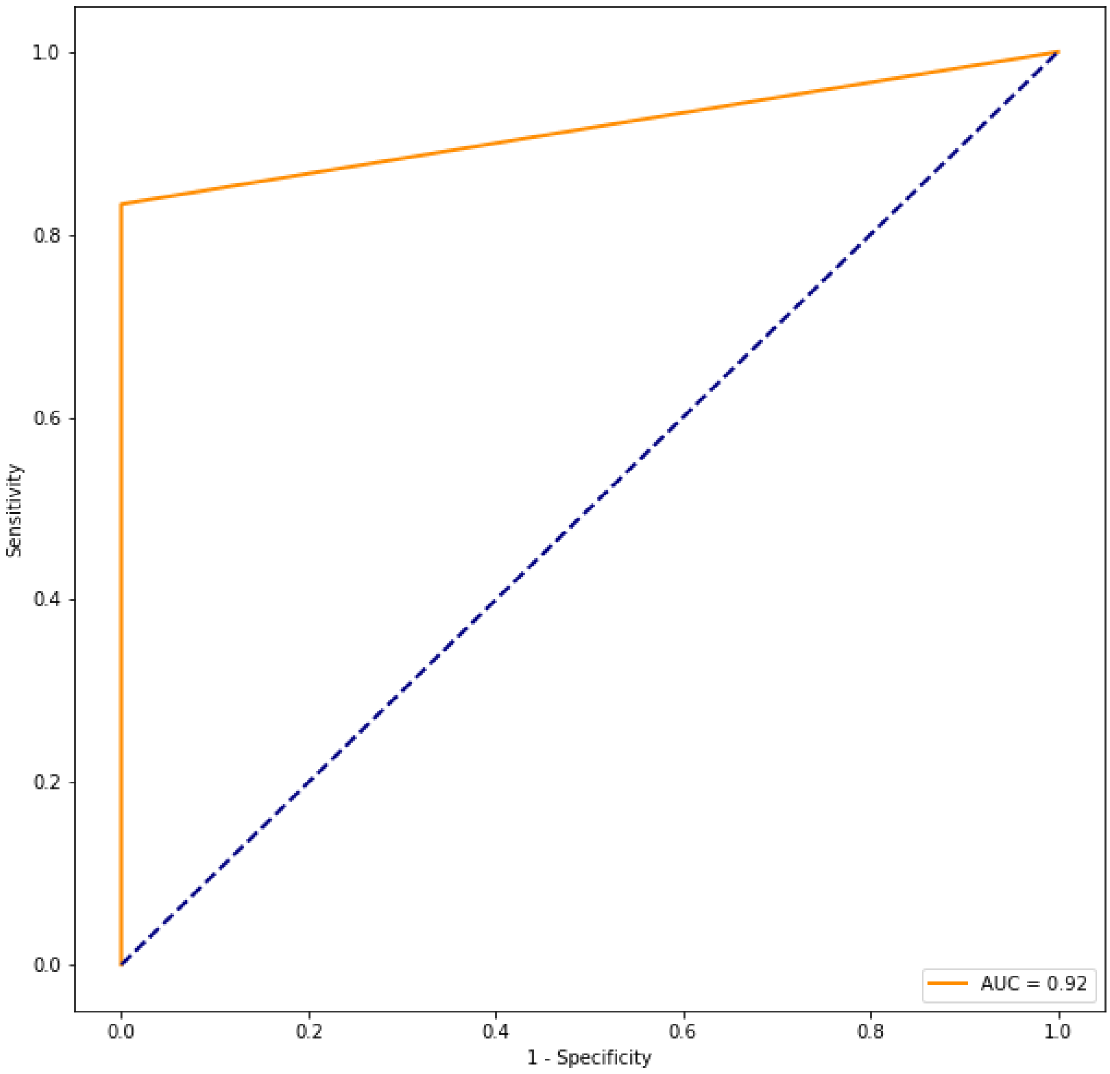
[155]:

```
[0, 1, 1, 0, 1, 0, 1, 1]
```

[156]:

```
plot_ROC(test_labels_1,test_pred_1)
```

```
<Figure size 432x288 with 0 Axes>
```



1.6.4 feature importances

```
[157]: importances=grid_search_cv_best.feature_importances_
```

