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Project Title: ANN Mining process flotation plant database

In [1]:

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

In [2]:

```
df = pd.read_csv("D:\ML Lecture\ML Datasets\MiningProcess_Flotation_Plant_Database.csv")
df.head()
```

Out[2]:

	date	% Iron Feed	% Silica Feed	Starch Flow	Amina Flow	Ore Pulp Flow	Ore Pulp pH	Ore Pulp Density	Flotation Column 01 Air Flow	Flotation Column 02 Air Flow	...	Flotation Column 07 Air Flow	Flotation Column 01 Level	Flotation Column 02 Level	Fl
0	2017-03-10 01:00:00	55,2	16,98	3019,53	557,434	395,713	10,0664	1,74	249,214	253,235	...	250,884	457,396	432,962	
1	2017-03-10 01:00:00	55,2	16,98	3024,41	563,965	397,383	10,0672	1,74	249,719	250,532	...	248,994	451,891	429,56	
2	2017-03-10 01:00:00	55,2	16,98	3043,46	568,054	399,668	10,068	1,74	249,741	247,874	...	248,071	451,24	468,927	
3	2017-03-10 01:00:00	55,2	16,98	3047,36	568,665	397,939	10,0689	1,74	249,917	254,487	...	251,147	452,441	458,165	
4	2017-03-10 01:00:00	55,2	16,98	3033,69	558,167	400,254	10,0697	1,74	250,203	252,136	...	248,928	452,441	452,9	

5 rows × 24 columns

In [3]:

```
# replacing ',' with '.'
def XYZ(x):
    return x.str.replace(",",".")
```

In [4]:

```
# applying changes
df = df.apply(XYZ)
```

In [5]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 737453 entries, 0 to 737452
Data columns (total 24 columns):
 #   Column                        Non-Null Count   Dtype
---  ------                        --------------   -----
 0   date                          737453 non-null  object
 1   % Iron Feed                   737453 non-null  object
```

```
 1   % Iron Feed                   737453 non-null  object
 2   % Silica Feed                 737453 non-null  object
 3   Starch Flow                   737453 non-null  object
 4   Amina Flow                    737453 non-null  object
 5   Ore Pulp Flow                 737453 non-null  object
 6   Ore Pulp pH                   737453 non-null  object
 7   Ore Pulp Density              737453 non-null  object
 8   Flotation Column 01 Air Flow  737453 non-null  object
 9   Flotation Column 02 Air Flow  737453 non-null  object
 10  Flotation Column 03 Air Flow  737453 non-null  object
 11  Flotation Column 04 Air Flow  737453 non-null  object
 12  Flotation Column 05 Air Flow  737453 non-null  object
 13  Flotation Column 06 Air Flow  737453 non-null  object
 14  Flotation Column 07 Air Flow  737453 non-null  object
 15  Flotation Column 01 Level     737453 non-null  object
 16  Flotation Column 02 Level     737453 non-null  object
 17  Flotation Column 03 Level     737453 non-null  object
 18  Flotation Column 04 Level     737453 non-null  object
 19  Flotation Column 05 Level     737453 non-null  object
 20  Flotation Column 06 Level     737453 non-null  object
 21  Flotation Column 07 Level     737453 non-null  object
 22  % Iron Concentrate            737453 non-null  object
 23  % Silica Concentrate          737453 non-null  object
dtypes: object(24)
memory usage: 135.0+ MB
```

In [6]:

```
# droping unwanted columns
df.drop("date",axis=1,inplace=True)
```

In [7]:

```
# changing datatype
df = df.astype(float)
```

In [8]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 737453 entries, 0 to 737452
Data columns (total 23 columns):
 #   Column                        Non-Null Count   Dtype  
---  ------                        --------------   -----  
 0   % Iron Feed                   737453 non-null  float64
 1   % Silica Feed                 737453 non-null  float64
 2   Starch Flow                   737453 non-null  float64
 3   Amina Flow                    737453 non-null  float64
 4   Ore Pulp Flow                 737453 non-null  float64
 5   Ore Pulp pH                   737453 non-null  float64
 6   Ore Pulp Density              737453 non-null  float64
 7   Flotation Column 01 Air Flow  737453 non-null  float64
 8   Flotation Column 02 Air Flow  737453 non-null  float64
 9   Flotation Column 03 Air Flow  737453 non-null  float64
 10  Flotation Column 04 Air Flow  737453 non-null  float64
 11  Flotation Column 05 Air Flow  737453 non-null  float64
 12  Flotation Column 06 Air Flow  737453 non-null  float64
 13  Flotation Column 07 Air Flow  737453 non-null  float64
 14  Flotation Column 01 Level     737453 non-null  float64
 15  Flotation Column 02 Level     737453 non-null  float64
 16  Flotation Column 03 Level     737453 non-null  float64
 17  Flotation Column 04 Level     737453 non-null  float64
 18  Flotation Column 05 Level     737453 non-null  float64
 19  Flotation Column 06 Level     737453 non-null  float64
 20  Flotation Column 07 Level     737453 non-null  float64
 21  % Iron Concentrate            737453 non-null  float64
 22  % Silica Concentrate          737453 non-null  float64
dtypes: float64(23)
memory usage: 129.4 MB
```

In [9]:

```
df
```

Out[9]:

	% Iron Feed	% Silica Feed	Starch Flow	Amina Flow	Ore Pulp Flow	Ore Pulp pH	Ore Pulp Density	Flotation Column 01 Air Flow	Flotation Column 02 Air Flow	Flotation Column 03 Air Flow	...	Flotation Column 07 Air Flow	Flotation Column 01 Level	Flot Col 02 l
0	55.20	16.98	3019.53	557.434	395.713	10.06640	1.74000	249.214	253.235	250.576	...	250.884	457.396	432
1	55.20	16.98	3024.41	563.965	397.383	10.06720	1.74000	249.719	250.532	250.862	...	248.994	451.891	429
2	55.20	16.98	3043.46	568.054	399.668	10.06800	1.74000	249.741	247.874	250.313	...	248.071	451.240	468
3	55.20	16.98	3047.36	568.665	397.939	10.06890	1.74000	249.917	254.487	250.049	...	251.147	452.441	458
4	55.20	16.98	3033.69	558.167	400.254	10.06970	1.74000	250.203	252.136	249.895	...	248.928	452.441	452
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
737448	49.75	23.20	2710.94	441.052	386.570	9.62129	1.65365	302.344	298.786	299.163	...	313.695	392.160	430
737449	49.75	23.20	2692.01	473.436	384.939	9.62063	1.65352	303.013	301.879	299.487	...	236.700	401.505	404
737450	49.75	23.20	2692.20	500.488	383.496	9.61874	1.65338	303.662	307.397	299.487	...	225.879	408.899	399
737451	49.75	23.20	1164.12	491.548	384.976	9.61686	1.65324	302.550	301.959	298.045	...	308.115	405.107	466
737452	49.75	23.20	1164.12	468.019	384.801	9.61497	1.65310	300.355	292.865	298.625	...	308.115	413.754	514

737453 rows × 23 columns

In [10]:

```
# Preprocessing the data  X split,Y split
from sklearn.preprocessing import StandardScaler
SS = StandardScaler()
X = df.iloc[:,:-1]
X = SS.fit_transform(X)
X
```

Out[10]:

```
array([[-0.21225167,  0.34202086,  0.12375664, ...,  0.18282424,
         1.20533681,  1.66266665],
       [-0.21225167,  0.34202086,  0.12777243, ...,  0.17783883,
         0.90767427,  1.66266665],
       [-0.21225167,  0.34202086,  0.14344883, ...,  0.19902684,
         0.44227984,  1.66266665],
       ...,
       [-1.26891589,  1.25572783, -0.14560578, ..., -1.04500062,
         0.1426383 , -0.69733357],
       [-1.26891589,  1.25572783, -1.40307479, ..., -0.99148533,
         0.15248617, -0.69733357],
       [-1.26891589,  1.25572783, -1.40307479, ..., -0.61858089,
         0.23748886, -0.69733357]])
```

