

Analysis of Turbines / Gear component of Wind Mill customers with focus on 42CrMo4 material

In [1]:

Prerequisites

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

```
#pd.set_option('display.max_columns', None)
#pd.set_option('display.max_rows', None)
```

In [2]:

Loading data

```
df=pd.read_excel(r'C:\Users\mohammed\Desktop\42Cr\42Crtest.xlsx')
```

df

3	88	C1	1108631	341	452479	PS	42CRMO4/09	Tempering + Stress Relieving	7.45	JSB5-1680001	...	0.0	3.0	True	8.0	841.5	T
4	89	C1	1108631	341	452479	PS	42CRMO4/09	Quenching + Tempering + Stress Relieving	7.45	JSB5-1680001	...	0.0	3.0	True	8.0	833.4	N
...
1178	28822	C2	1238036	36362	222869	OS	42CRMO4M-Ni JOM30	Quenching + Tempering	NaN	ROR03450-032BA03-001-112	...	2.5	20.0	NaN	6.0	819.5	N
1179	28830	C1	1237571	36373	T54345	OS	42CRMO4/09	Quenching + Tempering + Stress Relieving	6.50	JSB3-0474002	...	0.0	0.0	True	8.0	854.9	N
							42CRMO4M-Ni	Quenching + Tempering									

In [3]:

Size of the dataframe

df.shape

Out[3]:

(1183, 96)

In [95]:

Column info

df.columns

Out[95]:

```
Index(['Sn', 'Customer', 'Order ID', 'Batch ID', 'Heat Number', 'Coupon',
       'Material', 'Heat Treatment', 'Reduction Ratio', 'Customer Drawing ID',
       'Customer Drawing Revision ID', 'Weight', 'Ø Ex', 'Ø In', 'Height',
       'Thickness', 'Certificate Number', 'Supplier', 'Certificate Date',
       'PLM Raw Material Name', 'Primary Melting', 'Secondary Melting',
       'Refining', 'De-Oxidation', 'Degassing', 'Casting', 'Al [Aluminium]',
       'As [Arsenic]', 'B [Boron]', 'Bi [Bismuth]', 'C [Carbon]',
       'Ca [Calcium]', 'Co [Cobalt]', 'Cr [Chromium]', 'Cu [Copper]',
       'Fe (balance)', 'H [Hydrogen]', 'Mn [Manganese]', 'Mo [Molybdenum]',
       'N [Nitrogen]', 'Nb [Niobium]', 'Ni [Nickel]', 'O [Oxygen]',
       'P [Phosphorus]', 'Pb [Lead]', 'S [Sulfur]', 'Sb [Antimony]',
       'Si [Silicon]', 'Sn [Tin]', 'Ta [Tantalum]', 'Ti [Titanium]',
       'V [Vanadium]', 'W [Tungsten]', 'Zr [Zirconium]', 'B/N(ppm)',
       'Cu+10*Sn', 'V+Ti+Nb', 'Sn+As+Sb',
       'CEQ (Std) = C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15', 'D.I.Value/IdealDiameter',
       'De', 'HRC at 1 mm', 'HRC at 1,5 mm', 'HRC at 3 mm', 'HRC at 5 mm',
       'HRC at 7 mm', 'HRC at 9 mm', 'HRC at 10 mm', 'HRC at 11 mm',
       'HRC at 13 mm', 'HRC at 15 mm', 'HRC at 20 mm', 'HRC at 25 mm',
       'HRC at 30 mm', 'HRC at 35 mm', 'HRC at 40 mm', 'HRC at 45 mm',
       'HRC at 50 mm', 'ASTM E45 Met.A - A heavy', 'ASTM E45 Met.A - A thin',
       'ASTM E45 Met.A - B heavy', 'ASTM E45 Met.A - B thin',
       'ASTM E45 Met.A - C heavy', 'ASTM E45 Met.A - C thin',
       'ASTM E45 Met.A - D heavy', 'ASTM E45 Met.A - D thin', 'ISO 4967 Met.A',
       'DIN 50602 - K4', 'Fine Grain Practice', 'Grain size',
       '0.2% Yield Strength (YS)', 'Upper Yield Strength (ReH)',
       'Ultimate Tensile Strength (UTS)', 'YS/UTS Ratio', '% Elongation (A)',
       '% Reduction of Area (RoA | Z)'],
      dtype='object')
```

In [5]:

#Length of columns

len(df.columns)

Out[5]:

96

In [6]:

Memory usage

df.memory_usage()

Out[6]:

Index	128
Sn	9464
Customer	9464
Order ID	9464
Batch ID	9464
...	
Upper Yield Strength (ReH)	9464
Ultimate Tensile Strength (UTS)	9464
YS/UTS Ratio	9464
% Elongation (A)	9464
% Reduction of Area (RoA z)	9464
Length: 97, dtype: int64	

In [7]:

```
# Basic information
# Datatypes of columns and the non-null column counts.
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1183 entries, 0 to 1182
Data columns (total 96 columns):
 #   Column           Non-Null Count Dtype  
 --- 
 0   Sn               1183 non-null   int64   
 1   Customer         1183 non-null   object  
 2   Order ID         1183 non-null   int64   
 3   Batch ID         1183 non-null   int64   
 4   Heat Number      1183 non-null   object  
 5   Coupon           1183 non-null   object  
 6   Material          1183 non-null   object  
 7   Heat Treatment    1166 non-null   object  
 8   Reduction Ratio   979 non-null    float64 
 9   Customer Drawing ID 1183 non-null   object  
 10  Customer Drawing Revision ID 1182 non-null   object  
 11  Weight            1166 non-null   float64 
 12  Ø Ex              1083 non-null   float64 
 13  Ø In              1083 non-null   float64 
 14  Height            1083 non-null   float64 
 15  Thickness          1083 non-null   float64 
 16  Certificate Number 1179 non-null   object  
 17  Supplier          1183 non-null   object  
 18  Certificate Date   122 non-null    object  
 19  PLM Raw Material Name 1183 non-null   object  
 20  Primary Melting    1181 non-null   object  
 21  Secondary Melting   2 non-null     object  
 22  Refining           66 non-null    object  
 23  De-Oxidation       1114 non-null   object  
 24  Degassing          1172 non-null   object  
 25  Casting             164 non-null    object  
 26  Al [Aluminium]     1182 non-null   float64 
 27  As [Arsenic]       1182 non-null   float64 
 28  B [Boron]          1140 non-null   float64 
 29  Bi [Bismuth]        26 non-null    float64 
 30  C [Carbon]          1182 non-null   float64 
 31  Ca [Calcium]        1180 non-null   float64 
 32  Co [Cobalt]          187 non-null   float64 
 33  Cr [Chromium]       1182 non-null   float64 
 34  Cu [Copper]          1182 non-null   float64 
 35  Fe (balance)        27 non-null    float64 
 36  H [Hydrogen]         1182 non-null   float64 
 37  Mn [Manganese]       1182 non-null   float64 
 38  Mo [Molybdenum]      1182 non-null   float64 
 39  N [Nitrogen]         1182 non-null   float64 
 40  Nb [Niobium]          1182 non-null   float64 
 41  Ni [Nickel]          1182 non-null   float64 
 42  O [Oxygen]           1181 non-null   float64 
 43  P [Phosphorus]        1182 non-null   float64 
 44  Pb [Lead]             1098 non-null   float64 
 45  S [Sulfur]            1182 non-null   float64 
 46  Sb [Antimony]         1165 non-null   float64 
 47  Si [Silicon]          1182 non-null   float64 
 48  Sn [Tin]              1182 non-null   float64 
 49  Ta [Tantalum]         2 non-null    float64 
 50  Ti [Titanium]         1182 non-null   float64 
 51  V [Vanadium]          1179 non-null   float64 
 52  W [Tungsten]          27 non-null    float64 
 53  Zr [Zirconium]         1 non-null    float64 
 54  B/N(ppm)              2 non-null    float64 
 55  Cu+10*Sn              1 non-null    float64 
 56  V+Ti+Nb              42 non-null   float64 
 57  Sn+As+Sb              1004 non-null  float64 
 58  CEQ (Std) = C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15 1143 non-null   float64 
 59  D.I.Value/IdealDiameter 23 non-null    float64 
 60  De                   1 non-null    object  
 61  HRC at 1 mm            0 non-null    float64 
 62  HRC at 1,5 mm          1132 non-null   float64 
 63  HRC at 3 mm            1132 non-null   float64 
 64  HRC at 5 mm            1139 non-null   float64 
 65  HRC at 7 mm            1132 non-null   float64 
 66  HRC at 9 mm            1132 non-null   float64 
 67  HRC at 10 mm           54 non-null    float64 
 68  HRC at 11 mm           1132 non-null   float64 
 69  HRC at 13 mm           1132 non-null   float64 
 70  HRC at 15 mm           1132 non-null   float64 
 71  HRC at 20 mm           1132 non-null   float64 
 72  HRC at 25 mm           1133 non-null   float64 
 73  HRC at 30 mm           1139 non-null   float64 
 74  HRC at 35 mm           1132 non-null   float64 
 75  HRC at 40 mm           1132 non-null   float64 
 76  HRC at 45 mm           1130 non-null   float64 
 77  HRC at 50 mm           980 non-null   float64 
 78  ASTM E45 Met.A - A heavy 1182 non-null   float64 
 79  ASTM E45 Met.A - A thin  1182 non-null   float64 
 80  ASTM E45 Met.A - B heavy 1182 non-null   float64 
 81  ASTM E45 Met.A - B thin  1182 non-null   float64 
 82  ASTM E45 Met.A - C heavy 1182 non-null   float64 
 83  ASTM E45 Met.A - C thin  1182 non-null   float64 
 84  ASTM E45 Met.A - D heavy 1182 non-null   float64 
 85  ASTM E45 Met.A - D thin  1182 non-null   float64
```

```

86 ISO 4967 Met.A          1182 non-null  float64
87 DIN 50602 - K4         1182 non-null  float64
88 Fine Grain Practice    1116 non-null  object
89 Grain size              1141 non-null  float64
90 0.2% Yield Strength (YS) 1129 non-null  float64
91 Upper Yield Strength (ReH) 148 non-null  float64
92 Ultimate Tensile Strength (UTS) 1130 non-null  float64
93 YS/UTS Ratio            6 non-null   float64
94 % Elongation (A)       1127 non-null  float64
95 % Reduction of Area (RoA | z) 1122 non-null  float64
dtypes: float64(74), int64(3), object(19)
memory usage: 887.4+ KB

```

In [8]:

Any null columns and their count ??

df.isnull().sum()

Out[8]:

Sn		0
Customer		0
Order ID		0
Batch ID		0
Heat Number		0
		...
Upper Yield Strength (ReH)		1035
Ultimate Tensile Strength (UTS)		53
YS/UTS Ratio		1177
% Elongation (A)		56
% Reduction of Area (RoA z)		61
Length:	96,	dtype: int64

In [9]:

df[df.isna().any(axis=1)]

Out[9]:

Sn	Customer	Order ID	Batch ID	Heat Number	Coupon	Material	Heat Treatment	Reduction Ratio	Customer Drawing ID	ISO 4967 Met.A	DIN 50602 - K4	Fine Grain Practice	Grain size S
0	73	C1	1106541	287	453375	PS	42CRMO4MOD-NI/09	Quenching + Tempering + Stress Relieving	5.98	JSB5-2087001	...	0.0	8.0
1	76	C1	1106571	290	453355	PS	42CRMO4MOD-NI/09	Quenching + Tempering + Stress Relieving	7.95	JSB5-2203001	...	0.0	5.0
2	79	C1	1107173	302	453374	OS	42CRMO4MOD-NI/09	Quenching + Tempering + Stress Relieving	5.98	JSB5-2087001	...	0.0	4.0
3	88	C1	1108621	340	452479	PS	42CRMO4/09	Quenching + Tempering + Stress Relieving	7.45	JSB5-1680001	...	0.0	3.0
4	89	C1	1108631	341	452479	PS	42CRMO4/09	Quenching + Tempering + Stress Relieving	7.45	JSB5-1680001	...	0.0	3.0
...
1178	28822	C2	1238036	36362	222869	OS	42CRMO4M-Ni JOM30	Quenching + Tempering	NaN	ROR03450-032BA03-001-112	...	2.5	20.0
1179	28830	C1	1237571	36373	T54345	OS	42CRMO4/09	Quenching + Tempering + Stress Relieving	6.50	JSB3-0474002	...	0.0	0.0
1180	28837	C1	1237578	36380	474661	PS	42CRMO4MOD-NI/09	Quenching + Tempering + Stress Relieving	7.95	JSB5-2203001	...	0.0	7.0
1181	28872	C1	1236885	36448	474710	PS	42CRMO4MOD-NI/09	Quenching + Tempering	8.60	USD/V010/0031/AB	...	0.0	0.0
1182	28946	C1	1238093	36601	474658	PS	42CRMO4MOD-NI/09	Quenching + Tempering	5.60	USD/V010/0023/AA	...	0.0	9.0

1183 rows × 96 columns

In [10]:

Any duplicates ??

df[df.duplicated()]

Out[10]:

Sn	Customer	Order ID	Batch ID	Heat Number	Coupon	Material	Heat Treatment	Reduction Ratio	Customer Drawing ID	...	ISO 4967 Met.A	DIN 50602 - K4	Fine Grain Practice	Grain size	0.2% Yield Strength (YS)	Upper Yield Strength (ReH)	Ultimate Tensile Strength (UT)
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0 rows × 96 columns

In [11]:

Basic statistics

df.describe().T.round()

Out[11]:

	count	mean	std	min	25%	50%	75%	max
Sn	1183.0	14600.0	8013.0	73.0	8117.0	13770.0	21942.0	28946.0
Order ID	1183.0	1166432.0	263621.0	148195.0	1153075.0	1181106.0	1211433.0	3006385.0
Batch ID	1183.0	18158.0	9851.0	287.0	10211.0	16618.0	27294.0	36601.0
Reduction Ratio	979.0	8.0	2.0	4.0	7.0	8.0	8.0	20.0
Weight	1166.0	3964.0	2047.0	171.0	2482.0	4177.0	5379.0	9893.0
...
Upper Yield Strength (ReH)	148.0	816.0	255.0	580.0	769.0	796.0	831.0	3842.0
Ultimate Tensile Strength (UTS)	1130.0	1014.0	64.0	795.0	968.0	1015.0	1061.0	1198.0
YS/UTS Ratio	6.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0
% Elongation (A)	1127.0	18.0	2.0	12.0	17.0	18.0	19.0	63.0
% Reduction of Area (RoA Z)	1122.0	60.0	4.0	40.0	58.0	61.0	63.0	70.0

77 rows × 8 columns

In [12]:

Pearson Correlation of the data

df.corr().round(5)*100

Out[12]:

	Sn	Order ID	Batch ID	Reduction Ratio	Weight	ø Ex	ø In	Height	Thickness	Al [Aluminium]	ASTM E45 Met.A - D thin	ISO 4967 Met.A	DIN 50602 - K4	Grain size	0.2% Yield Strength (YS)	
Sn	100.000	6.956	99.954	7.303	6.421	-0.830	-0.435	9.786	-2.862	11.569	...	-5.021	4.354	12.030	0.800	1.41
Order ID	6.956	100.000	6.777	1.404	7.842	7.636	7.426	-0.296	4.364	27.650	...	23.599	5.563	9.086	2.949	1.71
Batch ID	99.954	6.777	100.000	6.929	6.374	-1.082	-0.695	10.007	-2.919	11.327	...	-4.637	4.347	12.091	0.484	1.46
Reduction Ratio	7.303	1.404	6.929	100.000	17.226	57.030	60.160	-18.817	-19.251	5.843	...	0.502	2.648	17.276	-10.308	-3.94
Weight	6.421	7.842	6.374	17.226	100.000	66.003	63.519	45.745	42.016	6.371	...	15.555	13.280	45.057	-35.965	-0.93
...
Upper Yield Strength (ReH)	-2.719	2.450	-2.920	83.646	-3.746	1.673	0.482	-10.405	5.148	4.509	...	-9.561	2.254	-3.965	0.745	26.56
Ultimate Tensile Strength (UTS)	-0.677	5.132	-0.582	-10.793	-6.410	-18.216	-15.257	10.965	-26.174	0.402	...	19.234	-16.989	5.789	-7.792	33.75
YS/UTS Ratio	-84.894	-81.530	-83.692	-15.335	-89.212	-43.718	-4.459	-78.459	-97.343	-76.610	...	0.147	NaN	-1.800	-46.205	92.67
% Elongation (A)	-14.629	-2.478	-14.868	13.092	2.032	16.525	14.770	-14.702	17.755	2.887	...	-18.396	11.283	-5.684	9.019	-16.67
% Reduction of Area (RoA Z)	-2.805	-4.073	-2.864	22.188	4.847	19.511	19.978	-8.718	4.705	2.668	...	-15.666	13.379	-5.676	8.428	-24.26

77 rows × 77 columns

In [13]:

Covariance

df.cov().round()

Out[13]:

	Sn	Order ID	Batch ID	Reduction Ratio	Weight	ø Ex	ø In	Height	Thickness	Al [Aluminium]	...	ASTM E45 Met.A - D thin	ISO 496 Met.
Sn	64208341.0	1.469295e+08	78896893.0	996.0	1054973.0	-52102.0	-25762.0	107142.0	-13170.0	4.0	...	-184.0	128.
Order ID	146929533.0	6.949627e+10	175992218.0	4208.0	42433193.0	13921567.0	12755453.0	-94062.0	583057.0	279.0	...	28437.0	5407.
Batch ID	78896893.0	1.759922e+08	97034801.0	1159.0	1287261.0	-83551.0	-50521.0	134689.0	-16515.0	4.0	...	-209.0	158.
Reduction Ratio	996.0	4.208000e+03	1159.0	3.0	598.0	532.0	559.0	-38.0	-14.0	0.0	...	0.0	0.
Weight	1054973.0	4.243319e+07	1287261.0	598.0	4192112.0	963372.0	873478.0	116429.0	44947.0	0.0	...	146.0	101.
...
Upper Yield Strength (ReH)	-45147.0	1.715795e+06	-59518.0	250.0	-11833.0	2179.0	688.0	-1303.0	746.0	0.0	...	-12.0	3.
Ultimate Tensile Strength (UTS)	-3460.0	8.419220e+05	-3657.0	-12.0	-8290.0	-9157.0	-7227.0	956.0	-965.0	0.0	...	6.0	-4.
YS/UTS Ratio	-194.0	-1.084000e+03	-224.0	-0.0	-190.0	-21.0	-2.0	-3.0	-10.0	-0.0	...	0.0	0.
% Elongation (A)	-2860.0	-1.554800e+04	-3571.0	0.0	101.0	322.0	272.0	-50.0	25.0	0.0	...	-0.0	0.
% Reduction of Area (RoA Z)	-834.0	-3.833800e+04	-1046.0	1.0	360.0	570.0	550.0	-44.0	10.0	0.0	...	-0.0	0.