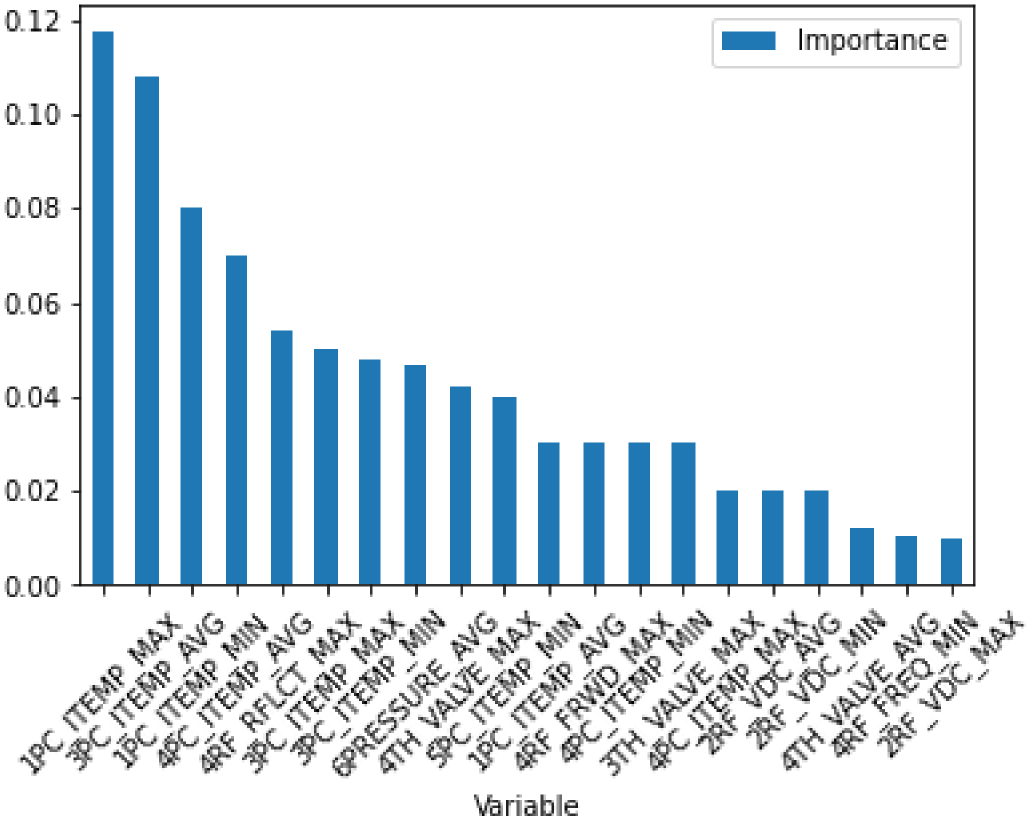
```
[158]: cols=data.columns[2:-1]
df_importances_1=pd.DataFrame({'Variable':cols,'Importance':importances})
df_importances_1=df_importances_1.sort_values(by='Importance',ascending=False).
 ↪head(20)
df_importances_1
```

```
[158]:          Variable  Importance
1     1PC_ITEMP_MAX    0.117355
44    3PC_ITEMP_AVG    0.108142
```

```
2    1PC_ITEMP_MIN    0.080000
75   4PC_ITEMP_AVG    0.070000
100  4RF_RFLCT_MAX    0.054301
45   3PC_ITEMP_MAX    0.050000
46   3PC_ITEMP_MIN    0.047715
167  6PRESSURE_AVG    0.046483
109  4TH_VALVE_MAX    0.042429
123  5PC_ITEMP_MIN    0.039800
0    1PC_ITEMP_AVG    0.030200
94    4RF_FRWD_MAX    0.030000
77   4PC_ITEMP_MIN    0.030000
63   3TH_VALVE_MAX    0.030000
76   4PC_ITEMP_MAX    0.020000
34     2RF_VDC_AVG    0.020000
36     2RF_VDC_MIN    0.020000
108  4TH_VALVE_AVG    0.012285
92    4RF_FREQ_MIN    0.010164
35     2RF_VDC_MAX    0.010000
```

[159]:
```
df_importances_1.head(20).plot(kind='bar',x='Variable', y='Importance', rot=45)
```

[159]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1bb269dca48>
```



```
[160]: Arcing_Issue_standard.loc[:, df_importances_1.iloc[:20,0]].head()
```

```
[160]:    1PC_ITEMP_MAX  3PC_ITEMP_AVG  1PC_ITEMP_MIN  4PC_ITEMP_AVG  4RF_RFLCT_MAX  \
       0      -0.284609       0.131372      -0.399929       0.990137      -0.797009
       1       1.471051       1.086804       1.428320       0.751010       1.420755
       2       0.812679       1.086804       0.818903       1.109701      -1.536264
       3      -0.723524      -1.015147      -0.806207      -1.162010      -0.797009
       4       0.812679       0.991261       0.818903       0.870573       0.681501

          3PC_ITEMP_MAX  3PC_ITEMP_MIN  6PRESSURE_AVG  4TH_VALVE_MAX  5PC_ITEMP_MIN  \
       0       0.561551      -0.221346       0.081557      -1.664790       1.039797
       1       1.167268       1.066484      -0.676131       0.418523       0.643684
       2       1.066315       1.066484       1.091807      -0.871147       1.039797
       3      -1.255602      -0.773273      -0.676131      -1.367174      -1.072806
       4       0.965362       1.066484      -0.339381      -1.069558       0.775721

          1PC_ITEMP_AVG  4RF_FRWD_MAX  4PC_ITEMP_MIN  3TH_VALVE_MAX  4PC_ITEMP_MAX  \
       0      -0.384757     -0.477036       0.792619      -0.455407       0.914145
       1       1.435313      1.000237       0.792619      -0.455407       0.792765
       2       0.792935     -0.723248       1.023199      -0.102122       1.156906
       3      -0.705946     -0.230824      -1.282602      -0.190443      -1.027939
       4       0.899998      1.000237       0.907909      -0.720371       0.792765

          2RF_VDC_AVG  2RF_VDC_MIN  4TH_VALVE_AVG  4RF_FREQ_MIN  2RF_VDC_MAX
       0     1.044185     0.254219      -0.578877      1.264786     1.539865
       1    -0.240966     0.254219      -0.167231      1.632723    -0.778991
       2    -1.526117    -1.623089      -0.270143      0.160973    -0.778991
       3     0.401610     0.254219      -0.270143      0.528910     0.380437
       4    -1.526117    -0.997320      -0.784700     -0.758871    -1.358705
```

1.7 save model using joblib

```
[161]: my_model =grid_search_cv_best
       my_model
```

```
[161]: RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
                              max_depth=None, max_features=120, max_leaf_nodes=None,
                              min_impurity_decrease=0.0, min_impurity_split=None,
                              min_samples_leaf=7, min_samples_split=3,
                              min_weight_fraction_leaf=0.0, n_estimators=100,
                              n_jobs=-1, oob_score=False, random_state=42, verbose=0,
                              warm_start=False)
```

[162]:

```
#save my_model
import joblib
#from sklearn.externals import joblib
joblib.dump(my_model, "random_forest.pkl")
```

[162]:

```
['random_forest.pkl']
```