In [11]:

```
Y = df.iloc[:,-1]
Y
```

Out[11]:

```
0         1.31
1         1.31
2         1.31
3         1.31
4         1.31
          ...
737448    1.71
737449    1.71
737450    1.71
737451    1.71
```

```
737451    1.71
737452    1.71
Name: % Silica Concentrate, Length: 737453, dtype: float64
```

In [12]:

```
# Spliting data and training the data
from sklearn.model_selection import train_test_split
X_train,X_test,Y_train,Y_test = train_test_split(X,Y,train_size=0.3,random_state=1)
```

In [13]:

```
#!pip install tensorflow
```

In [14]:

```
import tensorflow as tf
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense,Dropout
```

In [15]:

```
# Implementing the early stop method
from tensorflow.keras.callbacks import EarlyStopping
early_stop=EarlyStopping(monitor="val_loss",mode="min",verbose=1,patience=20)
```

In [16]:

```
# step1 :- initialize the Model
ann = Sequential()

# step2 :- Add Layers into model
ann.add(Dense(units = 20, activation = "relu") )# HL add
ann.add(Dropout(0.06))

ann.add( Dense(units = 20, activation = "relu") )
ann.add(Dropout(0.04))

ann.add( Dense(units = 1) ) #op layer

# step3 :- Establihing connection
ann.compile(optimizer='adam', loss = 'mse')

# step4 :- Fit the model
ann.fit(X_train,Y_train,epochs=600,validation_data=(X_test,Y_test),verbose=1,batch_size=
128,callbacks=[early_stop])


# step5 :- Predict the model
#Y_pred = ann.predict(X_test)
```

```
Epoch 1/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.7106 - val_loss: 0.350
7
Epoch 2/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.3908 - val_loss: 0.322
9
Epoch 3/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.3585 - val_loss: 0.302
8
Epoch 4/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.3374 - val_loss: 0.289
9
Epoch 5/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.3220 - val_loss: 0.279
2
Epoch 6/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.3112 - val_loss: 0.272
8
Epoch 7/600
1729/1729 [==============================] - 11s 6ms/step - loss: 0.3041 - val_loss: 0.27
15
```

```
Epoch 8/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.3003 - val_loss: 0.267
3
Epoch 9/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2955 - val_loss: 0.262
4
Epoch 10/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2941 - val_loss: 0.262
1
Epoch 11/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2908 - val_loss: 0.260
2
Epoch 12/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2892 - val_loss: 0.257
9
Epoch 13/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2874 - val_loss: 0.255
6
Epoch 14/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2851 - val_loss: 0.253
0
Epoch 15/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2832 - val_loss: 0.253
8
Epoch 16/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2830 - val_loss: 0.253
0
Epoch 17/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2813 - val_loss: 0.251
8
Epoch 18/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2803 - val_loss: 0.250
0
Epoch 19/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2785 - val_loss: 0.247
7
Epoch 20/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2784 - val_loss: 0.248
4
Epoch 21/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2775 - val_loss: 0.248
3
Epoch 22/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2771 - val_loss: 0.245
8
Epoch 23/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2765 - val_loss: 0.247
2
Epoch 24/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2764 - val_loss: 0.246
7
Epoch 25/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2753 - val_loss: 0.244
4
Epoch 26/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2747 - val_loss: 0.245
0
Epoch 27/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2738 - val_loss: 0.243
3
Epoch 28/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2735 - val_loss: 0.242
5
Epoch 29/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2723 - val_loss: 0.246
5
Epoch 30/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2723 - val_loss: 0.242
4
Epoch 31/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2719 - val_loss: 0.243
1
```

```
Epoch 32/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2702 - val_loss: 0.240
7
Epoch 33/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2713 - val_loss: 0.242
9
Epoch 34/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2711 - val_loss: 0.240
2
Epoch 35/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2702 - val_loss: 0.239
6
Epoch 36/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2692 - val_loss: 0.238
6
Epoch 37/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2701 - val_loss: 0.239
2
Epoch 38/600
1729/1729 [==============================] - 12s 7ms/step - loss: 0.2690 - val_loss: 0.23
75
Epoch 39/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2701 - val_loss: 0.238
3
Epoch 40/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2689 - val_loss: 0.237
5
Epoch 41/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2681 - val_loss: 0.237
8
Epoch 42/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2687 - val_loss: 0.237
6
Epoch 43/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2679 - val_loss: 0.236
4
Epoch 44/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2678 - val_loss: 0.236
0
Epoch 45/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2674 - val_loss: 0.236
2
Epoch 46/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2669 - val_loss: 0.236
4
Epoch 47/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2664 - val_loss: 0.240
1
Epoch 48/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2666 - val_loss: 0.233