77 rows × 77 columns

In [14]:

Skewness

df.skew()

Out[14]:

Sn	0.071849
Order ID	1.584986
Batch ID	0.145082
Reduction Ratio	1.886473
Weight	0.263263
...	...
Upper Yield Strength (ReH)	11.485904
Ultimate Tensile Strength (UTS)	-0.269814
YS/UTS Ratio	-2.097015
% Elongation (A)	9.317781
% Reduction of Area (RoA Z)	-0.785555
Length: 78, dtype: float64	

In [15]:

Creating Categorical and Numerical columns

```
cat_columns=[x for x in df.columns if df[x].dtype=='O']
num_columns=[x for x in df.columns if df[x].dtype!='O']
```

In [16]:

df[cat_columns].head()

Out[16]:

Customer	Heat Number	Coupon	Material	Heat Treatment	Customer Drawing ID	Customer Drawing Revision ID	Certificate Number	Supplier	Certificate Date	PLM Raw Material Name	Primary Melting	Secondary Melting	R
0	C1 453375	PS	42CRMO4MOD-NI/09	Quenching + Tempering + Stress Relieving	JSB5-2087001	REV.C	235114/1	S1	NaN	42CRMO4MOD-NI/09	EAF - Electric Arc Furnace	NaN	
1	C1 453355	PS	42CRMO4MOD-NI/09	Quenching + Tempering + Stress Relieving	JSB5-2203001	REV.A	235023/1	S1	NaN	42CRMO4MOD-NI/09	EAF - Electric Arc Furnace	NaN	
2	C1 453374	OS	42CRMO4MOD-NI/09	Quenching + Tempering + Stress Relieving	JSB5-2087001	REV.C	235272/1	S1	NaN	42CRMO4MOD-NI/09	EAF - Electric Arc Furnace	NaN	
3	C1 452479	PS	42CRMO4/09	Quenching + Tempering + Stress Relieving	JSB5-1680001	B	231022/1	S1	NaN	42CRMO4/09	EAF - Electric Arc Furnace	NaN	
4	C1 452479	PS	42CRMO4/09	Quenching + Tempering + Stress Relieving	JSB5-1680001	B	231022/1	S1	NaN	42CRMO4/09	EAF - Electric Arc Furnace	NaN	

In [17]:

df[num_columns].head()

Out[17]:

Sn	Order ID	Batch ID	Reduction Ratio	Weight	ø Ex	ø In	Height	Thickness	Al [Aluminium]	ASTM E45 Met.A - D thin	ISO 4967 Met.A	DIN 50602 - K4	Grain size	0.2% Yield Strength (YS)	Upper Yield Strength (ReH)	Ultimate Tensile Strength (UTS)
0	73 1106541	287	5.98	3921.0	2087.0	1812.0	471.0	137.5	0.032 ...	1.5	0.0	8.0	9.0	890.3	NaN	1033.0
1	76 1106571	290	7.95	4703.0	2203.0	1893.0	493.0	155.0	0.023 ...	1.0	0.0	5.0	8.0	916.0	NaN	1038.2
2	79 1107173	302	5.98	3921.0	2087.0	1812.0	471.0	137.5	0.024 ...	1.0	0.0	4.0	8.0	875.8	NaN	1003.8
3	88 1108621	340	7.45	2529.0	1682.0	1432.0	398.0	125.0	0.024 ...	1.0	0.0	3.0	8.0	841.5	NaN	970.0
4	89 1108631	341	7.45	2529.0	1682.0	1432.0	398.0	125.0	0.024 ...	1.0	0.0	3.0	8.0	833.4	NaN	985.4

5 rows x 77 columns

In [18]:

Unique data in Categorical columns

[print(x, ' - ', len(df[x].unique()), ' - ', df[x].unique(), '\n') for x in df[cat_columns].columns]

Customer - 26 - ['C1' 'C2' 'C3' 'C4' 'C5' 'C6' 'C7' 'C8' 'C9' 'C10' 'C11' 'C12' 'C13' 'C14' 'C15' 'C16' 'C17' 'C18' 'C19' 'C20' 'C21' 'C22' 'C23' 'C24' 'C25' 'C26']

Heat Number - 589 - [453375 453355 453374 452479 453377 453354 453379 453358 453378 453356
 453376 190095 453575 451569 453359 451570 452481 '99286K' 453906 453910
 453909 453908 454124 453574 255559 '12963K' 454120 454122 453905 454161
 452482 451297 191405 454162 454160 'T26522' 455246 454159 454123 192685
 192726 455247 454158 454696 'T32356' 241270 454695 454694 256687 455784
 451296 'T32358' 453573 192786 455785 455787 455788 455786 455789 193568
 193628 451295 190233 193479 192670 193668 193922 456674 440946 241920
 456884 193724 456676 193627 457215 190094 'T32908' 256680 456693 457216
 'T36569' 193525 457218 457214 457219 457625 457786 457629 457765
 457764 'T36566' 'T36570' 457628 256676 457399 457787 457788 457627 457785
 457763 457767 457766 'T38633' 261830 261829 'T38875' 452321 'T38870'
 456414 261826 255562 261827 457334 261828 458127 457400 201262 193611
 193569 458126 458128 458436 458446 456890 458779 457335 457784 458520
 458435 458449 459312 201425 258959 458434 458447 453529 458448 459157
 459156 'T40611' 459300 458521 458522 459299 458523 458519 453528 459446
 459200 459202 459211 459215 459203 459001 459111 459207 459000 459171

In [19]:

df.groupby('Supplier').sum()

Out[19]:

	Sn	Order ID	Batch ID	Reduction Ratio	Weight	ø Ex	ø In	Height	Thickness	Al [Aluminium]	ASTM E45 Met.A ...	ISO 4967 Met.A	DIN 50602 - K4	Grasiz	
Supplier															
S1	13140993	1058545828	16335294	5933.86	3581674.0	1877988.0	1592753.0	366600.5	142617.5	24.074	...	837.5	111.0	3570.5	7189
S10	578	1110550	1232	4.30	816.0	1020.0	784.0	311.0	118.0	0.000	...	0.0	0.0	0.0	0
S2	1023	1115082	1853	7.30	816.0	1020.0	784.0	311.0	118.0	0.031	...	0.0	0.0	0.0	0
S3	100666	8964572	123462	0.00	28895.0	20953.0	17972.0	1416.0	1490.5	0.219	...	0.0	6.0	0.0	42
S4	50220	2448592	62475	16.35	14764.0	2163.0	1850.0	568.0	156.5	0.055	...	3.0	0.0	40.0	10
S5	2276007	156467823	2834481	1040.48	822621.0	227536.0	196891.0	43965.0	15322.5	3.651	...	187.5	12.0	2540.0	661
S6	54544	2462458	67902	19.10	16464.0	2750.0	2419.0	523.0	165.5	0.056	...	3.0	0.0	40.0	10
S7	1717	1120001	2853	9.38	1525.0	1823.0	1642.0	291.0	90.5	0.023	...	0.5	0.0	0.0	8
S8	21024	150933	26082	0.00	1043.0	0.0	0.0	0.0	0.0	0.018	...	0.0	0.0	0.0	0
S9	1625492	147503416	2025747	822.45	153382.0	127268.0	94663.0	41971.0	16302.5	3.234	...	109.0	0.0	8.0	938

10 rows × 77 columns

In [20]:

No. of Unique data per columns

df.nunique()

Out[20]:

Sn	1183
Customer	26
Order ID	1183
Batch ID	1182
Heat Number	589
	...
Upper Yield Strength (ReH)	119
Ultimate Tensile Strength (UTS)	807
YS/UTS Ratio	5
% Elongation (A)	75
% Reduction of Area (RoA z)	175
Length: 96, dtype: int64	

In [21]:

```
# Viewing the correlation of the dataframe whose contribution is greater than 50% with each other
```

```
dd=df.corr().round(2)
dd[dd>0.5].replace(np.nan,'')
```

Out[21]:

	Sn	Order ID	Batch ID	Reduction Ratio	Weight	ϕ_{Ex}	ϕ_{In}	Height	Thickness	Al [Aluminium]	ASTM E45 Met.A - D thin	ISO 4967 Met.A	DIN 50602 - K4	Grain size	0.2% Yield Strength (YS)	Upper Strength (ReH)	Ultimate Tensile Strength (UTS)
Sn	1.0										...						
Order ID		1.0									...						
Batch ID	1.0		1.0								...						
Reduction Ratio				1.0		0.57	0.6				...					0.84	
Weight					1.0	0.66	0.64				...						
...
Upper Yield Strength (ReH)				0.84							...					1.0	
Ultimate Tensile Strength (UTS)											...						1
YS/UTS Ratio											...					0.93	0.8
% Elongation (A)											...						
% Reduction of Area (RoA Z)											...						

77 rows × 77 columns

In [22]:

```
# Raw material (RM) heat data extraction
```

```
chemi_columns=df[['Heat Number','Al [Aluminium]', 'As [Arsenic]', 'B [Boron]', 'Bi [Bismuth]', 'C [Carbon]', 'Ca [Calcium]', 'Co [Cobalt]', 'Cr [Chromium]', 'Cu [Copper]', 'Fe (balance)', 'H [Hydrogen]', 'Mn [Manganese]', 'Mo [Molybdenum]', 'N [Nitrogen]', 'Nb [Niobium]', 'Ni [Nickel]', 'O [Oxygen]', 'P [Phosphorus]', 'Pb [Lead]', 'S [Sulfur]', 'Sb [Antimony]', 'Si [Silicon]', 'Sn [Tin]', 'Ta [Tantalum]', 'Ti [Titanium]', 'V [Vanadium]', 'W [Tungsten]', 'Zr [Zirconium]']]
```

chemi_columns

Out[22]:

	Heat Number	Al [Aluminium]	As [Arsenic]	B [Boron]	Bi [Bismuth]	C [Carbon]	Ca [Calcium]	Co [Cobalt]	Cr [Chromium]	Cu [Copper]	Pb [Lead]	S [Sulfur]	Sb [Antimony]	Si [Silicon]	
0	453375	0.032	0.006	0.0001	NaN	0.420	0.0012	NaN	1.070	0.150	...	0.0001	0.003	0.0010	0.250
1	453355	0.023	0.005	0.0001	NaN	0.421	0.0011	NaN	1.070	0.120	...	0.0001	0.002	0.0010	0.230
2	453374	0.024	0.006	0.0001	NaN	0.422	0.0010	NaN	1.070	0.150	...	0.0001	0.003	0.0010	0.220
3	452479	0.024	0.005	0.0004	NaN	0.416	0.0012	NaN	1.070	0.130	...	0.0001	0.001	0.0020	0.260
4	452479	0.024	0.005	0.0004	NaN	0.416	0.0012	NaN	1.070	0.130	...	0.0001	0.001	0.0020	0.260
...
1178	222869	0.029	0.006	0.0005	0.0004	0.414	0.0002	0.011	1.049	0.134	...	0.0003	0.001	0.0019	0.248
1179	T54345	0.030	0.003	0.0004	NaN	0.440	0.0007	NaN	1.070	0.050	...	0.0010	0.002	0.0010	0.250
1180	474661	0.027	0.006	0.0001	NaN	0.430	0.0013	0.010	1.080	0.200	...	0.0001	0.003	0.0010	0.240
1181	474710	0.025	0.005	0.0001	NaN	0.416	0.0016	0.009	1.060	0.190	...	0.0001	0.003	0.0010	0.230
1182	474658	0.027	0.006	0.0001	NaN	0.425	0.0014	0.009	1.070	0.160	...	0.0001	0.003	0.0010	0.230

1183 rows × 29 columns

Distribution plot with kernel density of RM data

col=chemi_columns.columns

fig, axes=plt.subplots(14,2,figsize=(15,50)) axes=axes.ravel()

localhost:8888/notebooks/ineuron notebook and practise/Statistics/42Cr.ipynb#

```
for col,ax in zip(col,axes): sns.histplot(data=chemi_columns,x=chemi_columns[col],kde=True, stat='density',ax=ax)
fig.tight_layout() plt.show()
```

Boxplot of RM data

```
col=chemi_columns.columns

fig, axes=plt.subplots(14,2,figsize=(15,50)) axes=axes.ravel()

for col,ax in zip(col,axes): sns.boxplot(data=chemi_columns,y=chemi_columns[col],ax=ax)

fig.tight_layout() plt.show()
```

In [23]:

```
chemi_columns[chemi_columns.columns[1:10]]
```

Out[23]:

	Al [Aluminium]	As [Arsenic]	B [Boron]	Bi [Bismuth]	C [Carbon]	Ca [Calcium]	Co [Cobalt]	Cr [Chromium]	Cu [Copper]
0	0.032	0.006	0.0001	NaN	0.420	0.0012	NaN	1.070	0.150
1	0.023	0.005	0.0001	NaN	0.421	0.0011	NaN	1.070	0.120
2	0.024	0.006	0.0001	NaN	0.422	0.0010	NaN	1.070	0.150
3	0.024	0.005	0.0004	NaN	0.416	0.0012	NaN	1.070	0.130
4	0.024	0.005	0.0004	NaN	0.416	0.0012	NaN	1.070	0.130
...
1178	0.029	0.006	0.0005	0.0004	0.414	0.0002	0.011	1.049	0.134
1179	0.030	0.003	0.0004	NaN	0.440	0.0007	NaN	1.070	0.050
1180	0.027	0.006	0.0001	NaN	0.430	0.0013	0.010	1.080	0.200
1181	0.025	0.005	0.0001	NaN	0.416	0.0016	0.009	1.060	0.190
1182	0.027	0.006	0.0001	NaN	0.425	0.0014	0.009	1.070	0.160

1183 rows × 9 columns

Violinplot of RM data

```
col=chemi_columns.columns

fig, axes=plt.subplots(14,2,figsize=(15,50)) axes=axes.ravel()

for col,ax in zip(col,axes): sns.violinplot(data=chemi_columns,y=chemi_columns[col],ax=ax)

fig.tight_layout() plt.show()
```

In [72]:

RM and Yield Strength data

```
ds = df[['Supplier', 'Heat Number', 'Al [Aluminium]', 'As [Arsenic]', 'B [Boron]', 'Bi [Bismuth]', 'C [Carbon]', 'Ca [Calcium]', 'Co [Cobalt]', 'Cr [Chromium]', 'Cu [Copper]', 'Fe (balance)', 'H [Hydrogen]', 'Mn [Manganese]', 'Mo [Molybdenum]', 'N [Nitrogen]', 'Nb [Niobium]', 'Ni [Nickel]', 'O [Oxygen]', 'P [Phosphorus]', 'Pb [Lead]', 'S [Sulfur]', 'Sb [Antimony]', 'Si [Silicon]', 'Sn [Tin]', 'Ta [Tantalum]', 'Ti [Titanium]', 'V [Vanadium]', 'W [Tungsten]', 'Zr [Zirconium]', '0.2% Yield Strength (YS)']]
```

ds

Out[72]:

	Supplier	Heat Number	Al [Aluminium]	As [Arsenic]	B [Boron]	Bi [Bismuth]	C [Carbon]	Ca [Calcium]	Co [Cobalt]	Cr [Chromium]	...	S [Sulfur]	Sb [Antimony]	Si [Silicon]	Sn [Tin]	[
0	S1	453375	0.032	0.006	0.0001	NaN	0.420	0.0012	NaN	1.070	...	0.003	0.0010	0.250	0.010	
1	S1	453355	0.023	0.005	0.0001	NaN	0.421	0.0011	NaN	1.070	...	0.002	0.0010	0.230	0.008	
2	S1	453374	0.024	0.006	0.0001	NaN	0.422	0.0010	NaN	1.070	...	0.003	0.0010	0.220	0.010	
3	S1	452479	0.024	0.005	0.0004	NaN	0.416	0.0012	NaN	1.070	...	0.001	0.0020	0.260	0.008	
4	S1	452479	0.024	0.005	0.0004	NaN	0.416	0.0012	NaN	1.070	...	0.001	0.0020	0.260	0.008	
...	
1178	S5	222869	0.029	0.006	0.0005	0.0004	0.414	0.0002	0.011	1.049	...	0.001	0.0019	0.248	0.008	
1179	S9	T54345	0.030	0.003	0.0004	NaN	0.440	0.0007	NaN	1.070	...	0.002	0.0010	0.250	0.005	
1180	S1	474661	0.027	0.006	0.0001	NaN	0.430	0.0013	0.010	1.080	...	0.003	0.0010	0.240	0.011	
1181	S1	474710	0.025	0.005	0.0001	NaN	0.416	0.0016	0.009	1.060	...	0.003	0.0010	0.230	0.009	
1182	S1	474658	0.027	0.006	0.0001	NaN	0.425	0.0014	0.009	1.070	...	0.003	0.0010	0.230	0.010	

1183 rows × 31 columns

In [25]:

ds.shape

Out[25]:

(1183, 31)

In [26]:

ds.corr().round(5)*100

#ds.to_excel(r'C:\Users\mohammed\Desktop\output.xlsx')

Out[26]:

	Al [Aluminium]	As [Arsenic]	B [Boron]	Bi [Bismuth]	C [Carbon]	Ca [Calcium]	Co [Cobalt]	Cr [Chromium]	Cu [Copper]	Fe (balance)	...	S [Sulfur]	Sb [Antimony]	Si [Silico]
Al [Aluminium]	100.000	1.772	10.784	-2.271	23.179	0.392	2.129	20.110	-7.150	23.463	...	-22.217	5.890	40.02
As [Arsenic]	1.772	100.000	-23.206	28.233	-37.393	-15.409	2.636	-3.693	65.125	9.224	...	-13.422	8.560	-12.58
B [Boron]	10.784	-23.206	100.000	-32.400	16.454	-46.548	11.888	-20.808	-49.358	NaN	...	-12.699	65.225	5.58
Bi [Bismuth]	-2.271	28.233	-32.400	100.000	27.019	-21.665	-19.609	27.587	-32.921	NaN	...	-30.762	-21.645	43.14
C [Carbon]	23.179	-37.393	16.454	27.019	100.000	9.945	-3.189	11.664	-42.099	-19.715	...	10.639	-4.144	47.08
Ca [Calcium]	0.392	-15.409	-46.548	-21.665	9.945	100.000	-15.595	9.529	11.799	10.463	...	18.462	-35.870	10.23
Co [Cobalt]	2.129	2.636	11.888	-19.609	-3.189	-15.595	100.000	-1.493	1.879	-81.225	...	-11.253	-8.345	2.58
Cr [Chromium]	20.110	-3.693	-20.808	27.587	11.664	9.529	-1.493	100.000	3.361	-46.183	...	4.634	-20.567	12.84
Cu [Copper]	-7.150	65.125	-49.358	-32.921	-42.099	11.799	1.879	3.361	100.000	-83.483	...	-6.031	-9.381	-19.62
Fe (balance)	23.463	9.224	NaN	NaN	-19.715	10.463	-81.225	-46.183	-83.483	100.000	...	17.697	NaN	-35.90
H [Hydrogen]	5.397	-23.305	47.778	15.123	11.257	-19.497	1.849	-14.054	-37.187	68.991	...	11.074	26.824	3.68
Mn [Manganese]	2.315	-7.311	46.558	42.546	15.789	-31.825	7.837	-0.466	-29.630	-26.411	...	0.159	30.047	16.21
Mo [Molybdenum]	24.621	-10.081	1.153	24.494	34.437	10.936	-2.104	-2.137	-5.911	5.821	...	-4.697	-6.113	53.58
N [Nitrogen]	-5.426	18.467	-53.986	-10.993	-7.880	42.808	-8.961	12.167	37.061	24.293	...	22.208	-40.402	1.38
Nb [Niobium]	-12.961	4.540	-25.715	-9.327	-18.812	-3.501	12.612	5.727	16.315	-50.616	...	3.255	-8.807	-10.22
Ni [Nickel]	-16.119	37.224	-11.747	-8.339	-58.726	-11.651	6.696	3.521	45.313	-85.485	...	-21.273	14.491	-67.28
O [Oxygen]	-5.551	25.833	29.403	-8.058	-26.538	-30.145	3.323	-17.123	16.893	37.736	...	-15.558	39.220	-20.78
P [Phosphorus]	-5.770	-27.590	7.691	21.148	30.928	6.251	-9.606	1.404	-31.305	-27.379	...	26.642	-14.832	17.32
Pb [Lead]	12.511	-54.609	53.343	46.098	43.512	-15.916	-1.083	-8.584	-74.002	NaN	...	13.535	15.144	20.61
S [Sulfur]	-22.217	-13.422	-12.699	-30.762	10.639	18.462	-11.253	4.634	-6.031	17.697	...	100.000	-19.798	-4.78
Sb [Antimony]	5.890	8.560	65.225	-21.645	-4.144	-35.870	-8.345	-20.567	-9.381	NaN	...	-19.798	100.000	-5.18
Si [Silicon]	40.023	-12.586	5.589	43.140	47.056	10.238	2.585	12.840	-19.624	-35.908	...	-4.791	-5.189	100.00
Sn [Tin]	-5.315	48.995	-39.298	1.937	-28.225	4.154	-0.041	6.106	70.161	-92.898	...	-6.304	-12.551	-5.08
Ta [Tantalum]	-100.000	NaN	-100.000	NaN	-100.000	-100.000	100.000	-100.000	100.000	NaN	...	NaN	-100.000	-100.00
Ti [Titanium]	3.571	12.783	-26.221	-36.572	6.869	26.816	-1.349	-7.265	23.773	5.295	...	7.300	-17.086	28.76
V [Vanadium]	12.886	20.751	-24.684	22.119	-11.759	15.559	-3.348	14.679	26.187	-24.868	...	7.526	-4.019	0.66
W [Tungsten]	-23.598	43.963	50.872	-10.942	-18.169	1.961	-46.869	7.804	31.981	NaN	...	-0.000	28.963	1.14
Zr [Zirconium]	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN
0.2% Yield Strength (YS)	-5.148	-1.683	0.807	5.005	0.528	5.218	10.958	-0.305	0.328	-46.692	...	-1.316	1.120	-6.00

