1. Time-Series Analysis (Trend Detection)

How does Downtime vary over time, and are there any noticeable trends or seasonal patterns in machine failures?

```
SELECT
    `COL 1`,
     COUNT(`COL 16`) AS downtime_count
FROM machine_downtime
GROUP BY `COL 3`
ORDER BY `COL 3`;
```

COL 1	downtime_count
Date	1
31-12-2021	874
31-05-2022	808
31-12-2021	818

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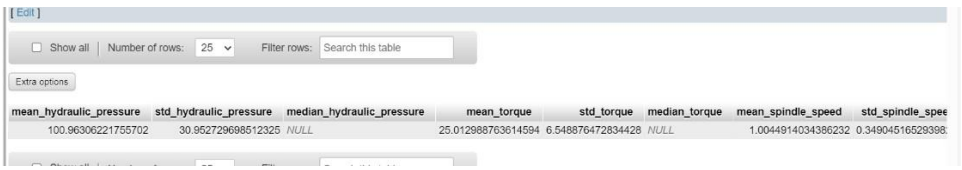
2. **Statistical Summary s Distribution** (Exploratory Data Analysis)

What are the mean, median, and standard deviation of the numerical features such as `Hydraulic_Pressure(bar)`, `Torque(Nm)`, and `Spindle_Speed(RPM)`?

```
SELECT
    AVG(`hydraulic_pressure`) AS mean_hydraulic_pressure,
    STDDEV(`hydraulic_pressure`) AS std_hydraulic_pressure,
    (SELECT hydraulic_pressure FROM OrderedData WHERE row_num_hp = total_rows / 2) AS median_hydraulic_pressure,

    AVG(`torque`) AS mean_torque,
    STDDEV(`torque`) AS std_torque,
    (SELECT torque FROM OrderedData WHERE row_num_torque = total_rows / 2) AS median_torque,

    AVG(`spindle_speed`) AS mean_spindle_speed,
    STDDEV(`spindle_speed`) AS std_spindle_speed,
    (SELECT spindle_speed FROM OrderedData WHERE row_num_speed = total_rows / 2) AS median_spindle_speed
FROM OrderedData;
```



Are some machines using too much energy inefficiently?

```
SELECT
    `COL 1` AS machine_id,
    AVG(`COL 4` * `COL 14`) AS avg_power_usage,
    (AVG(`COL 4` * `COL 14`) / AVG(`COL 10`)) AS energy_efficiency_ratio
FROM machine_downtime
GROUP BY `COL 1`
ORDER BY energy_efficiency_ratio DESC;
```

machine_id	avg_power_usage	energy_efficiency_ratio ▾ 1
17-05-2022	3894.548644080118	19769.282457299552
31-05-2022	3603.336468728	5830.6415351585765
27-05-2022	4198.603032105403	5520.845538600136
19-06-2022	2654.103504501406	4869.914687158543
18-01-2022	2552.537528496177	4786.007865930332
28-01-2022	4015.493474095964	4258.587864706281
6/6/2022	4307.814328509005	3877.420637721876
10/5/2022	3293.7990750636686	3827.2175164138484
27-01-2022	3242.2829660426264	3816.1341368752405
24-04-2022	3233.3292815183986	3744.6433035062514
9/6/2022	2626.481194931401	3688.878082768822
25-04-2022	3225.978429332891	3472.9952139231777
24-05-2022	2553.7168821232817	3418.630364288195
24-03-2022	3339.907998327746	3403.4388569915895
8/5/2022	3860.967702966269	3383.8454890151347
23-04-2022	3666.6891188856616	3382.9446374219
14-05-2022	2574.277106741332	3327.1676047247643
17-04-2022	3126.355405591661	3284.8493885911853
2/2/2022	2788.913520735844	3253.4311972291116
16-01-2022	2512.8308296202927	3238.8796944622463
23-01-2022	2548.794538632688	3171.457327207824
5/5/2022	2780.771119078166	3159.9671807706427
24-11-2021	2571.050072832	3154.662666051534
25-03-2022	3125.2626719723335	3143.3142768192097
24-01-2022	3012.977682206635	3140.69946025709

4-What are the top five hydraulic oil temperature levels that caused the most failures in the last year?

```
SELECT`COL 8`, COUNT(*) AS Failure_Count
FROM Machine_Downtime
WHERE `COL 16` = 'Machine_Failure'
  AND `COL 1` >= DATE_SUB(CURDATE(), INTERVAL 1 YEAR)
GROUP BY `COL 8`
ORDER BY Failure_Count DESC
LIMIT 5;
```

5- What are the top 5 spindle speeds that increase failure rates by 30% compared to other speeds?

```sql
SELECT `COL 12`, COUNT(*) AS Failure_Count
FROM Machine_Downtime
WHERE `COL 16` = 'Machine_Failure'
 GROUP BY `COL 12`
ORDER BY Failure_Count DESC
LIMIT 5;
```

COL 12	Failure_Count 1
26526	76
27613	76
23432	76
21951	76
26605	76

---

6. Do extreme operating temperatures lead to increased failures?

```sql
SELECT
    CASE
        WHEN `COL 7` < 10 THEN 'Very Cold'
        WHEN `COL 7` BETWEEN 10 AND 40 THEN 'Normal'
        ELSE 'Very Hot'
    END AS Temperature_Category,
    COUNT(*) AS Failure_Count
FROM Machine_Downtime
WHERE `COL 16` = 'Machine_Failure'
GROUP BY Temperature_Category
ORDER BY Failure_Count DESC;
```

Temperature_Category	Failure_Count 1
Normal	1034
Very Cold	231

7-How do voltage fluctuations affect machine downtimes in the last 12 months?

```
SELECT `COL 13`, COUNT(*) AS Failure_Count
FROM Machine_Downtime
WHERE`COL 16` = 'Machine_Failure'
GROUP BY `COL 13`
ORDER BY Failure_Count DESC
LIMIT 5;
```

COL 13	Failure_Count 1
341	18
363	18
356	15
340	15
330	14

---

8. How do high vibration levels impact machine failures in the last 6 months?

```
SELECT
    AVG(`COL 10`) AS Avg_Spindle_Vibration_During_Failure,
    AVG(`COL 11`) AS Avg_Tool_Vibration_During_Failure
FROM machine_downtime
WHERE `COL 16` = 'Machine_Failure';
```

Avg_Spindle_Vibration_During_Failure	Avg_Tool_Vibration_During_Failure
1.0005225296442686	25.254162845849805

9-What is the average spindle speed (RPM) for each machine?

```
SELECT `COL 2`, AVG(`COL 12`) AS Avg_Spindle_Speed
FROM Machine_Downtime
WHERE `COL 12` IS NOT NULL
GROUP BY`COL 2`
ORDER BY Avg_Spindle_Speed DESC;
```

COL 2	Avg_Spindle_Speed 1
Makino-L1-Unit1-2013	20334.99656750572
Makino-L2-Unit1-2015	20184.211633663366
Makino-L3-Unit1-2015	20151.224938875304

10-What is the average coolant temperature for each assembly line?

```
SELECT `COL 3`, AVG(`COL 7`) AS Avg_Coolant_Temperature
FROM Machine_Downtime
WHERE `COL 7` IS NOT NULL
GROUP BY `COL 3`
ORDER BY Avg_Coolant_Temperature DESC;
```

COL 3	Avg_Coolant_Temperature 1
Shopfloor-L1	18.746567505720805
Shopfloor-L3	18.530684596576982
Shopfloor-L2	18.111881188118797