5
Epoch 49/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2653 - val_loss: 0.236
8
Epoch 50/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2653 - val_loss: 0.233
8
Epoch 51/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2664 - val_loss: 0.236
4
Epoch 52/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2650 - val_loss: 0.233
9
Epoch 53/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2650 - val_loss: 0.232
6
Epoch 54/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2649 - val_loss: 0.233
1
Epoch 55/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2648 - val_loss: 0.233
5
```

```
Epoch 56/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2648 - val_loss: 0.235
3
Epoch 57/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2646 - val_loss: 0.233
4
Epoch 58/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2647 - val_loss: 0.233
4
Epoch 59/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2639 - val_loss: 0.233
3
Epoch 60/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2641 - val_loss: 0.233
3
Epoch 61/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2632 - val_loss: 0.236
2
Epoch 62/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2640 - val_loss: 0.231
2
Epoch 63/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2638 - val_loss: 0.234
0
Epoch 64/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2637 - val_loss: 0.233
4
Epoch 65/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2644 - val_loss: 0.231
7
Epoch 66/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2638 - val_loss: 0.232
2
Epoch 67/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2636 - val_loss: 0.232
4
Epoch 68/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2637 - val_loss: 0.231
4
Epoch 69/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2640 - val_loss: 0.232
5
Epoch 70/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2635 - val_loss: 0.231
3
Epoch 71/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2631 - val_loss: 0.232
4
Epoch 72/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2635 - val_loss: 0.233
5
Epoch 73/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2628 - val_loss: 0.230
1
Epoch 74/600
1729/1729 [==============================] - 13s 7ms/step - loss: 0.2632 - val_loss: 0.22
98
Epoch 75/600
1729/1729 [==============================] - 11s 6ms/step - loss: 0.2625 - val_loss: 0.23
43
Epoch 76/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2627 - val_loss: 0.229
6
Epoch 77/600
1729/1729 [==============================] - 10s 6ms/step - loss: 0.2624 - val_loss: 0.23
36
Epoch 78/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2638 - val_loss: 0.231
5
Epoch 79/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2618 - val_loss: 0.229
6
```

```
Epoch 80/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2617 - val_loss: 0.231
3
Epoch 81/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2635 - val_loss: 0.230
3
Epoch 82/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2620 - val_loss: 0.230
5
Epoch 83/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2624 - val_loss: 0.231
8
Epoch 84/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2613 - val_loss: 0.230
9
Epoch 85/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2623 - val_loss: 0.231
3
Epoch 86/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2618 - val_loss: 0.230
8
Epoch 87/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2616 - val_loss: 0.229
2
Epoch 88/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2616 - val_loss: 0.232
4
Epoch 89/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2618 - val_loss: 0.229
1
Epoch 90/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2622 - val_loss: 0.230
5
Epoch 91/600
1729/1729 [==============================] - 10s 6ms/step - loss: 0.2611 - val_loss: 0.22
88
Epoch 92/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2614 - val_loss: 0.229
0
Epoch 93/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2613 - val_loss: 0.229
6
Epoch 94/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2615 - val_loss: 0.230
6
Epoch 95/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2611 - val_loss: 0.233
0
Epoch 96/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2618 - val_loss: 0.229
6
Epoch 97/600
1729/1729 [==============================] - 10s 6ms/step - loss: 0.2613 - val_loss: 0.22
84
Epoch 98/600
1729/1729 [==============================] - 11s 6ms/step - loss: 0.2606 - val_loss: 0.22
96
Epoch 99/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2615 - val_loss: 0.230
2
Epoch 100/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2612 - val_loss: 0.229
0
Epoch 101/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2613 - val_loss: 0.230
9
Epoch 102/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2614 - val_loss: 0.229
2
Epoch 103/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2604 - val_loss: 0.230
0
```

```
Epoch 104/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2605 - val_loss: 0.232
8
Epoch 105/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2609 - val_loss: 0.228
4
Epoch 106/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2613 - val_loss: 0.228
1
Epoch 107/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2611 - val_loss: 0.228
9
Epoch 108/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2621 - val_loss: 0.229
1
Epoch 109/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2609 - val_loss: 0.228
4
Epoch 110/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2611 - val_loss: 0.228
4