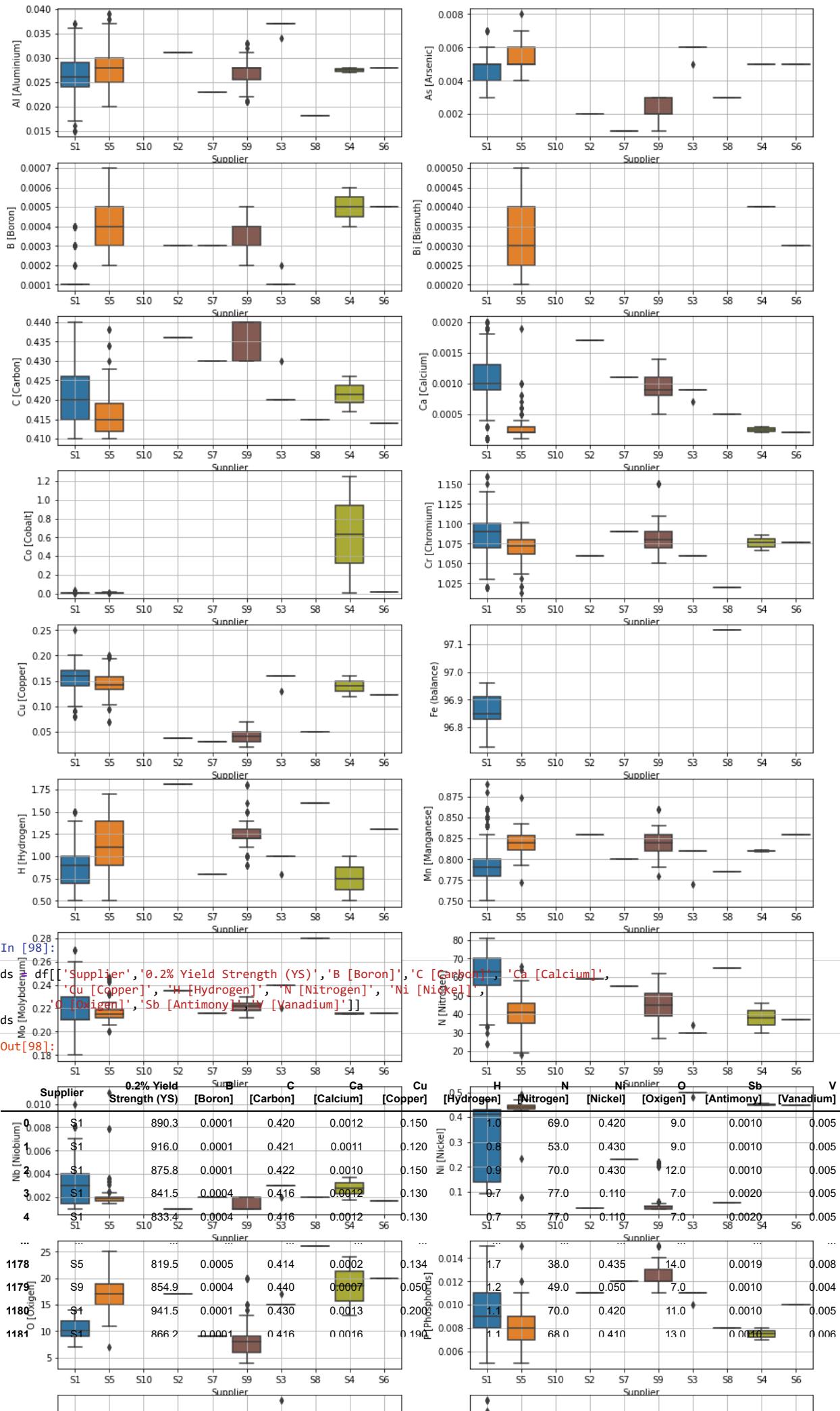
29 rows × 29 columns

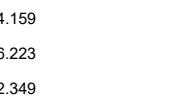
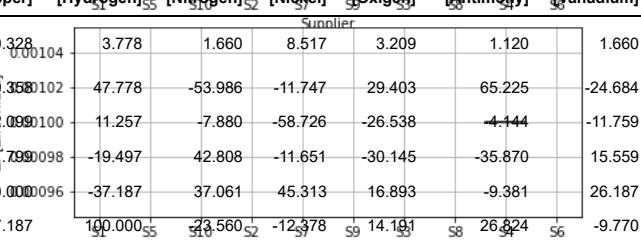
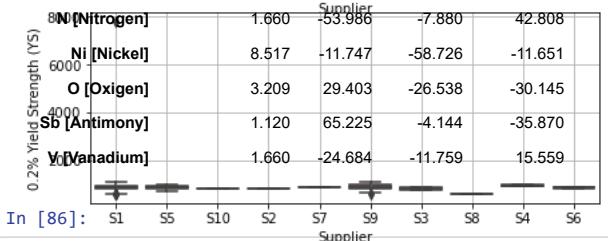
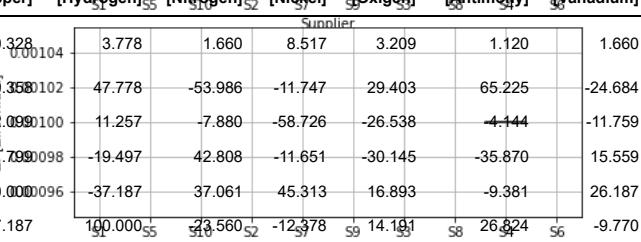
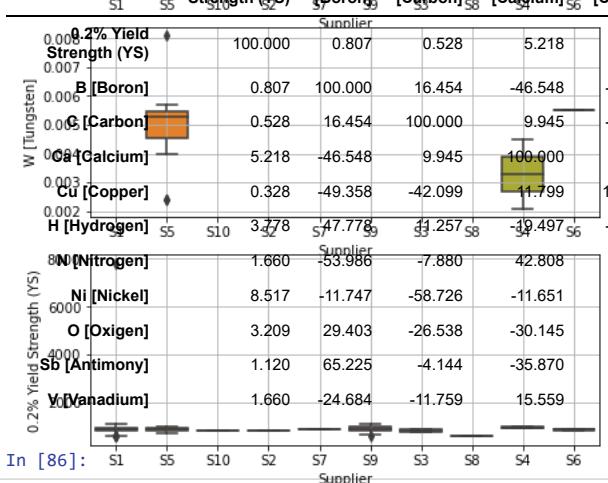
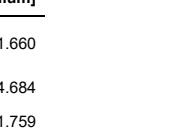
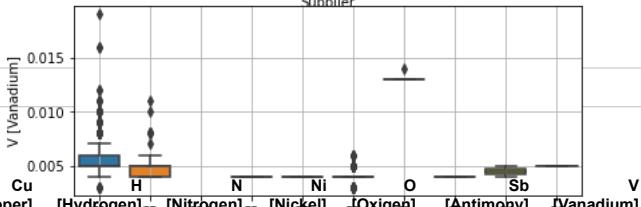
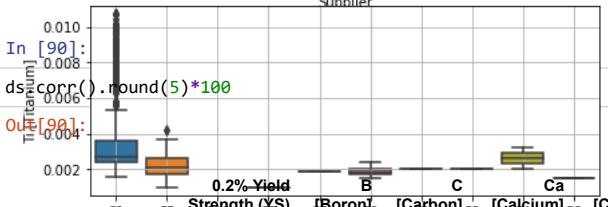
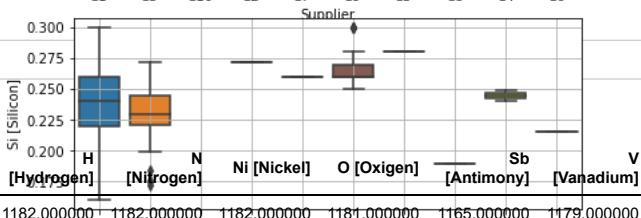
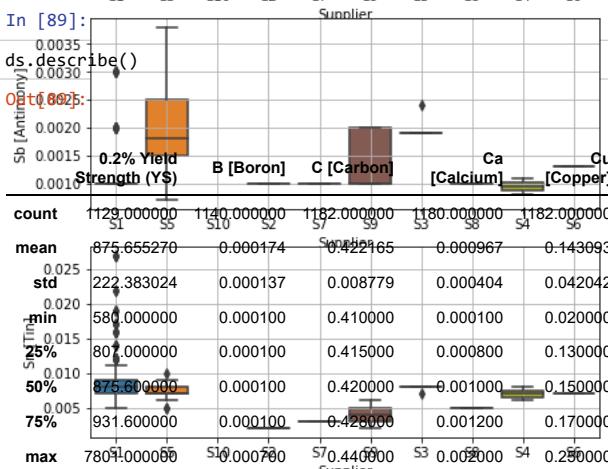
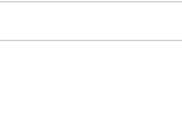
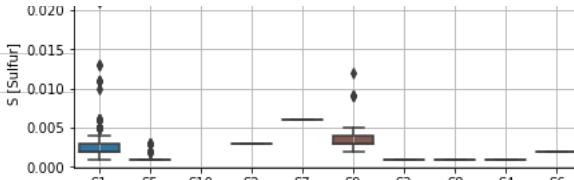
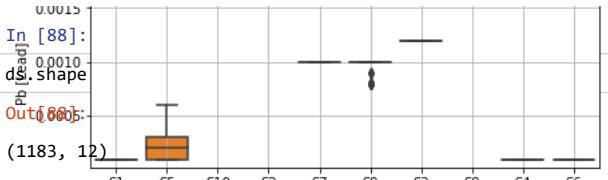
In [76]:

```
datacol = list(ds.select_dtypes(include=['float64', 'int64']))
datacol

#col=ds.columns
plt.figure(figsize=(15,100))

for i, column in enumerate(datacol):
    plt.subplot(32,2,i+1)
    sns.boxplot(data=ds, x=ds['Supplier'],y=ds[column])
    plt.grid()
```



C:\Users\mohammed\AppData\Local\Temp\ipykernel_8212\4252094064.py:1: FutureWarning: Dropping of nuisance columns in DataFra me reductions (with 'numeric_only=None') is deprecated; in a future version this will raise TypeError. Select only valid c olumns before calling the reduction.

```
ds.skew()
```

Out[86]:

0.2% Yield Strength (YS)	-0.418314
B [Boron]	1.570003
C [Carbon]	0.530078
Ca [Calcium]	-0.178551
Cu [Copper]	-1.348191
H [Hydrogen]	0.701522
N [Nitrogen]	-0.437642
Ni [Nickel]	-0.452080
O [Oxygen]	0.830703
Sb [Antimony]	3.110284
V [Vanadium]	2.406695

In [92]:

ds.groupby('Supplier').count()

Out[92]:

Supplier	0.2% Yield Strength (YS)	B [Boron]	C [Carbon]	Ca [Calcium]	Cu [Copper]	H [Hydrogen]	N [Nitrogen]	Ni [Nickel]	O [Oxygen]	Sb [Antimony]	V [Vanadium]
S1	873	881	919	917	919	919	919	919	919	918	916
S10	1	0	0	0	0	0	0	0	0	0	0
S2	1	1	1	1	1	1	1	1	1	1	1
S3	6	6	6	6	6	6	6	6	6	6	6
S4	2	2	2	2	2	2	2	2	2	2	2
S5	123	128	131	131	131	131	131	131	130	128	131
S6	2	2	2	2	2	2	2	2	2	2	2
S7	1	1	1	1	1	1	1	1	1	1	1
S8	1	0	1	1	1	1	1	1	1	1	1
S9	119	119	119	119	119	119	119	119	119	106	119

In [93]:

ds.groupby('Supplier').mean()

Out[93]:

Supplier	0.2% Yield Strength (YS)	B [Boron]	C [Carbon]	Ca [Calcium]	Cu [Copper]	H [Hydrogen]	N [Nitrogen]	Ni [Nickel]	O [Oxygen]	Sb [Antimony]	V [Vanadium]
S1	873.974914	0.000108	0.421103	0.001074	0.156485	0.889119	61.672470	0.307443	10.435256	0.001027	0.005676
S10	813.300000	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
S2	808.100000	0.000300	0.436000	0.001700	0.038000	1.810000	59.000000	0.033000	17.000000	0.001000	0.004000
S3	822.750000	0.000117	0.421667	0.000867	0.155000	0.966667	30.666667	0.496667	15.333333	0.001983	0.013167
S4	949.100000	0.000500	0.421500	0.000250	0.139500	0.750000	38.000000	0.450500	18.500000	0.000950	0.004500
S5	885.360976	0.000430	0.416588	0.000278	0.144908	1.148855	40.793893	0.435427	16.915385	0.002045	0.005008
S6	858.600000	0.000500	0.414000	0.000200	0.123000	1.300000	37.000000	0.446000	20.000000	0.001300	0.005000
S7	880.200000	0.000300	0.430000	0.001100	0.030000	0.800000	55.000000	0.230000	9.000000	0.001000	0.004000
S8	595.000000	NaN	0.415000	0.000500	0.050000	1.600000	65.000000	0.055000	26.000000	0.001000	0.004000
S9	883.082353	0.000378	0.436555	0.000925	0.040084	1.240336	45.840336	0.055294	8.294118	0.001264	0.004126

In [102]:

ds.columns

Out[102]:

```
Index(['Supplier', '0.2% Yield Strength (YS)', 'B [Boron]', 'C [Carbon]', 'Ca [Calcium]', 'Cu [Copper]', 'H [Hydrogen]', 'N [Nitrogen]', 'Ni [Nickel]', 'O [Oxygen]', 'Sb [Antimony]', 'V [Vanadium]', dtype='object')
```

In [101]:

ds.groupby('Supplier')['V [Vanadium]'].describe().T

Out[101]:

Supplier	S1	S10	S2	S3	S4	S5	S6	S7	S8	S9
count	916.000000	0.0	1.000	6.000000	2.000000	131.000000	2.000	1.000	1.000	119.000000
mean	0.005676	NaN	0.004	0.013167	0.004500	0.005008	0.005	0.004	0.004	0.004126
std	0.001474	NaN	NaN	0.000408	0.000707	0.001186	0.000	NaN	NaN	0.000683
min	0.003000	NaN	0.004	0.013000	0.004000	0.004000	0.005	0.004	0.004	0.003000
25%	0.005000	NaN	0.004	0.013000	0.004250	0.004000	0.005	0.004	0.004	0.004000
50%	0.005000	NaN	0.004	0.013000	0.004500	0.005000	0.005	0.004	0.004	0.004000
75%	0.006000	NaN	0.004	0.013000	0.004750	0.005000	0.005	0.004	0.004	0.004000
max	0.019000	NaN	0.004	0.014000	0.005000	0.011000	0.005	0.004	0.004	0.006000

In [110]:

```
for i in ds.columns:  
    print(i, ":")  
    print(ds.groupby('Supplier')[i].describe().T)  
    print()
```

Supplier :

Supplier	S1	S10	S2	S3	S4	S5	S6	S7	S8	S9
count	919	1	1	6	2	131	2	1	1	119
unique	1	1	1	1	1	1	1	1	1	1
top	S1	S10	S2	S3	S4	S5	S6	S7	S8	S9
freq	919	1	1	6	2	131	2	1	1	119

0.2% Yield Strength (YS) :

Supplier	S1	S10	S2	S3	S4	S5	\
count	873.000000	1.0	1.0	6.000000	2.000000	123.000000	
mean	873.974914	813.3	808.1	822.750000	949.100000	885.360976	
std	248.919715	NaN	NaN	60.928343	44.123463	63.096053	
min	580.000000	813.3	808.1	756.300000	917.900000	722.500000	
25%	804.000000	813.3	808.1	775.200000	933.500000	826.850000	
50%	872.400000	813.3	808.1	812.600000	949.100000	905.400000	
75%	930.600000	813.3	808.1	871.600000	964.700000	931.950000	
max	7801.000000	813.3	808.1	901.000000	980.300000	984.000000	

Supplier	S6	S7	S8	S9
count	2.000000	1.0	1.0	119.000000
mean	858.600000	880.2	595.0	883.082353
std	27.011479	NaN	NaN	97.048916
min	839.500000	880.2	595.0	596.400000
25%	849.050000	880.2	595.0	828.500000
50%	858.600000	880.2	595.0	882.500000
75%	868.150000	880.2	595.0	962.850000
max	877.700000	880.2	595.0	1074.400000

B [Boron] :

Supplier	S1	S10	S2	S3	S4	S5	S6	\
count	881.000000	0.0	1.0000	6.000000	2.000000	128.000000	2.0000	
mean	0.000108	NaN	0.0003	0.000117	0.000500	0.000430	0.0005	
std	0.000044	NaN	NaN	0.000041	0.000141	0.000109	0.0000	
min	0.000100	NaN	0.0003	0.000100	0.000400	0.000200	0.0005	
25%	0.000100	NaN	0.0003	0.000100	0.000450	0.000300	0.0005	
50%	0.000100	NaN	0.0003	0.000100	0.000500	0.000400	0.0005	
75%	0.000100	NaN	0.0003	0.000100	0.000550	0.000500	0.0005	
max	0.000400	NaN	0.0003	0.000200	0.000600	0.000700	0.0005	

Supplier	S7	S8	S9
count	1.0000	0.0	119.000000
mean	0.0003	NaN	0.000378
std	NaN	NaN	0.000070
min	0.0003	NaN	0.000200
25%	0.0003	NaN	0.000300
50%	0.0003	NaN	0.000400
75%	0.0003	NaN	0.000400
max	0.0003	NaN	0.000500

C [Carbon] :

Supplier	S1	S10	S2	S3	S4	S5	S6	S7	\
count	919.000000	0.0	1.000	6.000000	2.000000	131.000000	2.000	1.00	
mean	0.421103	NaN	0.436	0.421667	0.421500	0.416588	0.414	0.43	
std	0.007654	NaN	NaN	0.004882	0.006364	0.005714	0.000	NaN	
min	0.410000	NaN	0.436	0.420000	0.417000	0.410000	0.414	0.43	
25%	0.415000	NaN	0.436	0.420000	0.419250	0.412000	0.414	0.43	
50%	0.420000	NaN	0.436	0.420000	0.421500	0.415000	0.414	0.43	
75%	0.426000	NaN	0.436	0.420000	0.423750	0.419000	0.414	0.43	
max	0.440000	NaN	0.436	0.430000	0.426000	0.438000	0.414	0.43	

Supplier	S8	S9
count	1.000	119.000000
mean	0.415	0.436555
std	NaN	0.004772
min	0.415	0.430000
25%	0.415	0.430000
50%	0.415	0.440000
75%	0.415	0.440000
max	0.415	0.440000

Ca [Calcium] :

Supplier	S1	S10	S2	S3	S4	S5	S6	\
count	917.000000	0.0	1.000	6.000000	2.000000	131.000000	2.0000	
mean	0.001074	NaN	0.0017	0.000867	0.000250	0.000278	0.0002	
std	0.000336	NaN	NaN	0.000082	0.000071	0.000224	0.0000	
min	0.000100	NaN	0.0017	0.000700	0.000200	0.000100	0.0002	
25%	0.000900	NaN	0.0017	0.000900	0.000225	0.000200	0.0002	
50%	0.001000	NaN	0.0017	0.000900	0.000250	0.000200	0.0002	
75%	0.001300	NaN	0.0017	0.000900	0.000275	0.000300	0.0002	
max	0.002000	NaN	0.0017	0.000900	0.000300	0.001900	0.0002	

Supplier	S7	S8	S9
count	1.0000	1.0000	119.000000
mean	0.0011	0.0005	0.000925
std	NaN	NaN	0.000234
min	0.0011	0.0005	0.000500
25%	0.0011	0.0005	0.000800
50%	0.0011	0.0005	0.000900
75%	0.0011	0.0005	0.001100
max	0.0011	0.0005	0.001400

Cu [Copper] :

Supplier	S1	S10	S2	S3	S4	S5	S6	S7	\
count	919.000000	0.0	1.000	6.000000	2.000000	131.000000	2.000	1.00	
mean	0.156485	NaN	0.038	0.155000	0.139500	0.144908	0.123	0.03	
std	0.024077	NaN	NaN	0.012247	0.028991	0.022648	0.000	NaN	
min	0.080000	NaN	0.038	0.130000	0.119000	0.069000	0.123	0.03	
25%	0.140000	NaN	0.038	0.160000	0.129250	0.134000	0.123	0.03	
50%	0.160000	NaN	0.038	0.160000	0.139500	0.143000	0.123	0.03	
75%	0.170000	NaN	0.038	0.160000	0.149750	0.158000	0.123	0.03	
max	0.250000	NaN	0.038	0.160000	0.160000	0.200000	0.123	0.03	

Supplier	S8	S9
count	1.00	119.000000
mean	0.05	0.040084
std	NaN	0.014526
min	0.05	0.020000
25%	0.05	0.030000
50%	0.05	0.040000
75%	0.05	0.050000
max	0.05	0.070000

H [Hydrogen] :

Supplier	S1	S10	S2	S3	S4	S5	S6	S7	\
count	919.000000	0.0	1.00	6.000000	2.000000	131.000000	2.0	1.0	
mean	0.889119	NaN	1.81	0.966667	0.750000	1.148855	1.3	0.8	
std	0.185273	NaN	NaN	0.081650	0.353553	0.300862	0.0	NaN	
min	0.500000	NaN	1.81	0.800000	0.500000	0.500000	1.3	0.8	
25%	0.700000	NaN	1.81	1.000000	0.625000	0.900000	1.3	0.8	
50%	0.900000	NaN	1.81	1.000000	0.750000	1.100000	1.3	0.8	
75%	1.000000	NaN	1.81	1.000000	0.875000	1.400000	1.3	0.8	
max	1.500000	NaN	1.81	1.000000	1.000000	1.700000	1.3	0.8	

Supplier	S8	S9
count	1.0	119.000000
mean	1.6	1.240336
std	NaN	0.165867
min	1.6	0.900000
25%	1.6	1.200000
50%	1.6	1.200000
75%	1.6	1.300000
max	1.6	1.800000

N [Nitrogen] :

Supplier	S1	S10	S2	S3	S4	S5	S6	S7	\
count	919.000000	0.0	1.0	6.000000	2.000000	131.000000	2.0	1.0	
mean	61.672470	NaN	59.0	30.666667	38.000000	40.793893	37.0	55.0	
std	9.815976	NaN	NaN	1.632993	11.313708	8.999759	0.0	NaN	
min	24.000000	NaN	59.0	30.000000	30.000000	18.000000	37.0	55.0	
25%	55.500000	NaN	59.0	30.000000	34.000000	35.000000	37.0	55.0	
50%	63.000000	NaN	59.0	30.000000	38.000000	41.000000	37.0	55.0	
75%	70.000000	NaN	59.0	30.000000	42.000000	46.000000	37.0	55.0	
max	81.000000	NaN	59.0	34.000000	46.000000	66.000000	37.0	55.0	

Supplier	S8	S9
count	1.0	119.000000
mean	65.0	45.840336
std	NaN	8.363544
min	65.0	27.000000
25%	65.0	39.000000
50%	65.0	45.000000
75%	65.0	51.000000
max	65.0	62.000000

Ni [Nickel] :

Supplier	S1	S10	S2	S3	S4	S5	S6	S7	\
count	919.000000	0.0	1.000	6.000000	2.000000	131.000000	2.000	1.00	
mean	0.307443	NaN	0.033	0.496667	0.450500	0.435427	0.446	0.23	
std	0.143901	NaN	NaN	0.008165	0.006364	0.049869	0.000	NaN	
min	0.090000	NaN	0.033	0.480000	0.446000	0.077000	0.446	0.23	
25%	0.140000	NaN	0.033	0.500000	0.448250	0.434000	0.446	0.23	
50%	0.410000	NaN	0.033	0.500000	0.450500	0.440000	0.446	0.23	
75%	0.430000	NaN	0.033	0.500000	0.452750	0.449000	0.446	0.23	
max	0.470000	NaN	0.033	0.500000	0.455000	0.490000	0.446	0.23	

Supplier	S8	S9
count	1.000	119.000000
mean	0.055	0.055294
std	NaN	0.053675
min	0.055	0.030000
25%	0.055	0.030000
50%	0.055	0.040000
75%	0.055	0.040000
max	0.055	0.220000

O [Oxygen] :

Supplier	S1	S10	S2	S3	S4	S5	S6	S7	\
count	919.000000	0.0	1.0	6.000000	2.000000	130.000000	2.0	1.0	
mean	10.435256	NaN	17.0	15.333333	18.500000	16.915385	20.0	9.0	
std	2.298502	NaN	NaN	0.816497	7.778175	3.057675	0.0	NaN	
min	7.000000	NaN	17.0	15.000000	13.000000	7.000000	20.0	9.0	
25%	9.000000	NaN	17.0	15.000000	15.750000	15.000000	20.0	9.0	
50%	10.000000	NaN	17.0	15.000000	18.500000	17.000000	20.0	9.0	

```
75%      12.000000  NaN  17.0  15.000000  21.250000  19.000000  20.0  9.0
max       14.000000  NaN  17.0  17.000000  24.000000  25.000000  20.0  9.0
```

```
Supplier    S8      S9
count      1.0   119.000000
mean      26.0    8.294118
std       NaN     3.880313
min      26.0    4.000000
25%      26.0    6.000000
50%      26.0    8.000000
75%      26.0    9.000000
max      26.0   20.000000
```

Sb [Antimony] :

Supplier	S1	S10	S2	S3	S4	S5	S6	\
count	918.000000	0.0	1.000	6.000000	2.000000	128.000000	2.0000	
mean	0.001027	NaN	0.001	0.001983	0.000950	0.002045	0.0013	
std	0.000204	NaN	NaN	0.000204	0.000212	0.000725	0.0000	
min	0.001000	NaN	0.001	0.001900	0.000800	0.000700	0.0013	
25%	0.001000	NaN	0.001	0.001900	0.000875	0.001500	0.0013	
50%	0.001000	NaN	0.001	0.001900	0.000950	0.001800	0.0013	
75%	0.001000	NaN	0.001	0.001900	0.001025	0.002500	0.0013	
max	0.003000	NaN	0.001	0.002400	0.001100	0.003800	0.0013	

```
Supplier    S7      S8      S9
count      1.000   1.000  106.000000
mean      0.001   0.001  0.001264
std       NaN     NaN     0.000443
min      0.001   0.001  0.001000
25%      0.001   0.001  0.001000
50%      0.001   0.001  0.001000
75%      0.001   0.001  0.002000
max      0.001   0.001  0.002000
```

V [Vanadium] :

Supplier	S1	S10	S2	S3	S4	S5	S6	\
count	916.000000	0.0	1.000	6.000000	2.000000	131.000000	2.000	
mean	0.005676	NaN	0.004	0.013167	0.004500	0.005008	0.005	
std	0.001474	NaN	NaN	0.000408	0.000707	0.001186	0.000	
min	0.003000	NaN	0.004	0.013000	0.004000	0.004000	0.005	
25%	0.005000	NaN	0.004	0.013000	0.004250	0.004000	0.005	
50%	0.005000	NaN	0.004	0.013000	0.004500	0.005000	0.005	
75%	0.006000	NaN	0.004	0.013000	0.004750	0.005000	0.005	
max	0.019000	NaN	0.004	0.014000	0.005000	0.011000	0.005	

```
Supplier    S7      S8      S9
count      1.000   1.000  119.000000
mean      0.004   0.004  0.004126
std       NaN     NaN     0.000683
min      0.004   0.004  0.003000
25%      0.004   0.004  0.004000
50%      0.004   0.004  0.004000
75%      0.004   0.004  0.004000
max      0.004   0.004  0.006000
```

In [113]:

```
for i in ds.columns:  
    print(i, ":")  
    print(df.groupby('Supplier').cov().round(3))  
    print()
```

Supplier :

		Sn	Order ID	\
Supplier				
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	

		Batch ID	Reduction Ratio	\
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05		Nan
	Ultimate Tensile Strength (UTS)	-7.615006e+04		-26.221
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-2.014228e+03		0.547
	% Reduction of Area (RoA Z)	-3.147625e+03		1.805

		Weight	Ø Ex	\
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)		Nan	Nan
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	

		Ø In	Height	\
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)		Nan	Nan
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	

		Thickness	Al [Aluminium]	...	\
Supplier					
S1	Sn	-12612.090	2.543	...	
	Order ID	881602.083	294.528	...	
	Batch ID	-16663.356	2.973	...	
	Reduction Ratio	-15.912	0.000	...	
	Weight	38885.482	0.301	...	
...		
S9	Upper Yield Strength (ReH)		Nan	0.079	...
	Ultimate Tensile Strength (UTS)	1807.784	-0.001	...	
	YS/UTS Ratio		Nan	Nan	...
	% Elongation (A)	-46.019	-0.000	...	
	% Reduction of Area (RoA Z)	-139.109	0.001	...	

		ASTM E45 Met.A - D thin \		
Supplier				
S1	Sn		-416.141	
	Order ID		32917.030	
	Batch ID		-486.555	
	Reduction Ratio		-0.060	
	Weight		12.231	
...			...	
S9	Upper Yield Strength (ReH)		2.950	
	Ultimate Tensile Strength (UTS)		-4.909	
	YS/UTS Ratio		Nan	
	% Elongation (A)		0.118	
	% Reduction of Area (RoA Z)		0.140	

		ISO 4967 Met.A DIN 50602 - K4 \		
Supplier				
S1	Sn	5.844	-949.024	
	Order ID	5680.202	160478.775	
	Batch ID	1.195	-1238.946	
	Reduction Ratio	0.010	0.391	

	Weight	87.736	438.188
...	
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	Nan	Nan
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA z)	0.000	0.178
	Grain size \		
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2107.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	Nan	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA z)	0.441	
	0.2% Yield Strength (YS) \		
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA z)	-382.301	
	Upper Yield Strength (ReH) \		
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA z)	45.290	
	Ultimate Tensile Strength (UTS) \		
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA z)	-336.165	
	YS/UTS Ratio % Elongation (A) \		
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	Nan	-12.680
	Ultimate Tensile Strength (UTS)	Nan	-108.429
	YS/UTS Ratio	Nan	Nan
	% Elongation (A)	Nan	3.156
	% Reduction of Area (RoA z)	Nan	7.048
	% Reduction of Area (RoA z)		
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	Nan	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA z)	24.866	

[770 rows x 77 columns]

0.2% Yield Strength (YS) :

		Sn	Order ID	\
Supplier				
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	

Batch ID Reduction Ratio \

		Batch ID	Reduction Ratio	\
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05		NaN
	Ultimate Tensile Strength (UTS)	-7.615006e+04		-26.221
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-2.014228e+03		0.547
	% Reduction of Area (RoA Z)	-3.147625e+03		1.805

Weight Ø Ex \

		Weight	Ø Ex	\
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)		NaN	NaN
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	

Ø In Height \

		Ø In	Height	\
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)		NaN	NaN
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	

Thickness Al [Aluminium] ... \

		Thickness	Al [Aluminium]	...	\
Supplier					
S1	Sn	-12612.090	2.543	...	
	Order ID	881602.083	294.528	...	
	Batch ID	-16663.356	2.973	...	
	Reduction Ratio	-15.912	0.000	...	
	Weight	38885.482	0.301	...	
...		
S9	Upper Yield Strength (ReH)		NaN	0.079	...
	Ultimate Tensile Strength (UTS)	1807.784	-0.001	...	
	YS/UTS Ratio		NaN	NaN	...
	% Elongation (A)	-46.019	-0.000	...	
	% Reduction of Area (RoA Z)	-139.109	0.001	...	

ASTM E45 Met.A - D thin \

		ASTM E45 Met.A - D thin	\
Supplier			
S1	Sn	-416.141	
	Order ID	32917.030	
	Batch ID	-486.555	
	Reduction Ratio	-0.060	
	Weight	12.231	
...		...	
S9	Upper Yield Strength (ReH)	2.950	
	Ultimate Tensile Strength (UTS)	-4.909	
	YS/UTS Ratio		NaN
	% Elongation (A)	0.118	
	% Reduction of Area (RoA Z)	0.140	

ISO 4967 Met.A DIN 50602 - K4 \

		ISO 4967 Met.A DIN 50602 - K4	\
Supplier			
S1	Sn	5.844	-949.024
	Order ID	5680.202	160478.775
	Batch ID	1.195	-1238.946

	Reduction Ratio	0.010	0.391
	Weight	87.736	438.188
...	
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA Z)	0.000	0.178

Grain size \			
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2107.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	NaN	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA Z)	0.441	

0.2% Yield Strength (YS) \			
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA Z)	-382.301	

Upper Yield Strength (ReH) \			
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA Z)	45.290	

Ultimate Tensile Strength (UTS) \			
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA Z)	-336.165	

YS/UTS Ratio % Elongation (A) \			
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	NaN	-12.680
	Ultimate Tensile Strength (UTS)	NaN	-108.429
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	NaN	3.156
	% Reduction of Area (RoA Z)	NaN	7.048

% Reduction of Area (RoA Z)			
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	NaN	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA Z)	24.866	

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[770 rows x 77 columns]
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B [Boron] :
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Supplier		Sn	Order ID	\
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	
		Batch ID	Reduction Ratio	\
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05		Nan
	Ultimate Tensile Strength (UTS)	-7.615006e+04		-26.221
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-2.014228e+03		0.547
	% Reduction of Area (RoA Z)	-3.147625e+03		1.805
		Weight	ø Ex	\
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)		Nan	Nan
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	
		ø In	Height	\
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)		Nan	Nan
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	
		Thickness	Al [Aluminium]	...
Supplier				
S1	Sn	-12612.090	2.543	...
	Order ID	881602.083	294.528	...
	Batch ID	-16663.356	2.973	...
	Reduction Ratio	-15.912	0.000	...
	Weight	38885.482	0.301	...
...	
S9	Upper Yield Strength (ReH)		0.079	...
	Ultimate Tensile Strength (UTS)	1807.784	-0.001	...
	YS/UTS Ratio		Nan	...
	% Elongation (A)	-46.019	-0.000	...
	% Reduction of Area (RoA Z)	-139.109	0.001	...
		ASTM E45 Met.A - D thin		\
Supplier				
S1	Sn	-416.141		
	Order ID	32917.030		
	Batch ID	-486.555		
	Reduction Ratio	-0.060		
	Weight	12.231		
...		...		
S9	Upper Yield Strength (ReH)	2.950		
	Ultimate Tensile Strength (UTS)	-4.909		
	YS/UTS Ratio		Nan	
	% Elongation (A)	0.118		
	% Reduction of Area (RoA Z)	0.140		
		ISO 4967 Met.A	DIN 50602 - K4	\
Supplier				
S1	Sn	5.844	-949.024	
	Order ID	5680.202	160478.775	
	Batch ID	1.195	-1238.946	
	Reduction Ratio	0.010	0.391	
	Weight	87.736	438.188	

...			
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA z)	0.000	0.178
	Grain size \		
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2187.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	NaN	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA z)	0.441	
	0.2% Yield Strength (YS) \		
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA z)	-382.301	
	Upper Yield Strength (ReH) \		
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA z)	45.290	
	Ultimate Tensile Strength (UTS) \		
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA z)	-336.165	
	YS/UTS Ratio % Elongation (A) \		
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	NaN	-12.680
	Ultimate Tensile Strength (UTS)	NaN	-108.429
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	NaN	3.156
	% Reduction of Area (RoA z)	NaN	7.048
	% Reduction of Area (RoA z)		
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	NaN	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA z)	24.866	

[770 rows x 77 columns]

C [Carbon] :

		Sn	Order ID	\
Supplier				
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio	Nan	Nan	
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	

Batch ID Reduction Ratio \

		Batch ID	Reduction Ratio	\
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05	Nan	
	Ultimate Tensile Strength (UTS)	-7.615006e+04	-26.221	
	YS/UTS Ratio	Nan	Nan	
	% Elongation (A)	-2.014228e+03	0.547	
	% Reduction of Area (RoA Z)	-3.147625e+03	1.805	

Weight Ø Ex \

		Weight	Ø Ex	\
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)	Nan	Nan	
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio	Nan	Nan	
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	

Ø In Height \

		Ø In	Height	\
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)	Nan	Nan	
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio	Nan	Nan	
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	

Thickness Al [Aluminium] ... \

		Thickness	Al [Aluminium]	...	\
Supplier					
S1	Sn	-12612.090	2.543	...	
	Order ID	881602.083	294.528	...	
	Batch ID	-16663.356	2.973	...	
	Reduction Ratio	-15.912	0.000	...	
	Weight	38885.482	0.301	...	
...		
S9	Upper Yield Strength (ReH)	Nan	0.079	...	
	Ultimate Tensile Strength (UTS)	1807.784	-0.001	...	
	YS/UTS Ratio	Nan	Nan	...	
	% Elongation (A)	-46.019	-0.000	...	
	% Reduction of Area (RoA Z)	-139.109	0.001	...	

ASTM E45 Met.A - D thin \

Supplier					
S1	Sn	-416.141			
	Order ID	32917.030			
	Batch ID	-486.555			
	Reduction Ratio	-0.060			
	Weight	12.231			
...		...			
S9	Upper Yield Strength (ReH)	2.950			
	Ultimate Tensile Strength (UTS)	-4.909			
	YS/UTS Ratio	Nan			
	% Elongation (A)	0.118			
	% Reduction of Area (RoA Z)	0.140			

ISO 4967 Met.A DIN 50602 - K4 \

Supplier				
S1	Sn	5.844	-949.024	
	Order ID	5680.202	160478.775	
	Batch ID	1.195	-1238.946	
	Reduction Ratio	0.010	0.391	

	Weight	87.736	438.188
...	
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	Nan	Nan
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA z)	0.000	0.178
	Grain size \		
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2107.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	Nan	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA z)	0.441	
	0.2% Yield Strength (YS) \		
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA z)	-382.301	
	Upper Yield Strength (ReH) \		
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA z)	45.290	
	Ultimate Tensile Strength (UTS) \		
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA z)	-336.165	
	YS/UTS Ratio % Elongation (A) \		
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	Nan	-12.680
	Ultimate Tensile Strength (UTS)	Nan	-108.429
	YS/UTS Ratio	Nan	Nan
	% Elongation (A)	Nan	3.156
	% Reduction of Area (RoA z)	Nan	7.048
	% Reduction of Area (RoA z)		
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	Nan	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA z)	24.866	

[770 rows x 77 columns]

Ca [Calcium] :

		Sn	Order ID	\
Supplier				
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	

Batch ID Reduction Ratio \

		Batch ID	Reduction Ratio	\
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05		NaN
	Ultimate Tensile Strength (UTS)	-7.615006e+04		-26.221
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-2.014228e+03		0.547
	% Reduction of Area (RoA Z)	-3.147625e+03		1.805

Weight Ø Ex \

		Weight	Ø Ex	\
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)		NaN	NaN
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	

Ø In Height \

		Ø In	Height	\
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)		NaN	NaN
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	

Thickness Al [Aluminium] ... \

		Thickness	Al [Aluminium]	...	\
Supplier					
S1	Sn	-12612.090	2.543	...	
	Order ID	881602.083	294.528	...	
	Batch ID	-16663.356	2.973	...	
	Reduction Ratio	-15.912	0.000	...	
	Weight	38885.482	0.301	...	
...		
S9	Upper Yield Strength (ReH)		NaN	0.079	...
	Ultimate Tensile Strength (UTS)	1807.784	-0.001	...	
	YS/UTS Ratio		NaN	NaN	...
	% Elongation (A)	-46.019	-0.000	...	
	% Reduction of Area (RoA Z)	-139.109	0.001	...	

ASTM E45 Met.A - D thin \

		ASTM E45 Met.A - D thin	\
Supplier			
S1	Sn	-416.141	
	Order ID	32917.030	
	Batch ID	-486.555	
	Reduction Ratio	-0.060	
	Weight	12.231	
...		...	
S9	Upper Yield Strength (ReH)		2.950
	Ultimate Tensile Strength (UTS)		-4.909
	YS/UTS Ratio		NaN
	% Elongation (A)		0.118
	% Reduction of Area (RoA Z)		0.140

ISO 4967 Met.A DIN 50602 - K4 \

		ISO 4967 Met.A DIN 50602 - K4	\
Supplier			
S1	Sn	5.844	-949.024
	Order ID	5680.202	160478.775
	Batch ID	1.195	-1238.946

	Reduction Ratio	0.010	0.391
	Weight	87.736	438.188
...	
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA Z)	0.000	0.178
	Grain size \		
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2107.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	NaN	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA Z)	0.441	
	0.2% Yield Strength (YS) \		
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA Z)	-382.301	
	Upper Yield Strength (ReH) \		
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA Z)	45.290	
	Ultimate Tensile Strength (UTS) \		
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA Z)	-336.165	
	YS/UTS Ratio % Elongation (A) \		
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	NaN	-12.680
	Ultimate Tensile Strength (UTS)	NaN	-108.429
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	NaN	3.156
	% Reduction of Area (RoA Z)	NaN	7.048
	% Reduction of Area (RoA Z)		
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	NaN	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA Z)	24.866	

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[770 rows x 77 columns]
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Cu [Copper] :
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Sn Order ID \				
Supplier				
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	
Batch ID Reduction Ratio \				
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05		Nan
	Ultimate Tensile Strength (UTS)	-7.615006e+04		-26.221
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-2.014228e+03		0.547
	% Reduction of Area (RoA Z)	-3.147625e+03		1.805
Weight φ Ex \				
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)		Nan	Nan
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	
φ In Height \				
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)		Nan	Nan
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	
Thickness Al [Aluminium] ... \				
Supplier				
S1	Sn	-12612.090	2.543	...
	Order ID	881602.083	294.528	...
	Batch ID	-16663.356	2.973	...
	Reduction Ratio	-15.912	0.000	...
	Weight	38885.482	0.301	...
...	
S9	Upper Yield Strength (ReH)		0.079	...
	Ultimate Tensile Strength (UTS)	1807.784	-0.001	...
	YS/UTS Ratio		Nan	...
	% Elongation (A)	-46.019	-0.000	...
	% Reduction of Area (RoA Z)	-139.109	0.001	...
ASTM E45 Met.A - D thin \				
Supplier				
S1	Sn	-416.141		
	Order ID	32917.030		
	Batch ID	-486.555		
	Reduction Ratio	-0.060		
	Weight	12.231		
...		...		
S9	Upper Yield Strength (ReH)		2.950	
	Ultimate Tensile Strength (UTS)		-4.909	
	YS/UTS Ratio		Nan	
	% Elongation (A)		0.118	
	% Reduction of Area (RoA Z)		0.140	
ISO 4967 Met.A DIN 50602 - K4 \				
Supplier				
S1	Sn	5.844	-949.024	
	Order ID	5680.202	160478.775	
	Batch ID	1.195	-1238.946	
	Reduction Ratio	0.010	0.391	
	Weight	87.736	438.188	

...			
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA z)	0.000	0.178
	Grain size \		
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2187.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	NaN	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA z)	0.441	
	0.2% Yield Strength (YS) \		
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA z)	-382.301	
	Upper Yield Strength (ReH) \		
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA z)	45.290	
	Ultimate Tensile Strength (UTS) \		
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA z)	-336.165	
	YS/UTS Ratio % Elongation (A) \		
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	NaN	-12.680
	Ultimate Tensile Strength (UTS)	NaN	-108.429
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	NaN	3.156
	% Reduction of Area (RoA z)	NaN	7.048
	% Reduction of Area (RoA z)		
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	NaN	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA z)	24.866	

[770 rows x 77 columns]

H [Hydrogen] :

		Sn	Order ID	\
Supplier				
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio	NaN	NaN	
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	

Batch ID Reduction Ratio \

		Batch ID	Reduction Ratio	\
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05	NaN	
	Ultimate Tensile Strength (UTS)	-7.615006e+04	-26.221	
	YS/UTS Ratio	NaN	NaN	
	% Elongation (A)	-2.014228e+03	0.547	
	% Reduction of Area (RoA Z)	-3.147625e+03	1.805	

Weight Ø Ex \

		Weight	Ø Ex	\
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)	NaN	NaN	
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio	NaN	NaN	
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	

Ø In Height \

		Ø In	Height	\
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)	NaN	NaN	
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio	NaN	NaN	
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	

Thickness Al [Aluminium] ... \

		Thickness	Al [Aluminium]	...	\
Supplier					
S1	Sn	-12612.090	2.543	...	
	Order ID	881602.083	294.528	...	
	Batch ID	-16663.356	2.973	...	
	Reduction Ratio	-15.912	0.000	...	
	Weight	38885.482	0.301	...	
...		
S9	Upper Yield Strength (ReH)	NaN	0.079	...	
	Ultimate Tensile Strength (UTS)	1807.784	-0.001	...	
	YS/UTS Ratio	NaN	NaN	...	
	% Elongation (A)	-46.019	-0.000	...	
	% Reduction of Area (RoA Z)	-139.109	0.001	...	

ASTM E45 Met.A - D thin \

Supplier					
S1	Sn	-416.141			
	Order ID	32917.030			
	Batch ID	-486.555			
	Reduction Ratio	-0.060			
	Weight	12.231			
...		...			
S9	Upper Yield Strength (ReH)	2.950			
	Ultimate Tensile Strength (UTS)	-4.909			
	YS/UTS Ratio	NaN			
	% Elongation (A)	0.118			
	% Reduction of Area (RoA Z)	0.140			

ISO 4967 Met.A DIN 50602 - K4 \

Supplier					
S1	Sn	5.844	-949.024		
	Order ID	5680.202	160478.775		
	Batch ID	1.195	-1238.946		
	Reduction Ratio	0.010	0.391		

	Weight	87.736	438.188
...	
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	Nan	Nan
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA z)	0.000	0.178
	Grain size \		
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2107.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	Nan	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA z)	0.441	
	0.2% Yield Strength (YS) \		
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA z)	-382.301	
	Upper Yield Strength (ReH) \		
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA z)	45.290	
	Ultimate Tensile Strength (UTS) \		
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA z)	-336.165	
	YS/UTS Ratio % Elongation (A) \		
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	Nan	-12.680
	Ultimate Tensile Strength (UTS)	Nan	-108.429
	YS/UTS Ratio	Nan	Nan
	% Elongation (A)	Nan	3.156
	% Reduction of Area (RoA z)	Nan	7.048
	% Reduction of Area (RoA z)		
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	Nan	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA z)	24.866	

[770 rows x 77 columns]

N [Nitrogen] :

		Sn	Order ID	\
Supplier				
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	

Batch ID Reduction Ratio \

		Batch ID	Reduction Ratio	\
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05		NaN
	Ultimate Tensile Strength (UTS)	-7.615006e+04		-26.221
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-2.014228e+03		0.547
	% Reduction of Area (RoA Z)	-3.147625e+03		1.805

Weight Ø Ex \

		Weight	Ø Ex	\
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)		NaN	NaN
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	

Ø In Height \

		Ø In	Height	\
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)		NaN	NaN
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	

Thickness Al [Aluminium] ... \

		Thickness	Al [Aluminium]	...	\
Supplier					
S1	Sn	-12612.090	2.543	...	
	Order ID	881602.083	294.528	...	
	Batch ID	-16663.356	2.973	...	
	Reduction Ratio	-15.912	0.000	...	
	Weight	38885.482	0.301	...	
...		
S9	Upper Yield Strength (ReH)		NaN	0.079	...
	Ultimate Tensile Strength (UTS)	1807.784	-0.001	...	
	YS/UTS Ratio		NaN	NaN	...
	% Elongation (A)	-46.019	-0.000	...	
	% Reduction of Area (RoA Z)	-139.109	0.001	...	