Epoch 111/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2611 - val_loss: 0.230
9
Epoch 112/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2603 - val_loss: 0.228
1
Epoch 113/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2599 - val_loss: 0.228
6
Epoch 114/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2608 - val_loss: 0.227
7
Epoch 115/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2599 - val_loss: 0.228
5
Epoch 116/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2600 - val_loss: 0.226
4
Epoch 117/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2591 - val_loss: 0.227
0
Epoch 118/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2601 - val_loss: 0.227
8
Epoch 119/600
1729/1729 [==============================] - 10s 6ms/step - loss: 0.2596 - val_loss: 0.22
80
Epoch 120/600
1729/1729 [==============================] - 12s 7ms/step - loss: 0.2607 - val_loss: 0.22
88
Epoch 121/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2593 - val_loss: 0.232
4
Epoch 122/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2596 - val_loss: 0.227
8
Epoch 123/600
1729/1729 [==============================] - 8s 4ms/step - loss: 0.2597 - val_loss: 0.227
1
Epoch 124/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2594 - val_loss: 0.226
4
Epoch 125/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2597 - val_loss: 0.225
6
Epoch 126/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2596 - val_loss: 0.227
1
Epoch 127/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2590 - val_loss: 0.227
8
```

```
Epoch 128/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2583 - val_loss: 0.228
0
Epoch 129/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2588 - val_loss: 0.231
6
Epoch 130/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2593 - val_loss: 0.228
1
Epoch 131/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2588 - val_loss: 0.228
2
Epoch 132/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2584 - val_loss: 0.228
1
Epoch 133/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2592 - val_loss: 0.225
9
Epoch 134/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2590 - val_loss: 0.225
9
Epoch 135/600
1729/1729 [==============================] - 9s 5ms/step - loss: 0.2579 - val_loss: 0.227
0
Epoch 136/600
1729/1729 [==============================] - 10s 6ms/step - loss: 0.2584 - val_loss: 0.22
70
Epoch 137/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2587 - val_loss: 0.225
7
Epoch 138/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2580 - val_loss: 0.228
0
Epoch 139/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2580 - val_loss: 0.227
1
Epoch 140/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2582 - val_loss: 0.227
2
Epoch 141/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2580 - val_loss: 0.227
3
Epoch 142/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2585 - val_loss: 0.228
4
Epoch 143/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2585 - val_loss: 0.226
5
Epoch 144/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2578 - val_loss: 0.224
1
Epoch 145/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2580 - val_loss: 0.225
5
Epoch 146/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2575 - val_loss: 0.227
2
Epoch 147/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2578 - val_loss: 0.225
9
Epoch 148/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2574 - val_loss: 0.226
3
Epoch 149/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2581 - val_loss: 0.225
5
Epoch 150/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2581 - val_loss: 0.226
7
Epoch 151/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2580 - val_loss: 0.225
9
```

```
Epoch 152/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2579 - val_loss: 0.223
8
Epoch 153/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2575 - val_loss: 0.226
6
Epoch 154/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2587 - val_loss: 0.228
2
Epoch 155/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2581 - val_loss: 0.227
4
Epoch 156/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2576 - val_loss: 0.225
6
Epoch 157/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2577 - val_loss: 0.225
9
Epoch 158/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2576 - val_loss: 0.228
5
Epoch 159/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2580 - val_loss: 0.226
7
Epoch 160/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2567 - val_loss: 0.224
9
Epoch 161/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2572 - val_loss: 0.229
7
Epoch 162/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2580 - val_loss: 0.226
3
Epoch 163/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2578 - val_loss: 0.224
9
Epoch 164/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2581 - val_loss: 0.225
3
Epoch 165/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2578 - val_loss: 0.224
9
Epoch 166/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2577 - val_loss: 0.228
1
Epoch 167/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2577 - val_loss: 0.227
6
Epoch 168/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2575 - val_loss: 0.224
5
Epoch 169/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2572 - val_loss: 0.224
5
Epoch 170/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2574 - val_loss: 0.225
6
Epoch 171/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2570 - val_loss: 0.223
6
Epoch 172/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2570 - val_loss: 0.226
0
Epoch 173/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2572 - val_loss: 0.224
5
Epoch 174/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2571 - val_loss: 0.224
4
Epoch 175/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2573 - val_loss: 0.225
8
```

```
Epoch 176/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2572 - val_loss: 0.225
2
Epoch 177/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2579 - val_loss: 0.224
3
Epoch 178/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2571 - val_loss: 0.226
6
Epoch 179/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2571 - val_loss: 0.224
3
Epoch 180/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2582 - val_loss: 0.226
1
Epoch 181/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2576 - val_loss: 0.224
0
Epoch 182/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2578 - val_loss: 0.224
9
Epoch 183/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2570 - val_loss: 0.226
4
Epoch 184/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2569 - val_loss: 0.224
0
Epoch 185/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2563 - val_loss: 0.223
9
Epoch 186/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2573 - val_loss: 0.226
1
Epoch 187/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2564 - val_loss: 0.223
4
Epoch 188/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2564 - val_loss: 0.224
3
Epoch 189/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2572 - val_loss: 0.224
4
Epoch 190/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2571 - val_loss: 0.226
5
Epoch 191/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2574 - val_loss: 0.223
1
Epoch 192/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2567 - val_loss: 0.224
7
Epoch 193/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2565 - val_loss: 0.224
7
Epoch 194/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2569 - val_loss: 0.224
8
Epoch 195/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2562 - val_loss: 0.224
0
Epoch 196/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2567 - val_loss: 0.223
2
Epoch 197/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2562 - val_loss: 0.224
3
Epoch 198/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2570 - val_loss: 0.223
6
Epoch 199/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2563 - val_loss: 0.223
8
```

```
Epoch 200/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2558 - val_loss: 0.224
7
Epoch 201/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2564 - val_loss: 0.225
7
Epoch 202/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2570 - val_loss: 0.224
8
Epoch 203/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2562 - val_loss: 0.224
2
Epoch 204/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2566 - val_loss: 0.224
2
Epoch 205/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2580 - val_loss: 0.227
0
Epoch 206/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2567 - val_loss: 0.224
3
Epoch 207/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2569 - val_loss: 0.223
1
Epoch 208/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2573 - val_loss: 0.223
8
Epoch 209/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2570 - val_loss: 0.224
5
Epoch 210/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2556 - val_loss: 0.224
4
Epoch 211/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2555 - val_loss: 0.223
7
Epoch 212/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2561 - val_loss: 0.222
9
Epoch 213/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2562 - val_loss: 0.222
3
Epoch 214/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2568 - val_loss: 0.223
8
Epoch 215/600
1729/1729 [==============================] - 6s 3ms/step - loss: 0.2559 - val_loss: 0.222
3
Epoch 216/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2559 - val_loss: 0.225
2
Epoch 217/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2570 - val_loss: 0.223
5
Epoch 218/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2564 - val_loss: 0.223
7
Epoch 219/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2558 - val_loss: 0.225
3
Epoch 220/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2560 - val_loss: 0.223
6
Epoch 221/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2564 - val_loss: 0.224
1
Epoch 222/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2560 - val_loss: 0.225
3
Epoch 223/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2566 - val_loss: 0.222
5
```

```
Epoch 224/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2554 - val_loss: 0.223
2
Epoch 225/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2551 - val_loss: 0.224
1
Epoch 226/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2560 - val_loss: 0.224
4
Epoch 227/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2563 - val_loss: 0.224
2
Epoch 228/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2564 - val_loss: 0.223
1
Epoch 229/600
1729/1729 [==============================] - 7s 4ms/step - loss: 0.2565 - val_loss: 0.223
4
Epoch 230/600
1729/1729 [==============================] - 8s 5ms/step - loss: 0.2562 - val_loss: 0.223
5
Epoch 231/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2563 - val_loss: 0.223
0
Epoch 232/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2554 - val_loss: 0.222
7
Epoch 233/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2564 - val_loss: 0.223
3
Epoch 234/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2552 - val_loss: 0.226
6
Epoch 235/600
1729/1729 [==============================] - 6s 4ms/step - loss: 0.2564 - val_loss: 0.222
6
Epoch 235: early stopping
```

Out[16]:

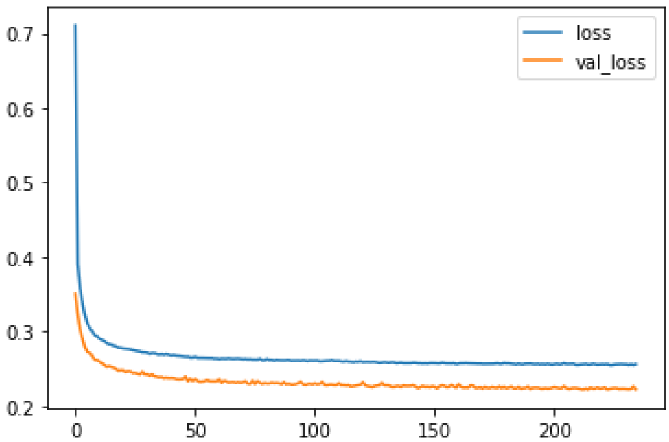
```
<keras.callbacks.History at 0x1e2144cb700>
```

In [17]:

```
# Plotting the Graph
lossdf=pd.DataFrame(ann.history.history)
lossdf.plot()
```

Out[17]:

```
<AxesSubplot: >
```



In [18]:

```
# step5 :- Predict the model
Y_pred = ann.predict(X_test)
```

```
16132/16132 [==============================] - 16s 989us/step
```

In [19]:

```
# R2 Score of the dataset
from sklearn.metrics import r2_score
print(f"R2 --> {r2_score(Y_test,Y_pred)}")
```

```
R2 --> 0.8245288584517543
```

In [20]:

```
from sklearn.metrics import mean_absolute_error,mean_squared_error
print(f"MAE ---> {mean_absolute_error(Y_test,Y_pred)}")
print(f"MSE ---> {mean_squared_error(Y_test,Y_pred)}")
print(f"RMSE --> {np.sqrt(mean_squared_error(Y_test,Y_pred))}")
```

```
MAE ---> 0.3486876390334765
MSE ---> 0.22257738618837422
RMSE --> 0.4717810786671867
```

In [ ]:

```

```

In [ ]:

```

```