ASTM E45 Met.A - D thin \

Supplier					
S1	Sn		-416.141		
	Order ID		32917.030		
	Batch ID		-486.555		
	Reduction Ratio		-0.060		
	Weight		12.231		
...			...		
S9	Upper Yield Strength (ReH)		2.950		
	Ultimate Tensile Strength (UTS)		-4.909		
	YS/UTS Ratio			NaN	
	% Elongation (A)		0.118		
	% Reduction of Area (RoA Z)		0.140		

ISO 4967 Met.A DIN 50602 - K4 \

Supplier				
S1	Sn	5.844	-949.024	
	Order ID	5680.202	160478.775	
	Batch ID	1.195	-1238.946	

	Reduction Ratio	0.010	0.391
	Weight	87.736	438.188
...	
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA Z)	0.000	0.178
	Grain size \		
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2107.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	NaN	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA Z)	0.441	
	0.2% Yield Strength (YS) \		
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA Z)	-382.301	
	Upper Yield Strength (ReH) \		
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA Z)	45.290	
	Ultimate Tensile Strength (UTS) \		
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA Z)	-336.165	
	YS/UTS Ratio % Elongation (A) \		
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	NaN	-12.680
	Ultimate Tensile Strength (UTS)	NaN	-108.429
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	NaN	3.156
	% Reduction of Area (RoA Z)	NaN	7.048
	% Reduction of Area (RoA Z)		
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	NaN	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA Z)	24.866	

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[770 rows x 77 columns]
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Ni [Nickel] :
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Sn Order ID \				
Supplier				
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	
Batch ID Reduction Ratio \				
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05		Nan
	Ultimate Tensile Strength (UTS)	-7.615006e+04		-26.221
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-2.014228e+03		0.547
	% Reduction of Area (RoA Z)	-3.147625e+03		1.805
Weight φ Ex \				
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)		Nan	Nan
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	
φ In Height \				
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)		Nan	Nan
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	
Thickness Al [Aluminium] ... \				
Supplier				
S1	Sn	-12612.090	2.543	...
	Order ID	881602.083	294.528	...
	Batch ID	-16663.356	2.973	...
	Reduction Ratio	-15.912	0.000	...
	Weight	38885.482	0.301	...
...	
S9	Upper Yield Strength (ReH)		0.079	...
	Ultimate Tensile Strength (UTS)	1807.784	-0.001	...
	YS/UTS Ratio		Nan	...
	% Elongation (A)	-46.019	-0.000	...
	% Reduction of Area (RoA Z)	-139.109	0.001	...
ASTM E45 Met.A - D thin \				
Supplier				
S1	Sn	-416.141		
	Order ID	32917.030		
	Batch ID	-486.555		
	Reduction Ratio	-0.060		
	Weight	12.231		
...		...		
S9	Upper Yield Strength (ReH)		2.950	
	Ultimate Tensile Strength (UTS)		-4.909	
	YS/UTS Ratio		Nan	
	% Elongation (A)		0.118	
	% Reduction of Area (RoA Z)		0.140	
ISO 4967 Met.A DIN 50602 - K4 \				
Supplier				
S1	Sn	5.844	-949.024	
	Order ID	5680.202	160478.775	
	Batch ID	1.195	-1238.946	
	Reduction Ratio	0.010	0.391	
	Weight	87.736	438.188	

...			
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA z)	0.000	0.178
	Grain size \		
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2187.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	NaN	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA z)	0.441	
	0.2% Yield Strength (YS) \		
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA z)	-382.301	
	Upper Yield Strength (ReH) \		
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA z)	45.290	
	Ultimate Tensile Strength (UTS) \		
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA z)	-336.165	
	YS/UTS Ratio % Elongation (A) \		
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	NaN	-12.680
	Ultimate Tensile Strength (UTS)	NaN	-108.429
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	NaN	3.156
	% Reduction of Area (RoA z)	NaN	7.048
	% Reduction of Area (RoA z)		
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	NaN	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA z)	24.866	

[770 rows x 77 columns]

0 [Oxygen] :

		Sn	Order ID	\
Supplier				
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	

Batch ID Reduction Ratio \

		Batch ID	Reduction Ratio	\
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05		Nan
	Ultimate Tensile Strength (UTS)	-7.615006e+04		-26.221
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-2.014228e+03		0.547
	% Reduction of Area (RoA Z)	-3.147625e+03		1.805

Weight Ø Ex \

		Weight	Ø Ex	\
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)		Nan	Nan
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	

Ø In Height \

		Ø In	Height	\
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)		Nan	Nan
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio		Nan	Nan
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	

Thickness Al [Aluminium] ... \

		Thickness	Al [Aluminium]	...	\
Supplier					
S1	Sn	-12612.090	2.543	...	
	Order ID	881602.083	294.528	...	
	Batch ID	-16663.356	2.973	...	
	Reduction Ratio	-15.912	0.000	...	
	Weight	38885.482	0.301	...	
...		
S9	Upper Yield Strength (ReH)		Nan	0.079	...
	Ultimate Tensile Strength (UTS)	1807.784		-0.001	...
	YS/UTS Ratio		Nan		...
	% Elongation (A)	-46.019	-0.000	...	
	% Reduction of Area (RoA Z)	-139.109	0.001	...	

ASTM E45 Met.A - D thin \

					\
Supplier					
S1	Sn		-416.141		
	Order ID		32917.030		
	Batch ID		-486.555		
	Reduction Ratio		-0.060		
	Weight		12.231		
...			...		
S9	Upper Yield Strength (ReH)		2.950		
	Ultimate Tensile Strength (UTS)		-4.909		
	YS/UTS Ratio			Nan	
	% Elongation (A)		0.118		
	% Reduction of Area (RoA Z)		0.140		

ISO 4967 Met.A DIN 50602 - K4 \

					\
Supplier					
S1	Sn		5.844	-949.024	
	Order ID		5680.202	160478.775	
	Batch ID		1.195	-1238.946	
	Reduction Ratio		0.010	0.391	

	Weight	87.736	438.188
...	
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	Nan	Nan
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA z)	0.000	0.178
	Grain size \		
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2107.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	Nan	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA z)	0.441	
	0.2% Yield Strength (YS) \		
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA z)	-382.301	
	Upper Yield Strength (ReH) \		
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA z)	45.290	
	Ultimate Tensile Strength (UTS) \		
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	Nan	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA z)	-336.165	
	YS/UTS Ratio % Elongation (A) \		
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	Nan	-12.680
	Ultimate Tensile Strength (UTS)	Nan	-108.429
	YS/UTS Ratio	Nan	Nan
	% Elongation (A)	Nan	3.156
	% Reduction of Area (RoA z)	Nan	7.048
	% Reduction of Area (RoA z)		
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	Nan	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA z)	24.866	

[770 rows x 77 columns]

Sb [Antimony] :

		Sn	Order ID	\
Supplier				
S1	Sn	6.335750e+07	2.311141e+07	
	Order ID	2.311141e+07	6.928242e+10	
	Batch ID	7.779238e+07	2.175783e+07	
	Reduction Ratio	7.929490e+02	1.715190e+04	
	Weight	-8.212380e+04	6.404896e+07	
...		
S9	Upper Yield Strength (ReH)	2.210890e+05	9.713930e+05	
	Ultimate Tensile Strength (UTS)	-6.192491e+04	-5.130284e+06	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-1.609849e+03	7.745014e+04	
	% Reduction of Area (RoA Z)	-2.551074e+03	1.306062e+05	

Batch ID Reduction Ratio \

		Batch ID	Reduction Ratio	\
Supplier				
S1	Sn	7.779238e+07	792.949	
	Order ID	2.175783e+07	17151.899	
	Batch ID	9.560653e+07	886.319	
	Reduction Ratio	8.863190e+02	2.959	
	Weight	-1.224654e+05	150.750	
...		
S9	Upper Yield Strength (ReH)	2.681365e+05		NaN
	Ultimate Tensile Strength (UTS)	-7.615006e+04		-26.221
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-2.014228e+03		0.547
	% Reduction of Area (RoA Z)	-3.147625e+03		1.805

Weight Ø Ex \

		Weight	Ø Ex	\
Supplier				
S1	Sn	-8.212380e+04	-3.256441e+05	
	Order ID	6.404896e+07	2.256435e+07	
	Batch ID	-1.224654e+05	-4.250093e+05	
	Reduction Ratio	1.507500e+02	4.987020e+02	
	Weight	2.874933e+06	7.196166e+05	
...		
S9	Upper Yield Strength (ReH)		NaN	NaN
	Ultimate Tensile Strength (UTS)	3.075252e+04	1.345721e+04	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-6.362050e+02	-1.980780e+02	
	% Reduction of Area (RoA Z)	-1.865134e+03	-5.810030e+02	

Ø In Height \

		Ø In	Height	\
Supplier				
S1	Sn	-3.004199e+05	78809.398	
	Order ID	2.080115e+07	-1051295.867	
	Batch ID	-3.916826e+05	100192.961	
	Reduction Ratio	5.305260e+02	-54.403	
	Weight	6.418457e+05	108402.834	
...		
S9	Upper Yield Strength (ReH)		NaN	NaN
	Ultimate Tensile Strength (UTS)	9.841638e+03	-1607.263	
	YS/UTS Ratio		NaN	NaN
	% Elongation (A)	-1.060410e+02	18.228	
	% Reduction of Area (RoA Z)	-3.027850e+02	53.683	

Thickness Al [Aluminium] ... \

		Thickness	Al [Aluminium]	...	\
Supplier					
S1	Sn	-12612.090	2.543	...	
	Order ID	881602.083	294.528	...	
	Batch ID	-16663.356	2.973	...	
	Reduction Ratio	-15.912	0.000	...	
	Weight	38885.482	0.301	...	
...		
S9	Upper Yield Strength (ReH)		NaN	0.079	...
	Ultimate Tensile Strength (UTS)	1807.784	-0.001	...	
	YS/UTS Ratio		NaN	NaN	...
	% Elongation (A)	-46.019	-0.000	...	
	% Reduction of Area (RoA Z)	-139.109	0.001	...	

ASTM E45 Met.A - D thin \

		ASTM E45 Met.A - D thin	\
Supplier			
S1	Sn	-416.141	
	Order ID	32917.030	
	Batch ID	-486.555	
	Reduction Ratio	-0.060	
	Weight	12.231	
...		...	
S9	Upper Yield Strength (ReH)		2.950
	Ultimate Tensile Strength (UTS)		-4.909
	YS/UTS Ratio		NaN
	% Elongation (A)		0.118
	% Reduction of Area (RoA Z)		0.140

ISO 4967 Met.A DIN 50602 - K4 \

		ISO 4967 Met.A DIN 50602 - K4	\
Supplier			
S1	Sn	5.844	-949.024
	Order ID	5680.202	160478.775
	Batch ID	1.195	-1238.946

	Reduction Ratio	0.010	0.391
	Weight	87.736	438.188
...	
S9	Upper Yield Strength (ReH)	0.000	0.000
	Ultimate Tensile Strength (UTS)	0.000	-2.413
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	0.000	0.030
	% Reduction of Area (RoA Z)	0.000	0.178
	Grain size \		
Supplier			
S1	Sn	1726.508	
	Order ID	15223.418	
	Batch ID	2107.756	
	Reduction Ratio	0.083	
	Weight	-54.786	
...		...	
S9	Upper Yield Strength (ReH)	0.000	
	Ultimate Tensile Strength (UTS)	-4.451	
	YS/UTS Ratio	NaN	
	% Elongation (A)	0.131	
	% Reduction of Area (RoA Z)	0.441	
	0.2% Yield Strength (YS) \		
Supplier			
S1	Sn	25947.417	
	Order ID	1557896.090	
	Batch ID	33017.656	
	Reduction Ratio	-15.310	
	Weight	-10079.098	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	7940.988	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-123.824	
	% Reduction of Area (RoA Z)	-382.301	
	Upper Yield Strength (ReH) \		
Supplier			
S1	Sn	-51364.203	
	Order ID	1772120.299	
	Batch ID	-67390.686	
	Reduction Ratio	271.310	
	Weight	-11162.858	
...		...	
S9	Upper Yield Strength (ReH)	916.680	
	Ultimate Tensile Strength (UTS)	466.630	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-12.680	
	% Reduction of Area (RoA Z)	45.290	
	Ultimate Tensile Strength (UTS) \		
Supplier			
S1	Sn	-7992.426	
	Order ID	1460768.015	
	Batch ID	-9276.891	
	Reduction Ratio	-11.074	
	Weight	-15547.252	
...		...	
S9	Upper Yield Strength (ReH)	466.630	
	Ultimate Tensile Strength (UTS)	6940.235	
	YS/UTS Ratio	NaN	
	% Elongation (A)	-108.429	
	% Reduction of Area (RoA Z)	-336.165	
	YS/UTS Ratio % Elongation (A) \		
Supplier			
S1	Sn	-193.605	-2753.119
	Order ID	-1084.171	-20285.034
	Batch ID	-224.168	-3436.119
	Reduction Ratio	-0.005	0.397
	Weight	-189.891	286.183
...	
S9	Upper Yield Strength (ReH)	NaN	-12.680
	Ultimate Tensile Strength (UTS)	NaN	-108.429
	YS/UTS Ratio	NaN	NaN
	% Elongation (A)	NaN	3.156
	% Reduction of Area (RoA Z)	NaN	7.048
	% Reduction of Area (RoA Z)		
Supplier			
S1	Sn	291.748	
	Order ID	-57026.565	
	Batch ID	326.091	
	Reduction Ratio	1.623	
	Weight	854.953	
...		...	
S9	Upper Yield Strength (ReH)	45.290	
	Ultimate Tensile Strength (UTS)	-336.165	
	YS/UTS Ratio	NaN	
	% Elongation (A)	7.048	
	% Reduction of Area (RoA Z)	24.866	

[770 rows x 77 columns]

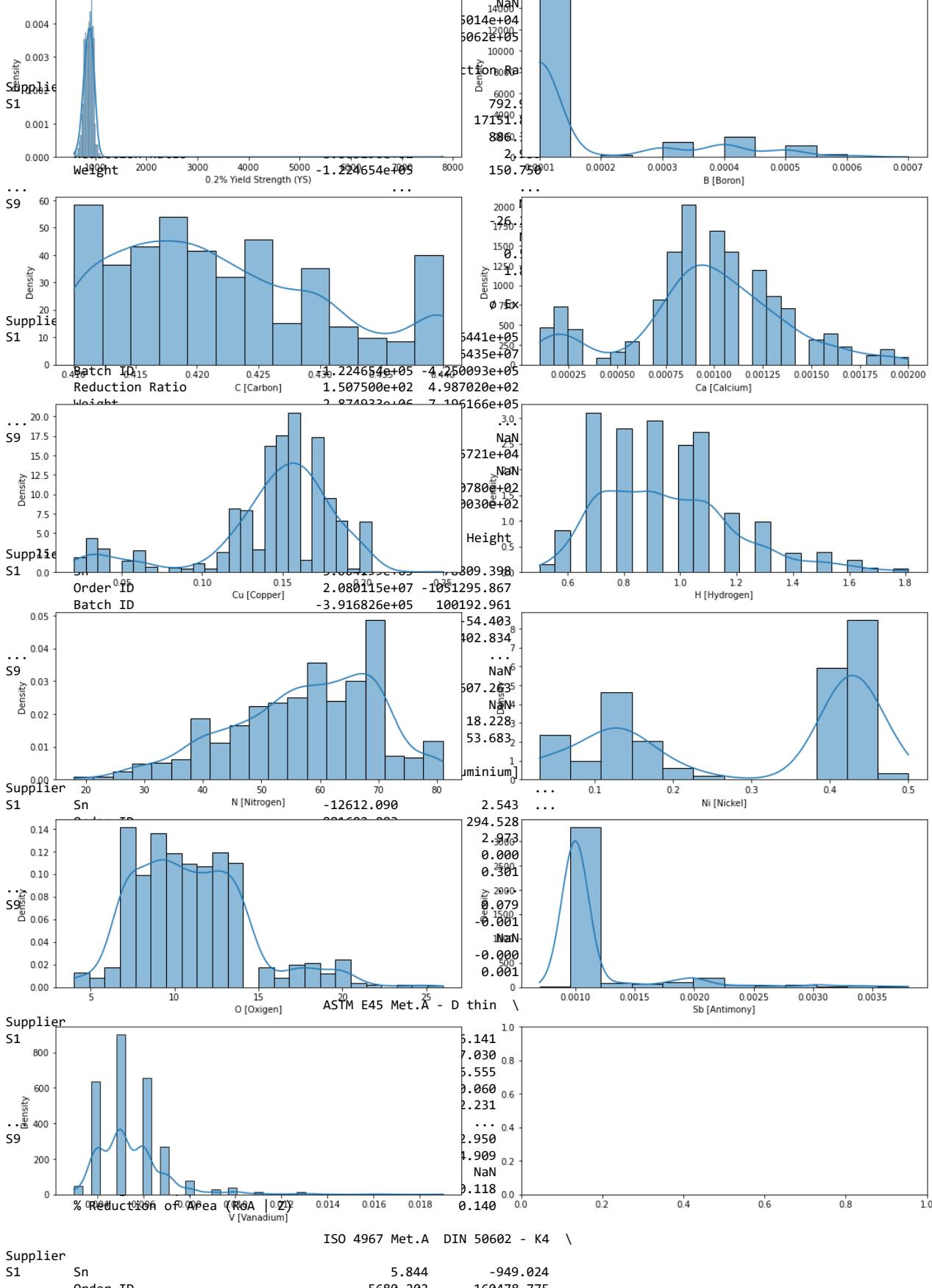
cols,columns:

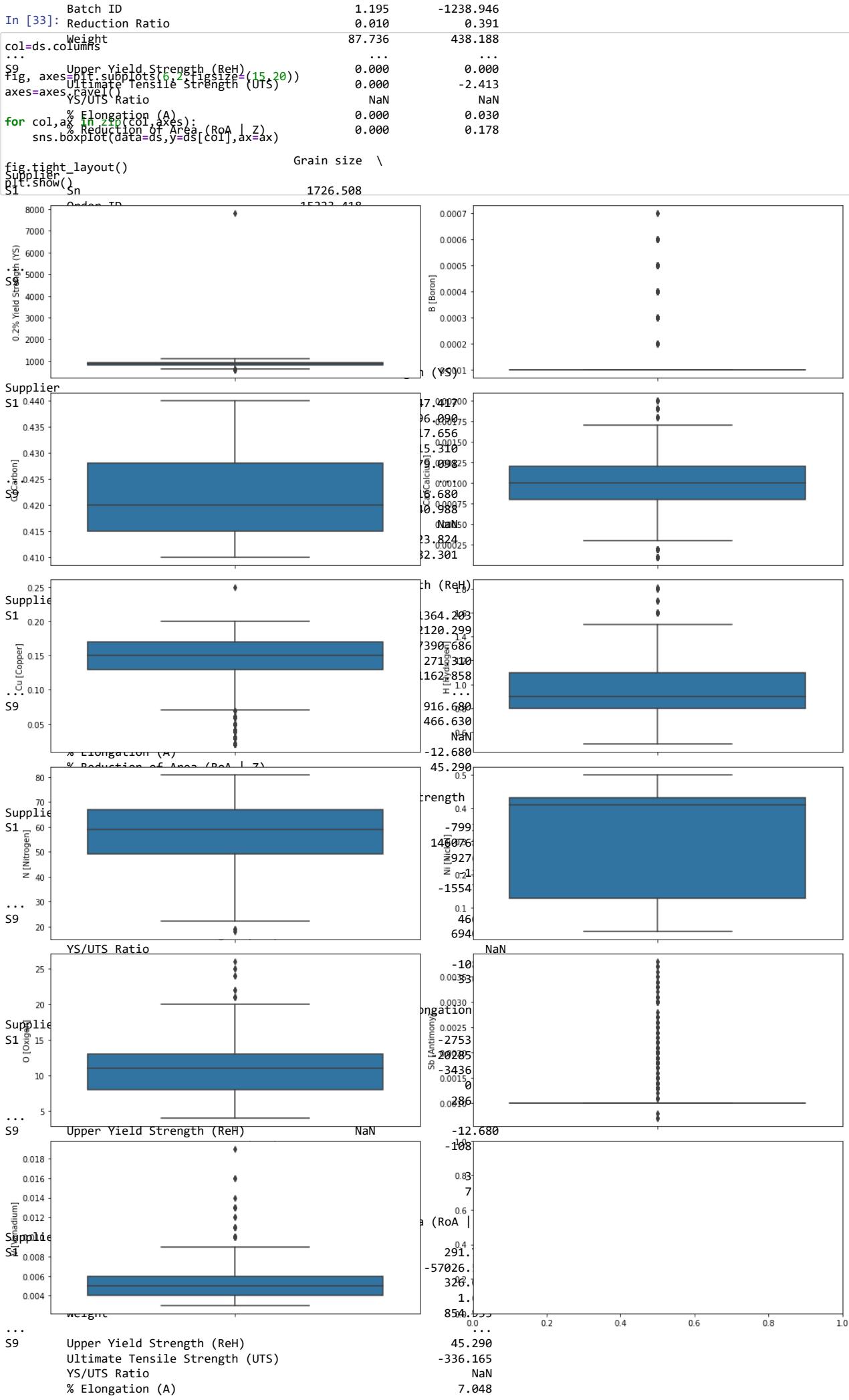
V [Vanadium]:

```
fig, axes=plt.subplots(6,2,figsize=(15,20))
Supplier_Sn = 6.335750e+07 2.311141e+07
Supplier_Sn = 6.928242e+10
for col,ax in zip(data.columns[1:],axes):
    BatchID = 2.311141e+07 6.928242e+10
    sns.histplot(data=ds,x=ds[col], kde=True, density=True)
    Reduction Ratio = 7.779238e+07 2.175783e+07
    Weight = 7.929490e+02 1.715190e+04
    fig.tight_layout()
plt.show()
```

Upper Yield Strength (ReH) 2.210890e+05 9.713930e+05

Ultimate Tensile Strength (UTS) -6.192491e+04 -5.130284e+06





% Reduction of Area (RoA | Z)

24.866

In [78]:

[770 rows x 77 columns] in Yield Strength

ds[ds['0.2% Yield Strength (YS)'] > 1100]

Out[78]:

Supplier	0.2% Yield Strength (YS)	B [Boron]	C [Carbon]	Ca [Calcium]	Cu [Copper]	H [Hydrogen]	N [Nitrogen]	Ni [Nickel]	O [Oxygen]	Sb [Antimony]	V [Vanadium]
815 S1	7801.0	0.0001	0.422	0.0016	0.18	1.1	70.0	0.42	11.0	0.001	0.005

In [114]:

Removing the outliers in Yield Strength

ds = ds[ds['0.2% Yield Strength (YS)'] < 1100]

ds

Out[114]:

Supplier	0.2% Yield Strength (YS)	B [Boron]	C [Carbon]	Ca [Calcium]	Cu [Copper]	H [Hydrogen]	N [Nitrogen]	Ni [Nickel]	O [Oxygen]	Sb [Antimony]	V [Vanadium]
0 S1	890.3	0.0001	0.420	0.0012	0.150	1.0	69.0	0.420	9.0	0.0010	0.005
1 S1	916.0	0.0001	0.421	0.0011	0.120	0.8	53.0	0.430	9.0	0.0010	0.005
2 S1	875.8	0.0001	0.422	0.0010	0.150	0.9	70.0	0.430	12.0	0.0010	0.005
3 S1	841.5	0.0004	0.416	0.0012	0.130	0.7	77.0	0.110	7.0	0.0020	0.005
4 S1	833.4	0.0004	0.416	0.0012	0.130	0.7	77.0	0.110	7.0	0.0020	0.005
...
1178 S5	819.5	0.0005	0.414	0.0002	0.134	1.7	38.0	0.435	14.0	0.0019	0.008
1179 S9	854.9	0.0004	0.440	0.0007	0.050	1.2	49.0	0.050	7.0	0.0010	0.004
1180 S1	941.5	0.0001	0.430	0.0013	0.200	1.1	70.0	0.420	11.0	0.0010	0.005
1181 S1	866.2	0.0001	0.416	0.0016	0.190	1.1	68.0	0.410	13.0	0.0010	0.006
1182 S1	904.4	0.0001	0.425	0.0014	0.160	0.7	70.0	0.430	8.0	0.0010	0.006

1128 rows x 12 columns

In [36]:

ds.shape

Out[36]:

(1128, 11)

In [37]:

```

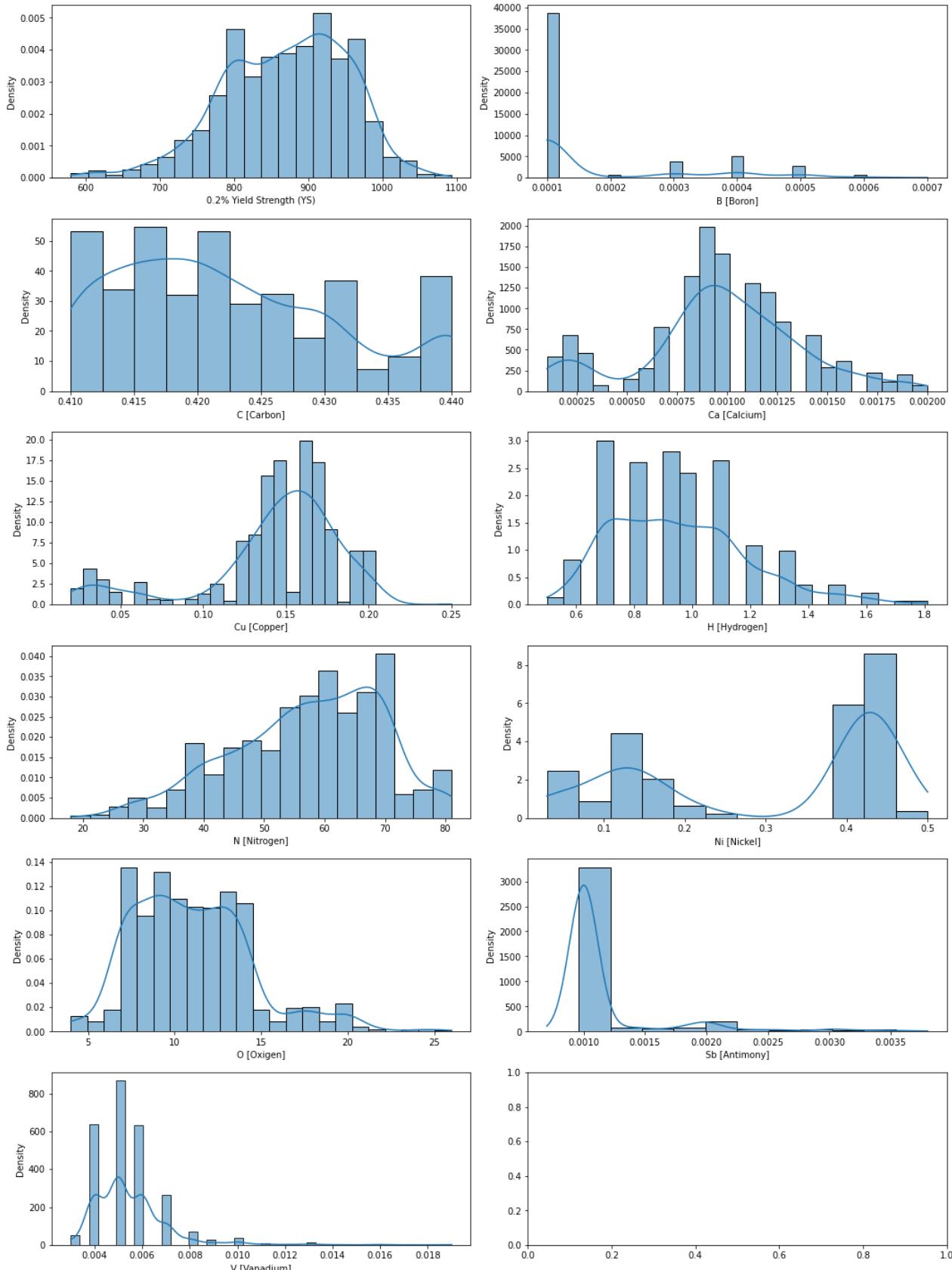
col=ds.columns

fig, axes=plt.subplots(6,2,figsize=(15,20))
axes=axes.ravel()

for col,ax in zip(col,axes):
    sns.histplot(data=ds,x=ds[col], kde=True, stat='density',ax=ax)

fig.tight_layout()
plt.show()

```



In [64]:

ds

Out[64]:

	0.2% Yield Strength (YS)	B [Boron]	C [Carbon]	Ca [Calcium]	Cu [Copper]	H [Hydrogen]	N [Nitrogen]	Ni [Nickel]	O [Oxygen]	Sb [Antimony]	V [Vanadium]
0	890.3	0.0001	0.420	0.0012	0.150	1.0	69.0	0.420	9.0	0.0010	0.005
1	916.0	0.0001	0.421	0.0011	0.120	0.8	53.0	0.430	9.0	0.0010	0.005
2	875.8	0.0001	0.422	0.0010	0.150	0.9	70.0	0.430	12.0	0.0010	0.005
3	841.5	0.0004	0.416	0.0012	0.130	0.7	77.0	0.110	7.0	0.0020	0.005
4	833.4	0.0004	0.416	0.0012	0.130	0.7	77.0	0.110	7.0	0.0020	0.005
...
1178	819.5	0.0005	0.414	0.0002	0.134	1.7	38.0	0.435	14.0	0.0019	0.008
1179	854.9	0.0004	0.440	0.0007	0.050	1.2	49.0	0.050	7.0	0.0010	0.004
1180	941.5	0.0001	0.430	0.0013	0.200	1.1	70.0	0.420	11.0	0.0010	0.005
1181	866.2	0.0001	0.416	0.0016	0.190	1.1	68.0	0.410	13.0	0.0010	0.006
1182	904.4	0.0001	0.425	0.0014	0.160	0.7	70.0	0.430	8.0	0.0010	0.006

1128 rows × 11 columns

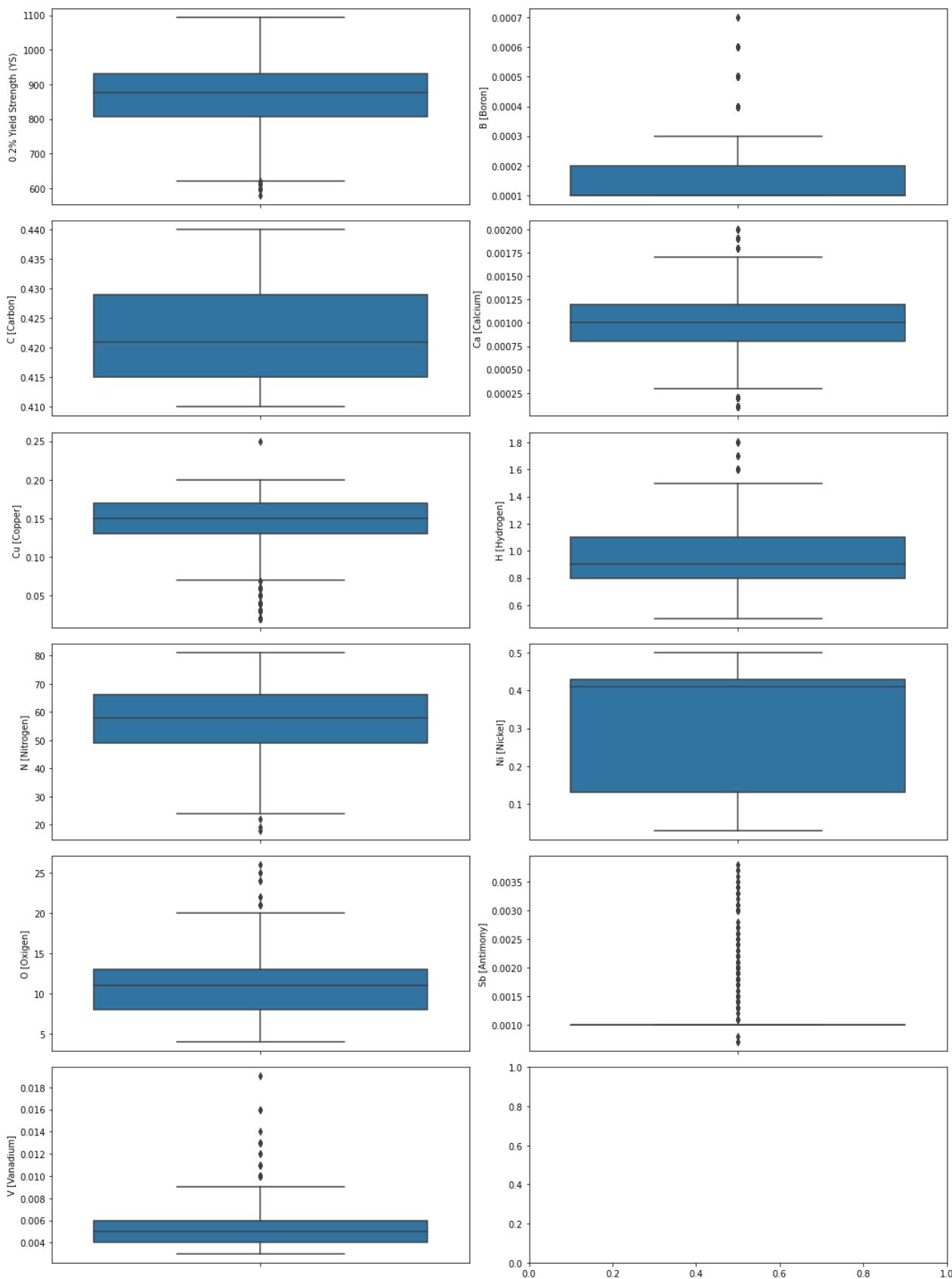
In [38]:

```
col=ds.columns

fig, axes=plt.subplots(6,2,figsize=(15,20))
axes=axes.ravel()

for col,ax in zip(col,axes):
    sns.boxplot(data=ds,y=ds[col],ax=ax)

fig.tight_layout()
plt.show()
```

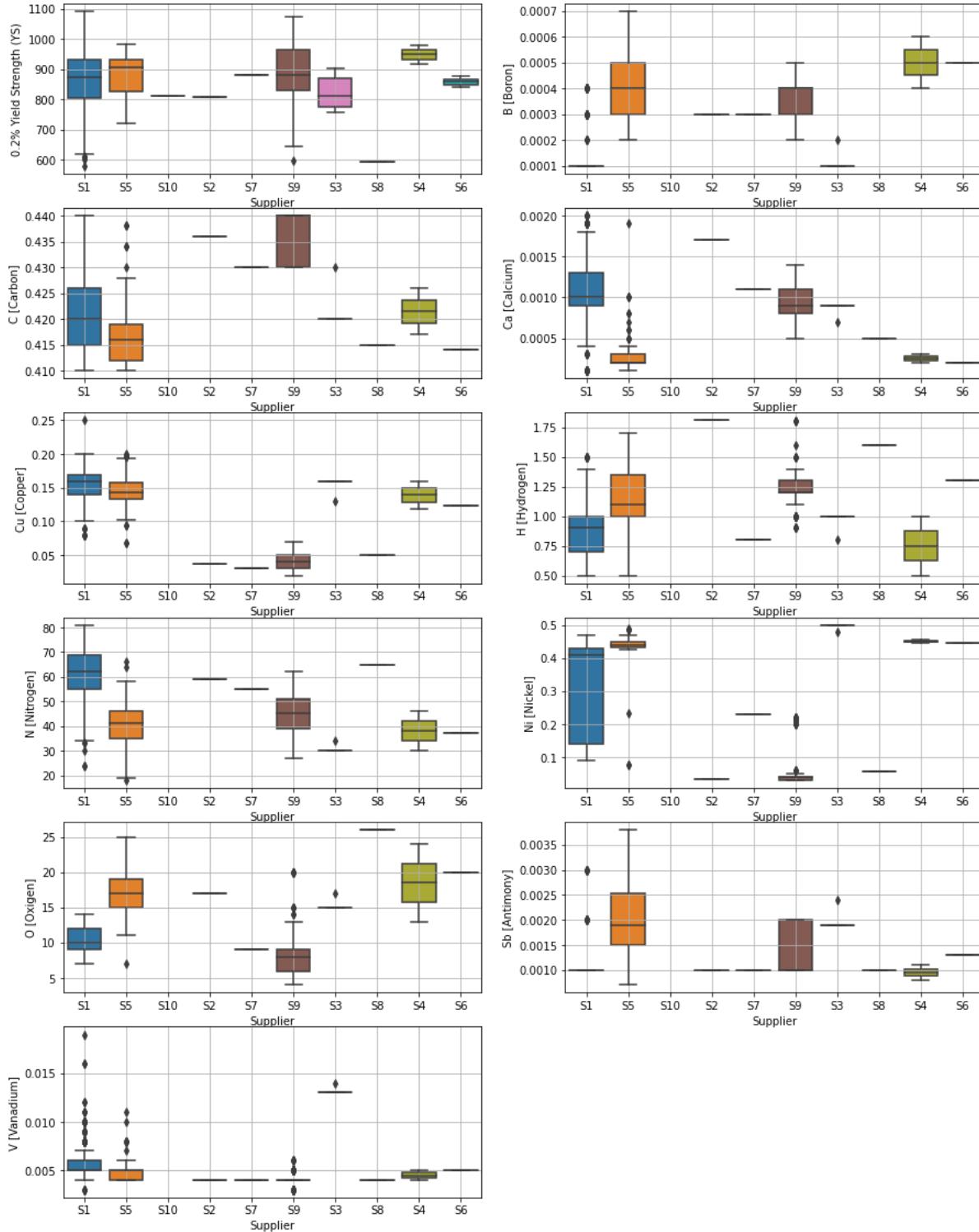


In [71]:

```
datacol = list(ds.select_dtypes(include=['float64', 'int64']))
datacol

#col=ds.columns
plt.figure(figsize=(15, 20))

for i, column in enumerate(datacol):
    plt.subplot(6, 2, i+1)
    sns.boxplot(data=ds, x=ds['Supplier'], y=ds[column])
    plt.grid()
```

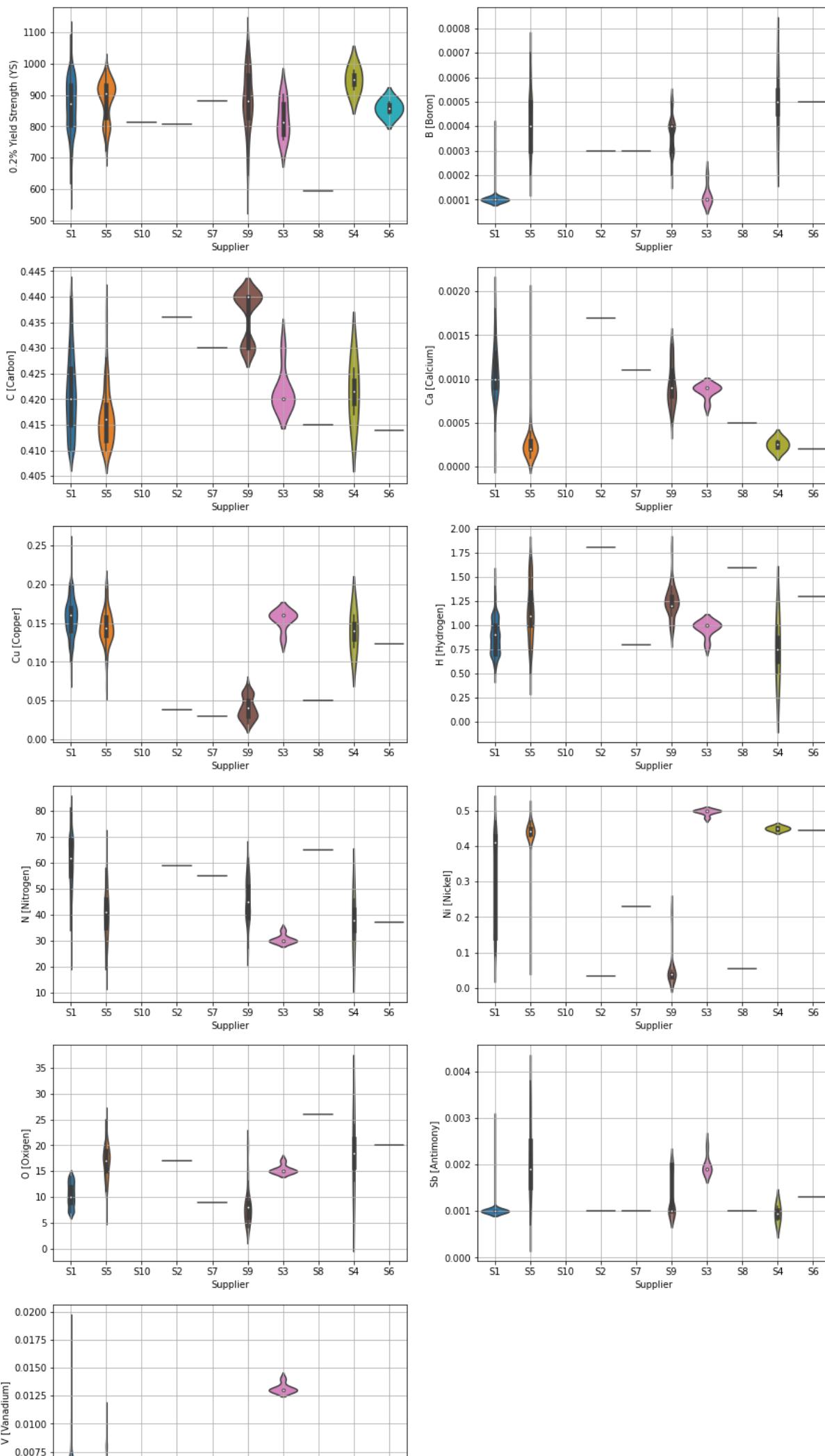


In [85]:

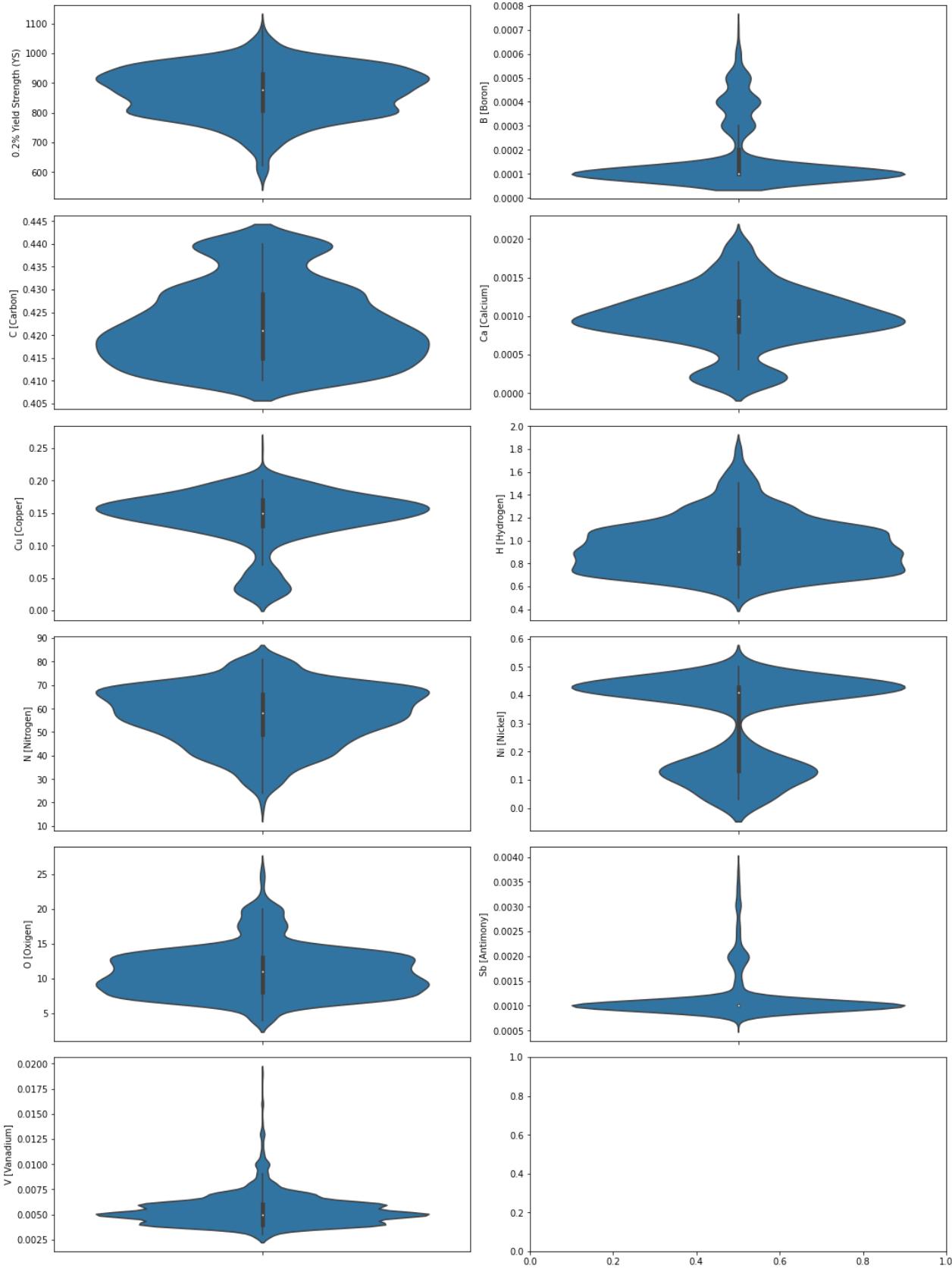
```
datacol = list(ds.select_dtypes(include=['float64', 'int64']))
datacol

#col=ds.columns
plt.figure(figsize=(15,30))

for i, column in enumerate(datacol):
    plt.subplot(6,2,i+1)
    sns.violinplot(data=ds, x=ds['Supplier'],y=ds[column])
    plt.grid()
```

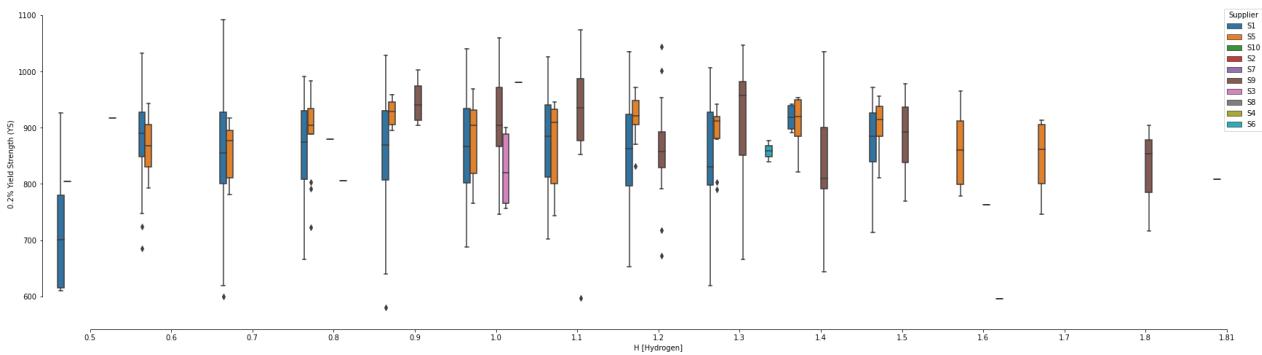



```
In [101]:  
cols=ds.columns  
fig, axes=plt.subplots(6,2,figsize=(15,20))  
Supplier  
for col,ax in zip(cols,axes):  
    sns.violinplot(data=ds,y=ds[col],ax=ax)  
  
fig.tight_layout()  
plt.show()
```



In [129]:

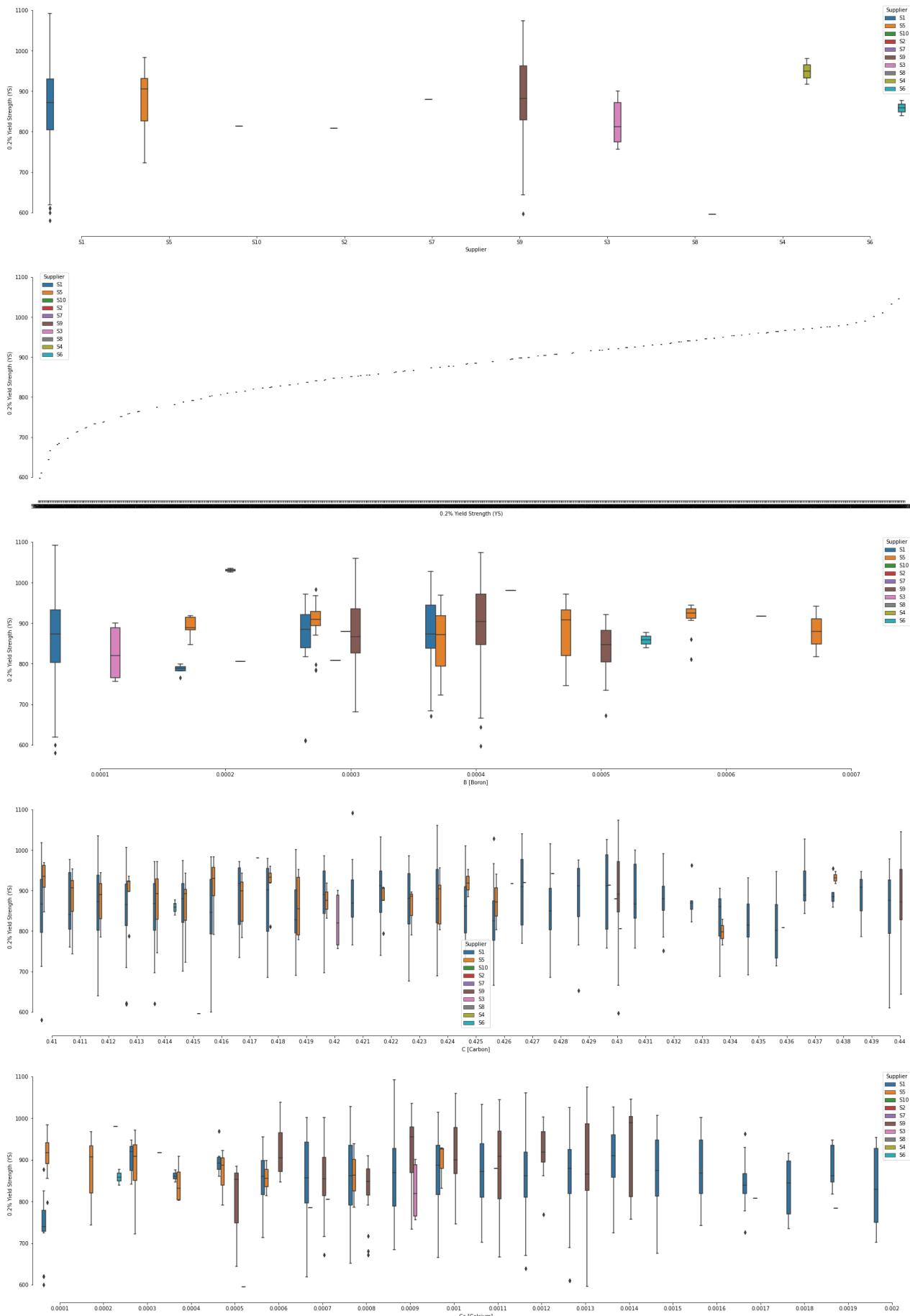
```
plt.figure(figsize=(30,8))
sns.boxplot(x="H [Hydrogen]", y="0.2% Yield Strength (YS)",hue="Supplier",data=ds)
sns.despine(offset=10, trim=True)
```

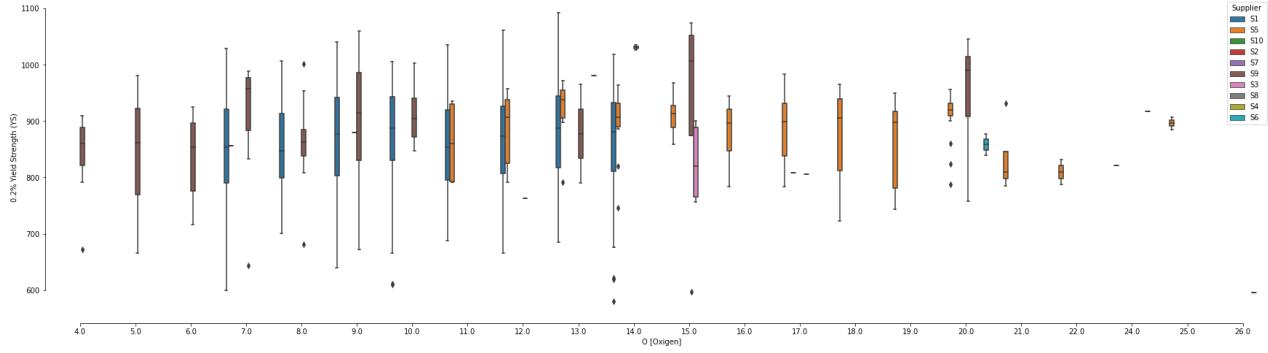
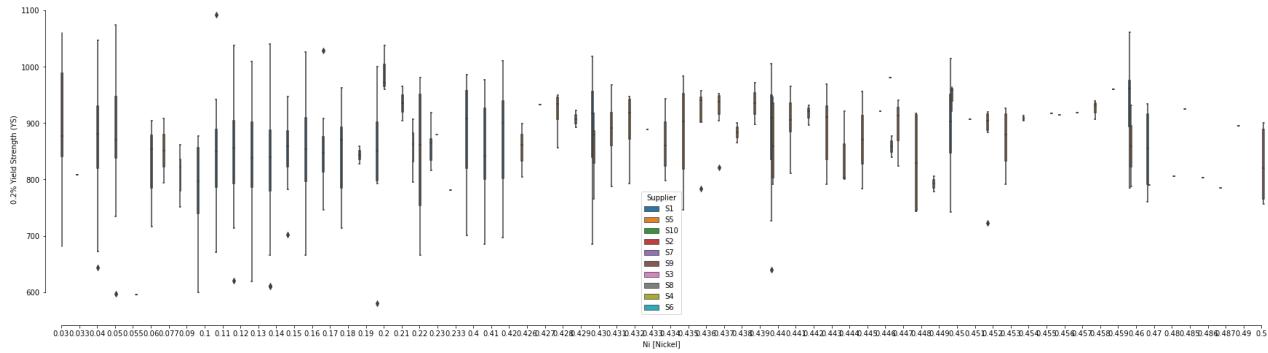
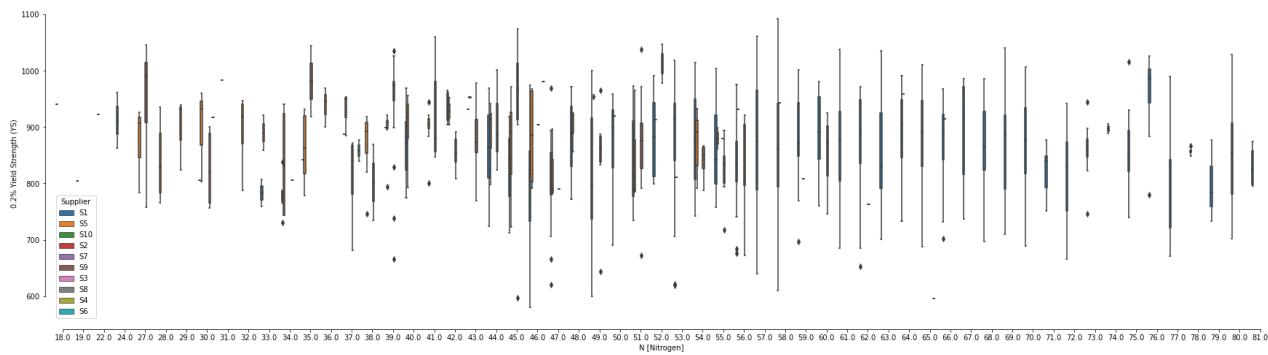
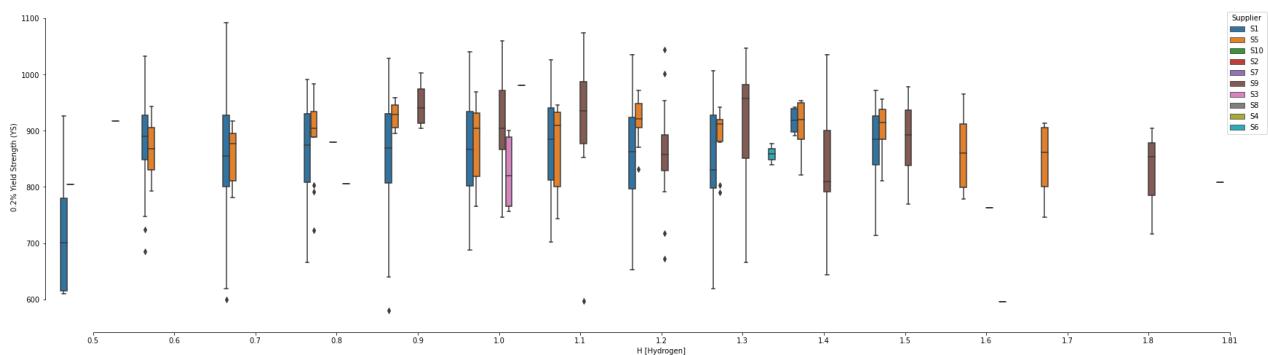
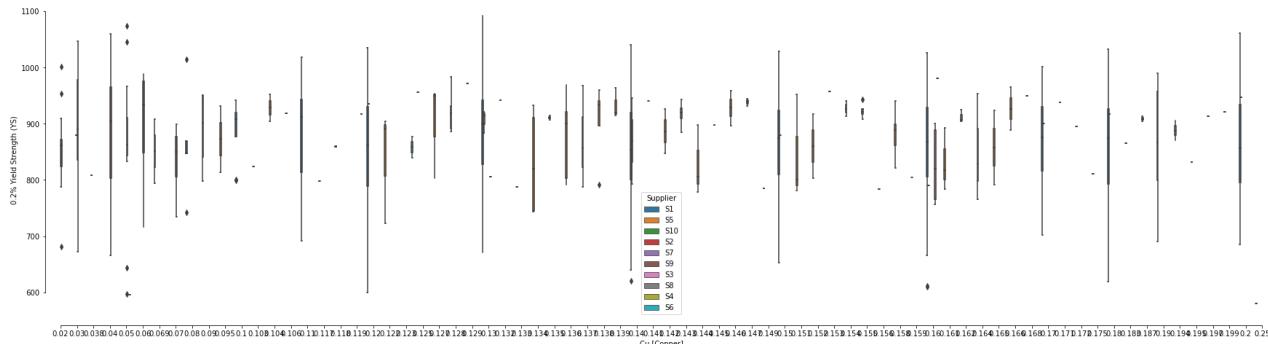


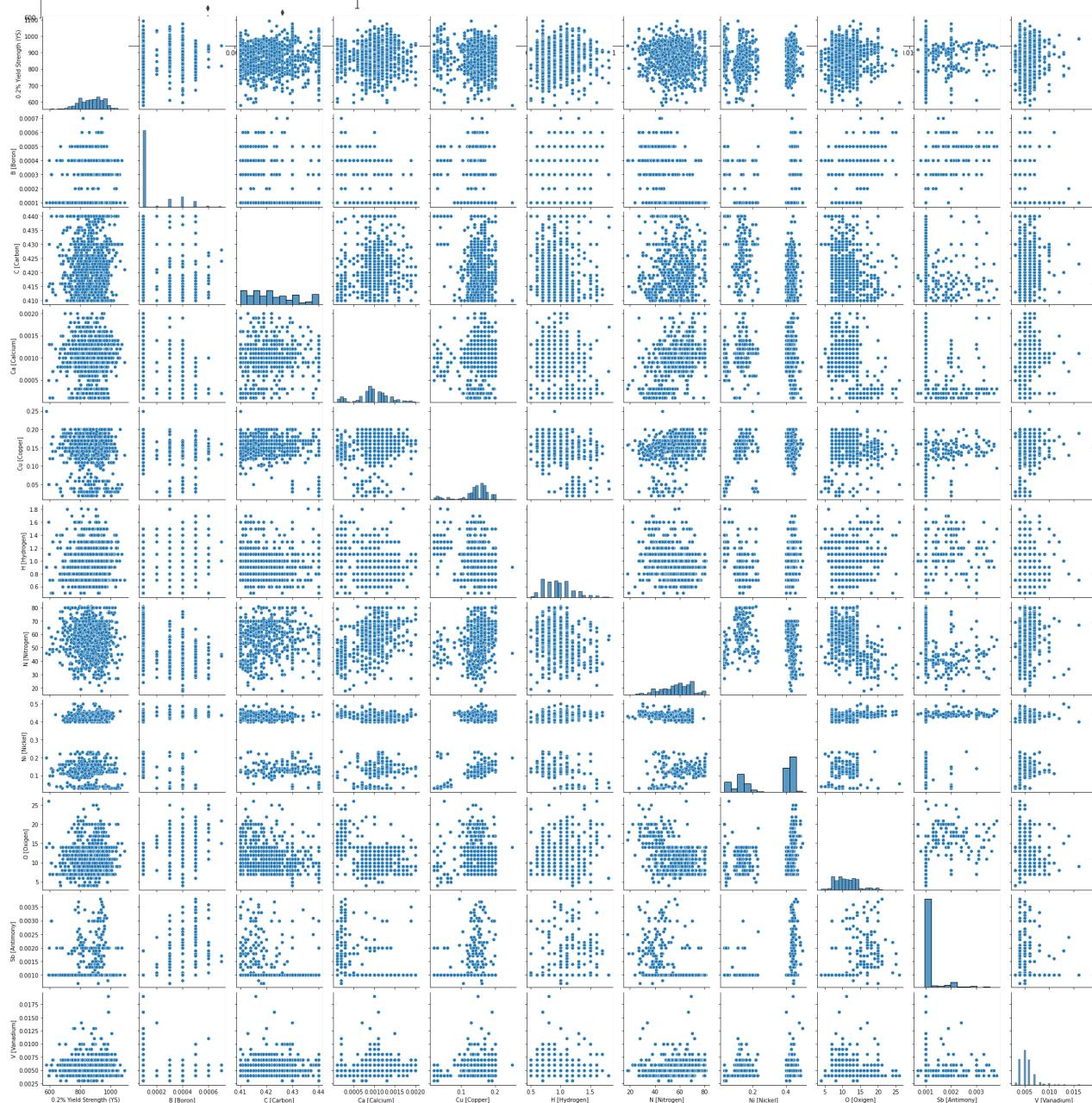
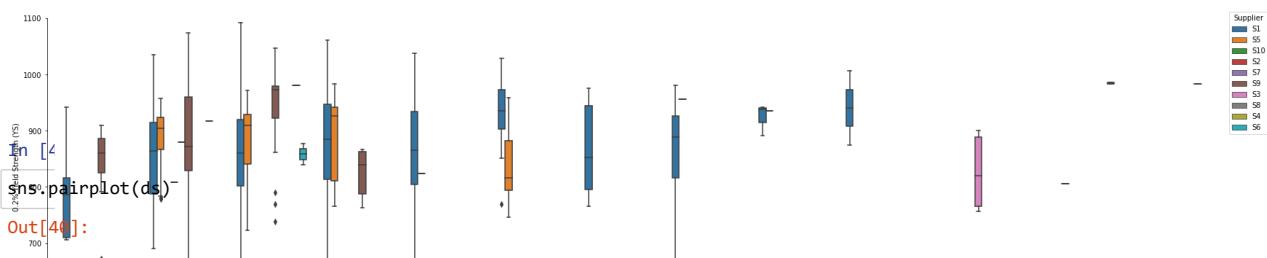
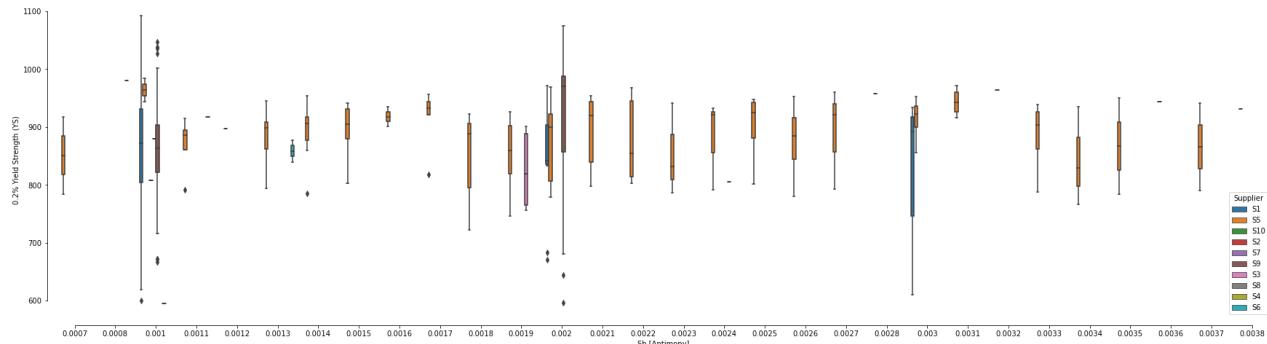
In [136]:

```
#plt.figure(figsize=(30,8))

for i in ds.columns:
    plt.figure(figsize=(30,8))
    sns.boxplot(x=ds[i], y="0.2% Yield Strength (YS)",hue="Supplier",data=ds)
    sns.despine(offset=10, trim=True)
    plt.show()
```





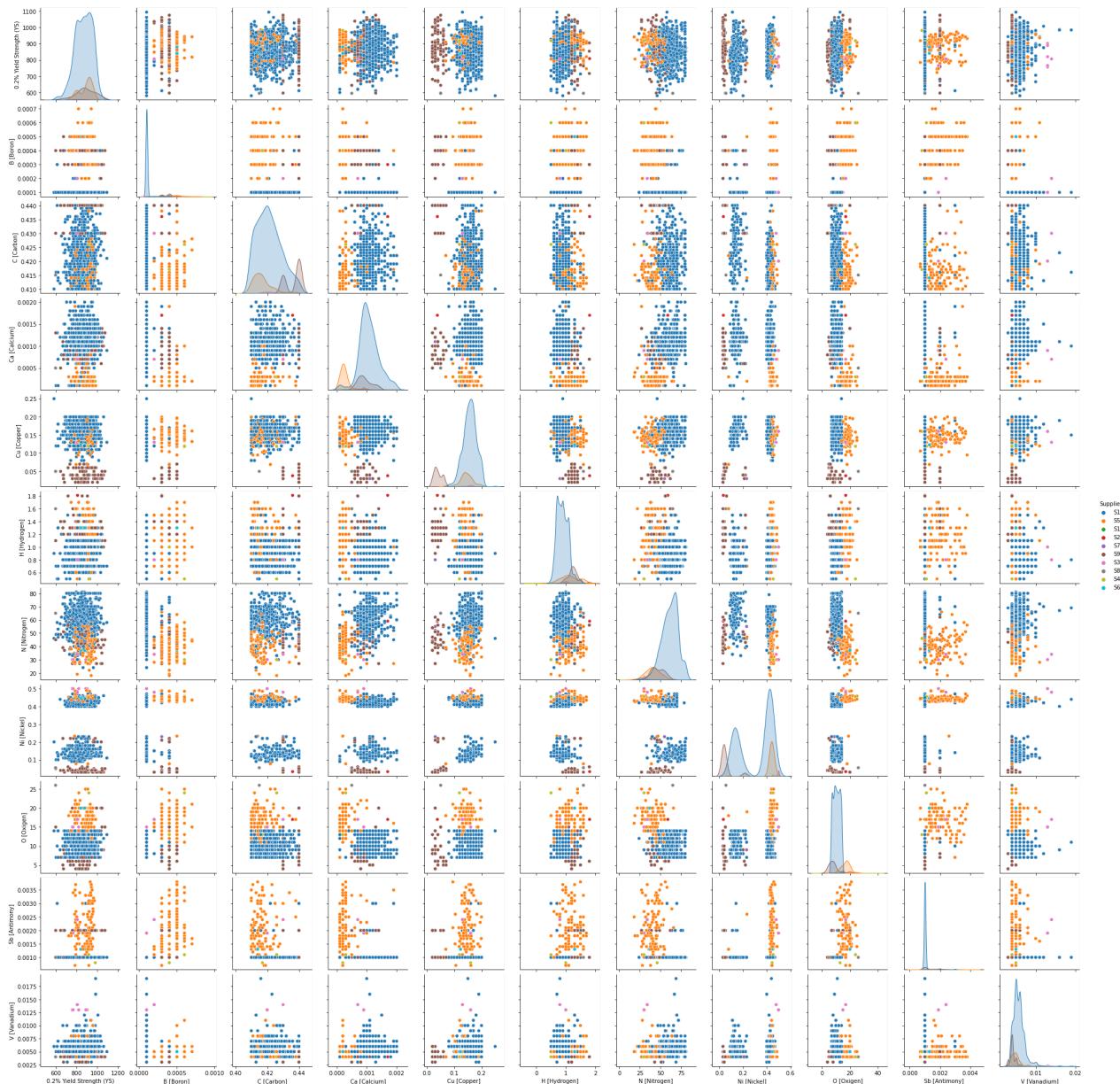


In [115]:

```
sns.pairplot(ds,hue='Supplier')
```

Out[115]:

```
<seaborn.axisgrid.PairGrid at 0x1e78e74f9d0>
```

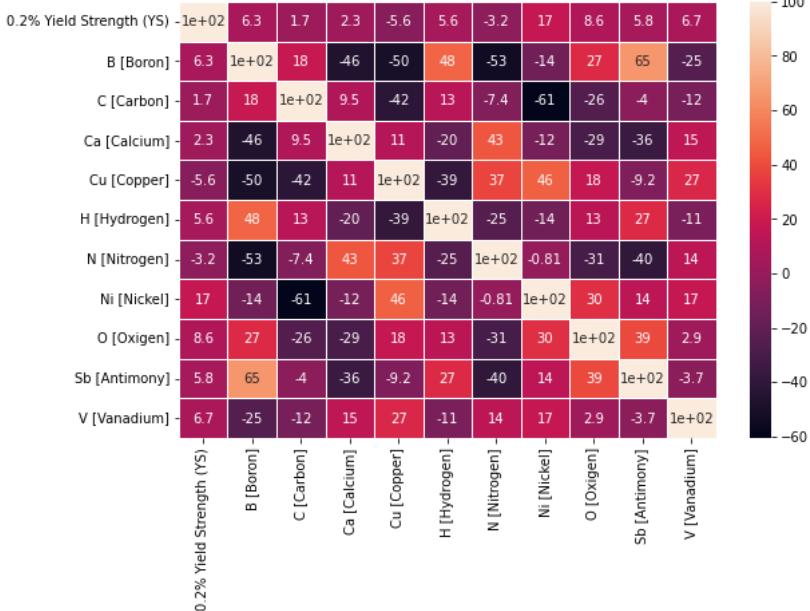


In [41]:

```
f, ax = plt.subplots(figsize=(9, 6))
dd = ds.corr()*100
sns.heatmap(dd, annot=True, linewidths=.5, ax=ax)
```

Out[41]:

<AxesSubplot:>

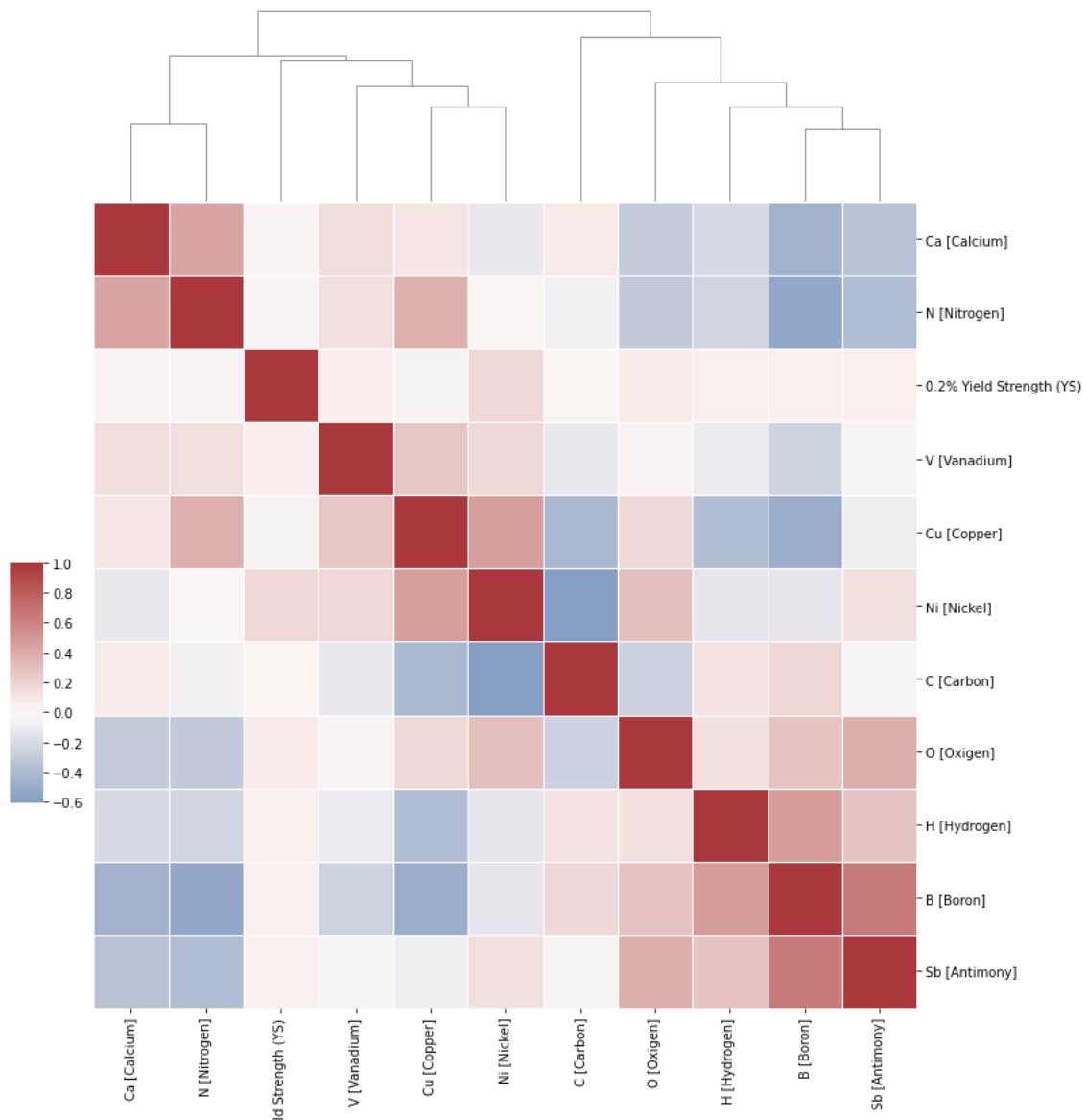


In [42]:

```
#networks = ds.columns.get_level_values("network")
#network_colors = pd.Series(networks, index=ds.columns).map(network_lut)

g = sns.clustermap(ds.corr(), center=0, cmap="vlag",
                    #row_colors=network_colors, #col_colors=network_colors,
                    dendrogram_ratio=(.1, .2),
                    cbar_pos=(.02, .32, .03, .2),
                    linewidths=.75, figsize=(12, 13))

g.ax_row_dendrogram.remove()
```



In [43]:

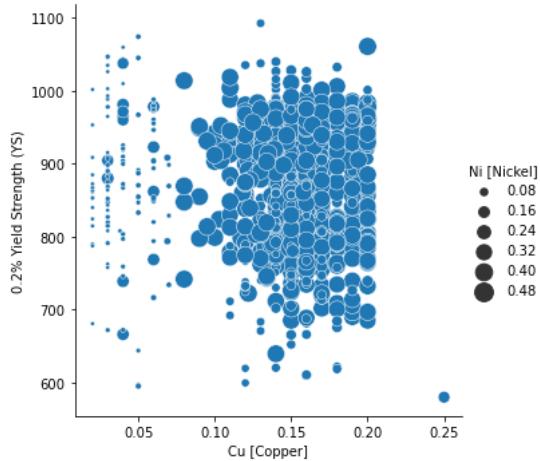
ds.columns

Out[43]:

```
Index(['0.2% Yield Strength (YS)', 'B [Boron]', 'C [Carbon]', 'Ca [Calcium]',
       'Cu [Copper]', 'H [Hydrogen]', 'N [Nitrogen]', 'Ni [Nickel]',
       'O [Oxygen]', 'Sb [Antimony]', 'V [Vanadium)'],
      dtype='object')
```

In [120]:

```
cmap = sns.cubehelix_palette(rot=-.2, as_cmap=True)
g = sns.relplot(data=ds,
    x="Cu [Copper]", y="0.2% Yield Strength (YS)",
    size="Ni [Nickel]",
    palette=cmap, sizes=(10, 200),
)
```



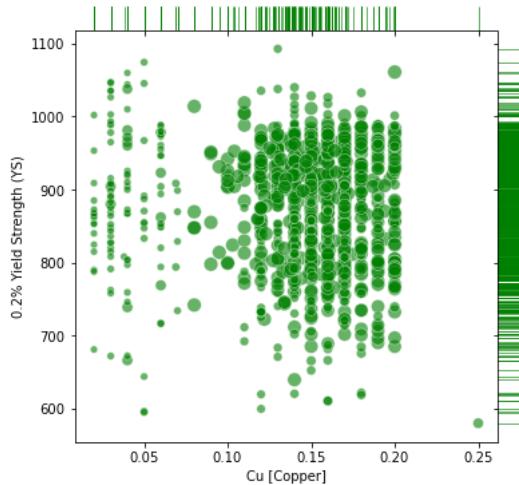
In [45]:

```
g = sns.JointGrid(data=ds, x="Cu [Copper]", y="0.2% Yield Strength (YS)", space=0, ratio=17)
g.plot_joint(sns.scatterplot, size=ds["Ni [Nickel]"], sizes=(30, 120),
             color="g", alpha=.6, legend=False)
g.plot_marginals(sns.rugplot, height=1, color="g", alpha=.6)
```

C:\Users\mohammed\Anaconda3\lib\site-packages\seaborn\axisgrid.py:1740: UserWarning: Tight layout not applied. tight_layout cannot make axes width small enough to accommodate all axes decorations
f.tight_layout()

Out[45]:

<seaborn.axisgrid.JointGrid at 0x1e78ae8cf0>

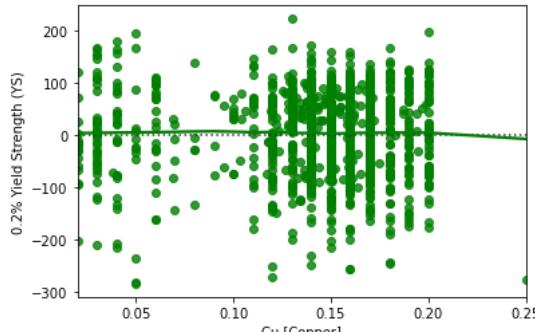


In [46]:

```
sns.residplot(x=ds["Cu [Copper]"], y=ds["0.2% Yield Strength (YS)"], lowess=True, color="g")
```

Out[46]:

<AxesSubplot:xlabel='Cu [Copper]', ylabel='0.2% Yield Strength (YS)'>



In [47]:

```
RMds = ds[['0.2% Yield Strength (YS)', 'B [Boron]', 'C [Carbon]', 'Ca [Calcium]',  
          'Cu [Copper]', 'H [Hydrogen]', 'N [Nitrogen]', 'Ni [Nickel]',  
          'O [Oxygen]', 'Sb [Antimony]', 'V [Vanadium]']]
```

RMds

Out[47]:

	0.2% Yield Strength (YS)	B [Boron]	C [Carbon]	Ca [Calcium]	Cu [Copper]	H [Hydrogen]	N [Nitrogen]	Ni [Nickel]	O [Oxygen]	Sb [Antimony]	V [Vanadium]
0	890.3	0.0001	0.420	0.0012	0.150	1.0	69.0	0.420	9.0	0.0010	0.005
1	916.0	0.0001	0.421	0.0011	0.120	0.8	53.0	0.430	9.0	0.0010	0.005
2	875.8	0.0001	0.422	0.0010	0.150	0.9	70.0	0.430	12.0	0.0010	0.005
3	841.5	0.0004	0.416	0.0012	0.130	0.7	77.0	0.110	7.0	0.0020	0.005
4	833.4	0.0004	0.416	0.0012	0.130	0.7	77.0	0.110	7.0	0.0020	0.005
...
1178	819.5	0.0005	0.414	0.0002	0.134	1.7	38.0	0.435	14.0	0.0019	0.008
1179	854.9	0.0004	0.440	0.0007	0.050	1.2	49.0	0.050	7.0	0.0010	0.004
1180	941.5	0.0001	0.430	0.0013	0.200	1.1	70.0	0.420	11.0	0.0010	0.005
1181	866.2	0.0001	0.416	0.0016	0.190	1.1	68.0	0.410	13.0	0.0010	0.006
1182	904.4	0.0001	0.425	0.0014	0.160	0.7	70.0	0.430	8.0	0.0010	0.006

1128 rows × 11 columns

In [48]:

RMds.shape

Out[48]:

(1128, 11)

In [49]:

```
RMds = RMds.dropna()  
RMds.shape
```

Out[49]:

(1075, 11)

In [50]:

```
from sklearn.model_selection import train_test_split, GridSearchCV
```

In [51]:

```
from sklearn.preprocessing import StandardScaler  
from sklearn.preprocessing import OneHotEncoder, LabelEncoder  
from sklearn.model_selection import train_test_split  
from sklearn.decomposition import PCA  
from sklearn.pipeline import Pipeline

from sklearn.tree import DecisionTreeRegressor  
from sklearn.ensemble import RandomForestRegressor  
from sklearn.linear_model import LinearRegression  
from xgboost import XGBRegressor  
from sklearn.neighbors import KNeighborsRegressor

from sklearn.model_selection import cross_val_score  
from sklearn.metrics import mean_squared_error  
from sklearn import metrics
```

In [52]:

```
X=RMds[['B [Boron]', 'C [Carbon]', 'Ca [Calcium]',  
        'Cu [Copper]', 'H [Hydrogen]', 'N [Nitrogen]', 'Ni [Nickel]',  
        'O [Oxygen]', 'Sb [Antimony]', 'V [Vanadium]']]  
  
y=RMds[['0.2% Yield Strength (YS)']]  
  
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25, random_state=7)
```

In [53]:

```
# Building pipelines of standard scaler and model for various regressors.

pipeline_lr=Pipeline([("scalar1",StandardScaler()),
                     ("lr_classifier",LinearRegression())])

pipeline_dt=Pipeline([("scalar2",StandardScaler()),
                     ("dt_classifier",DecisionTreeRegressor())])

pipeline_rf=Pipeline([("scalar3",StandardScaler()),
                     ("rf_classifier",RandomForestRegressor())])

pipeline_kn=Pipeline([("scalar4",StandardScaler()),
                     ("rf_classifier",KNeighborsRegressor())])

pipeline_xgb=Pipeline([("scalar5",StandardScaler()),
                     ("rf_classifier",XGBRegressor())])

# List of all the pipelines

pipelines = [pipeline_lr, pipeline_dt, pipeline_rf, pipeline_kn, pipeline_xgb]

# Dictionary of pipelines and model types for ease of reference

pipe_dict = {0: "LinearRegression", 1: "DecisionTree", 2: "RandomForest", 3: "KNeighbors", 4: "XGBRegressor"}
```

Fit the pipelines

for pipe in pipelines:
 pipe.fit(X_train, y_train)

C:\Users\mohammed\Anaconda3\lib\site-packages\sklearn\pipeline.py:346: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().
 self._final_estimator.fit(Xt, y, **fit_params_last_step)

In [54]:

```
cv_results_rms = []
for i, model in enumerate(pipelines):
    cv_score = cross_val_score(model, X_train,y_train,scoring="neg_root_mean_squared_error", cv=10)
    cv_results_rms.append(cv_score)
    print("%s: %f " %(pipe_dict[i], cv_score.mean()))

LinearRegression: -78.950987
DecisionTree: -94.750587

C:\Users\mohammed\Anaconda3\lib\site-packages\sklearn\pipeline.py:346: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().
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C:\Users\mohammed\Anaconda3\lib\site-packages\sklearn\pipeline.py:346: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().
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C:\Users\mohammed\Anaconda3\lib\site-packages\sklearn\pipeline.py:346: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().
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C:\Users\mohammed\Anaconda3\lib\site-packages\sklearn\pipeline.py:346: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().
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C:\Users\mohammed\Anaconda3\lib\site-packages\sklearn\pipeline.py:346: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().
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    self._final_estimator.fit(Xt, y, **fit_params_last_step)

RandomForest: -78.994502
KNeighbors: -82.280625
XGBRegressor: -86.967716
```

In [55]:

```
# Model prediction on test data
```

```
pred = pipeline_xgb.predict(X_test)
```

In [56]:

```
# Model Evaluation
```

```
print("R^2:",metrics.r2_score(y_test, pred))
print("Adjusted R^2:",1 - (1-metrics.r2_score(y_test, pred))*(len(y_test)-1)/(len(y_test)-X_test.shape[1]-1))
print("MAE:",metrics.mean_absolute_error(y_test, pred))
print("MSE:",metrics.mean_squared_error(y_test, pred))
print("RMSE:",np.sqrt(metrics.mean_squared_error(y_test, pred)))
```

```
R^2: -0.14246825583050682
Adjusted R^2: -0.18674997117277448
MAE: 65.80563352223223
MSE: 8023.158613133904
RMSE: 89.57208612695086
```

In []: