Testing

November 4, 2024

1 COMP1801 - Machine Learning Coursework Solution

Let's start by importing the essential Python libraries for data analysis and machine learning.

[23]:
```
# Import libraries
try:
    import glob
    import pandas as pd
    import numpy as np
    import matplotlib.pyplot as plt
    import seaborn as sns

    # Importing libraries for model building
    from sklearn.preprocessing import StandardScaler
    from sklearn.linear_model import Ridge
    from sklearn.ensemble import RandomForestRegressor
    from sklearn.linear_model import LogisticRegression
    from sklearn.ensemble import RandomForestClassifier
    from sklearn.model_selection import cross_val_score

    from statsmodels.stats.outliers_influence import variance_inflation_factor

except Exception as e:
    print(f"Error : {e}")
```

[24]:
```
# Find the CSV file in the Datasets directory
data_path = '../Datasets/*.csv'
file_list = glob.glob(data_path)

for file in file_list:
    print(f"Found file: {file}")

# Ensure there is exactly one file
if len(file_list) == 1:
    # Load the dataset
    df = pd.read_csv(file_list[0])
    print(f"Loaded dataset: {file_list[0]}")
else:
```

```
    raise FileNotFoundError("No CSV file found or multiple CSV files found in␣
↪the Datasets directory.")
```

```
Found file: ../Datasets/COMP1801_Coursework_Dataset.csv
Loaded dataset: ../Datasets/COMP1801_Coursework_Dataset.csv
```

[25]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 16 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   Lifespan        1000 non-null   float64
 1   partType        1000 non-null   object
 2   microstructure  1000 non-null   object
 3   coolingRate     1000 non-null   int64
 4   quenchTime      1000 non-null   float64
 5   forgeTime       1000 non-null   float64
 6   HeatTreatTime   1000 non-null   float64
 7   Nickel%         1000 non-null   float64
 8   Iron%           1000 non-null   float64
 9   Cobalt%         1000 non-null   float64
 10  Chromium%       1000 non-null   float64
 11  smallDefects    1000 non-null   int64
 12  largeDefects    1000 non-null   int64
 13  sliverDefects   1000 non-null   int64
 14  seedLocation    1000 non-null   object
 15  castType        1000 non-null   object
dtypes: float64(8), int64(4), object(4)
memory usage: 125.1+ KB
```

[26]:
```
# Check for missing values
df.isnull().sum()
```

[26]:
```
Lifespan          0
partType          0
microstructure    0
coolingRate       0
quenchTime        0
forgeTime         0
HeatTreatTime     0
Nickel%           0
Iron%             0
Cobalt%           0
Chromium%         0
smallDefects      0
largeDefects      0
```

```
sliverDefects     0
seedLocation      0
castType          0
dtype: int64
```

[27]:
```
df.head()
```

[27]:
```
   Lifespan partType microstructure  coolingRate  quenchTime  forgeTime  \
0   1469.17   Nozzle       equiGrain           13        3.84       6.47
1   1793.64    Block     singleGrain           19        2.62       3.48
2    700.60    Blade       equiGrain           28        0.76       1.34
3   1082.10   Nozzle        colGrain            9        2.01       2.19
4   1838.83    Blade        colGrain           16        4.13       3.87

   HeatTreatTime  Nickel%  Iron%  Cobalt%  Chromium%  smallDefects  \
0          46.87    65.73  16.52    16.82       0.93            10
1          44.70    54.22  35.38     6.14       4.26            19
2           9.54    51.83  35.95     8.81       3.41            35
3          20.29    57.03  23.33    16.86       2.78             0
4          16.13    59.62  27.37    11.45       1.56            10

   largeDefects  sliverDefects seedLocation    castType
0             0              0       Bottom         Die
1             0              0       Bottom  Investment
2             3              0       Bottom  Investment
3             1              0          Top  Continuous
4             0              0          Top         Die
```

[28]:
```
df.describe()
```

[28]:
```
          Lifespan  coolingRate   quenchTime    forgeTime  HeatTreatTime  \
count  1000.000000  1000.000000  1000.000000  1000.000000    1000.000000
mean   1298.556320    17.639000     2.764230     5.464600      30.194510
std     340.071434     7.491783     1.316979     2.604513      16.889415
min     417.990000     5.000000     0.500000     1.030000       1.030000
25%    1047.257500    11.000000     1.640000     3.170000      16.185000
50%    1266.040000    18.000000     2.755000     5.475000      29.365000
75%    1563.050000    24.000000     3.970000     7.740000      44.955000
max    2134.530000    30.000000     4.990000    10.000000      59.910000

           Nickel%        Iron%      Cobalt%    Chromium%  smallDefects  \
count  1000.000000  1000.000000  1000.000000  1000.000000   1000.000000
mean     60.243080    24.553580    12.434690     2.768650     17.311000
std       5.790475     7.371737     4.333197     1.326496     12.268365
min      50.020000     6.660000     5.020000     0.510000      0.000000
25%      55.287500    19.387500     8.597500     1.590000      7.000000
50%      60.615000    24.690000    12.585000     2.865000     18.000000
```

```
75%     65.220000   29.882500   16.080000    3.922500   26.000000
max     69.950000   43.650000   19.990000    4.990000   61.000000

       largeDefects  sliverDefects
count   1000.000000    1000.000000
mean       0.550000       0.292000
std        1.163982       1.199239
min        0.000000       0.000000
25%        0.000000       0.000000
50%        0.000000       0.000000
75%        0.000000       0.000000
max        4.000000       8.000000
```

[29]:

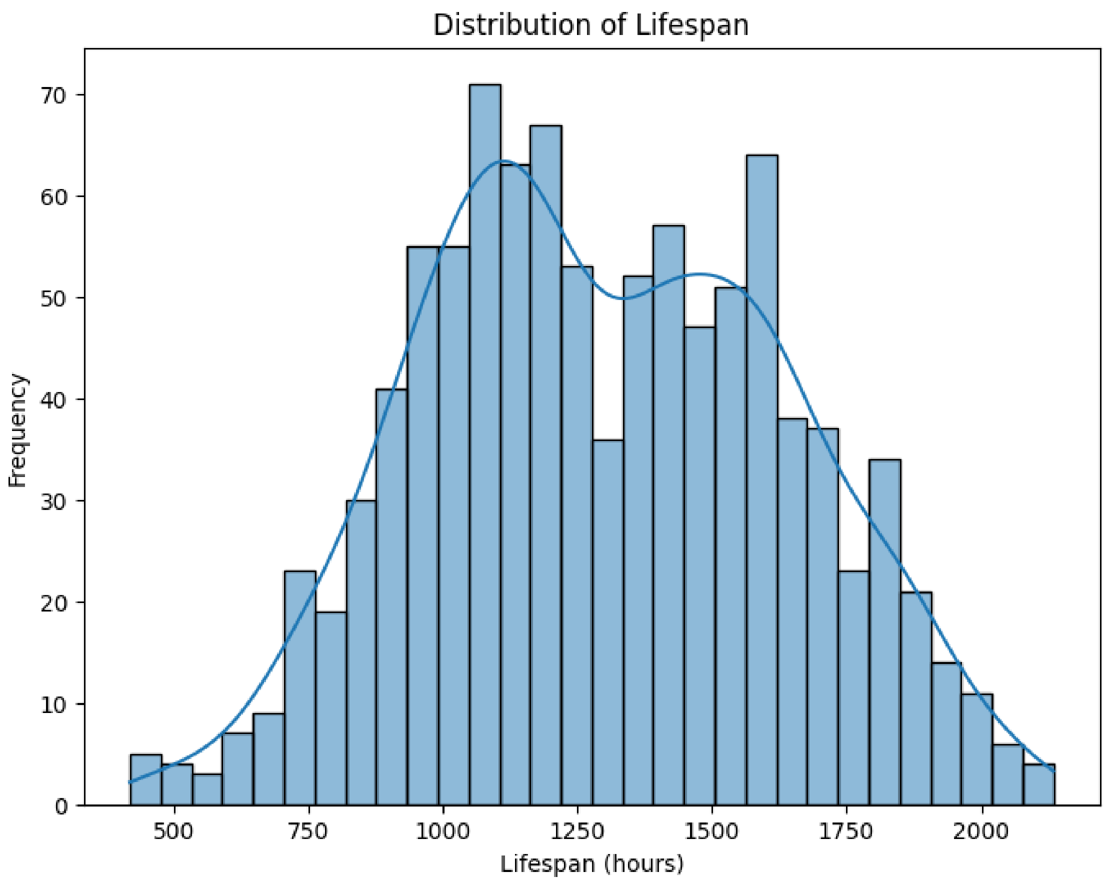
```
# Using nunique()
num_parts = df['partType'].nunique()
print(f"Number of unique parts types: {num_parts}")

# Or using value_counts() to see the distribution
parts_distribution = df['partType'].value_counts()
print("\nDistribution of parts types:")
print(parts_distribution)
```

```
Number of unique parts types: 4

Distribution of parts types:
partType
Valve     265
Block     253
Nozzle    245
Blade     237
Name: count, dtype: int64
```

1.1 Distribution of Lifespan

[30]:

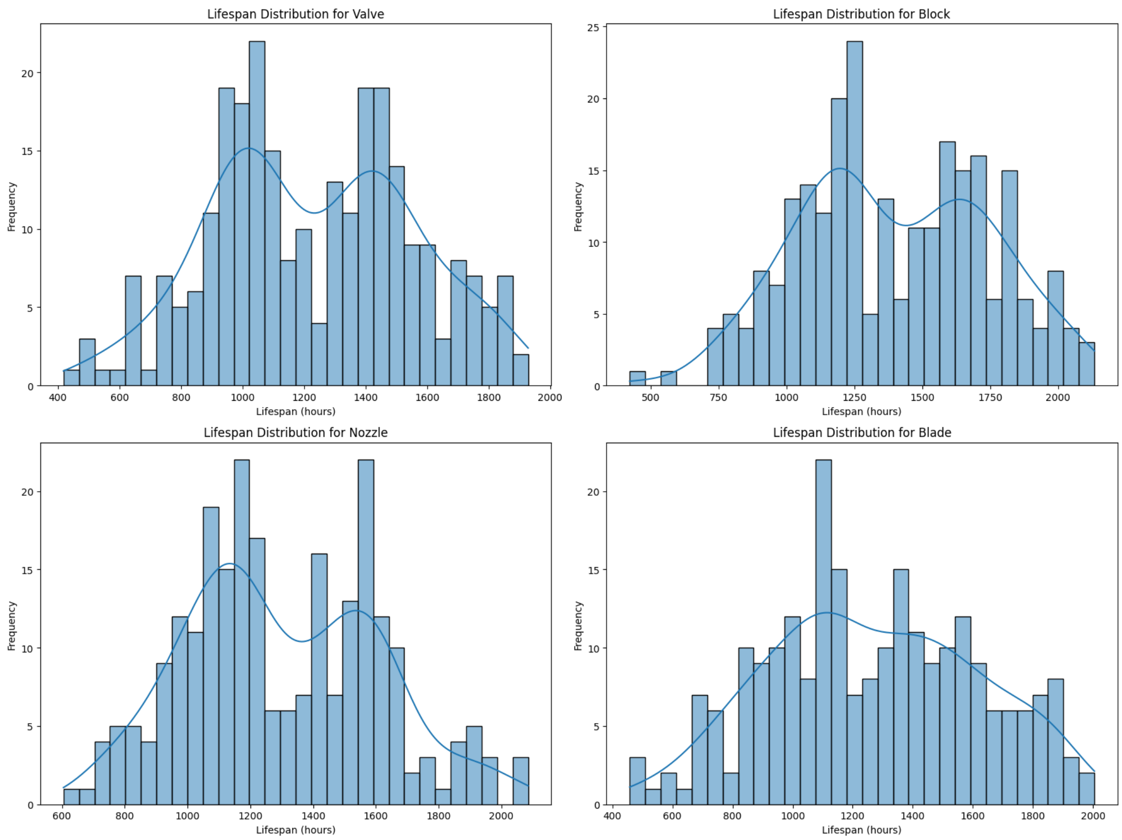
```
# Plotting the distribution of 'Lifespan'
plt.figure(figsize=(8, 6))
sns.histplot(df['Lifespan'], bins=30, kde=True)
plt.title('Distribution of Lifespan')
plt.xlabel('Lifespan (hours)')
plt.ylabel('Frequency')
plt.show()
```



1.2 Distribution of Lifespan Between Different Metal Parts

[31]:
```
# List of metal parts
part_types = ['Valve', 'Block', 'Nozzle', 'Blade']

# Set up the subplots: 2 rows and 2 columns (one for each metal part)
fig, axes = plt.subplots(nrows=2, ncols=2, figsize=(16, 12))
axes = axes.flatten()  # Flatten the axes array for easier iteration

# Loop through each metal part and create a histogram for its lifespan␣
↪distribution
for i, part in enumerate(part_types):
    subset = df[df['partType'] == part]
    sns.histplot(subset['Lifespan'], bins=30, kde=True, ax=axes[i])
    axes[i].set_title(f'Lifespan Distribution for {part}')
    axes[i].set_xlabel('Lifespan (hours)')
    axes[i].set_ylabel('Frequency')

# Adjust layout for better visualization
```

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

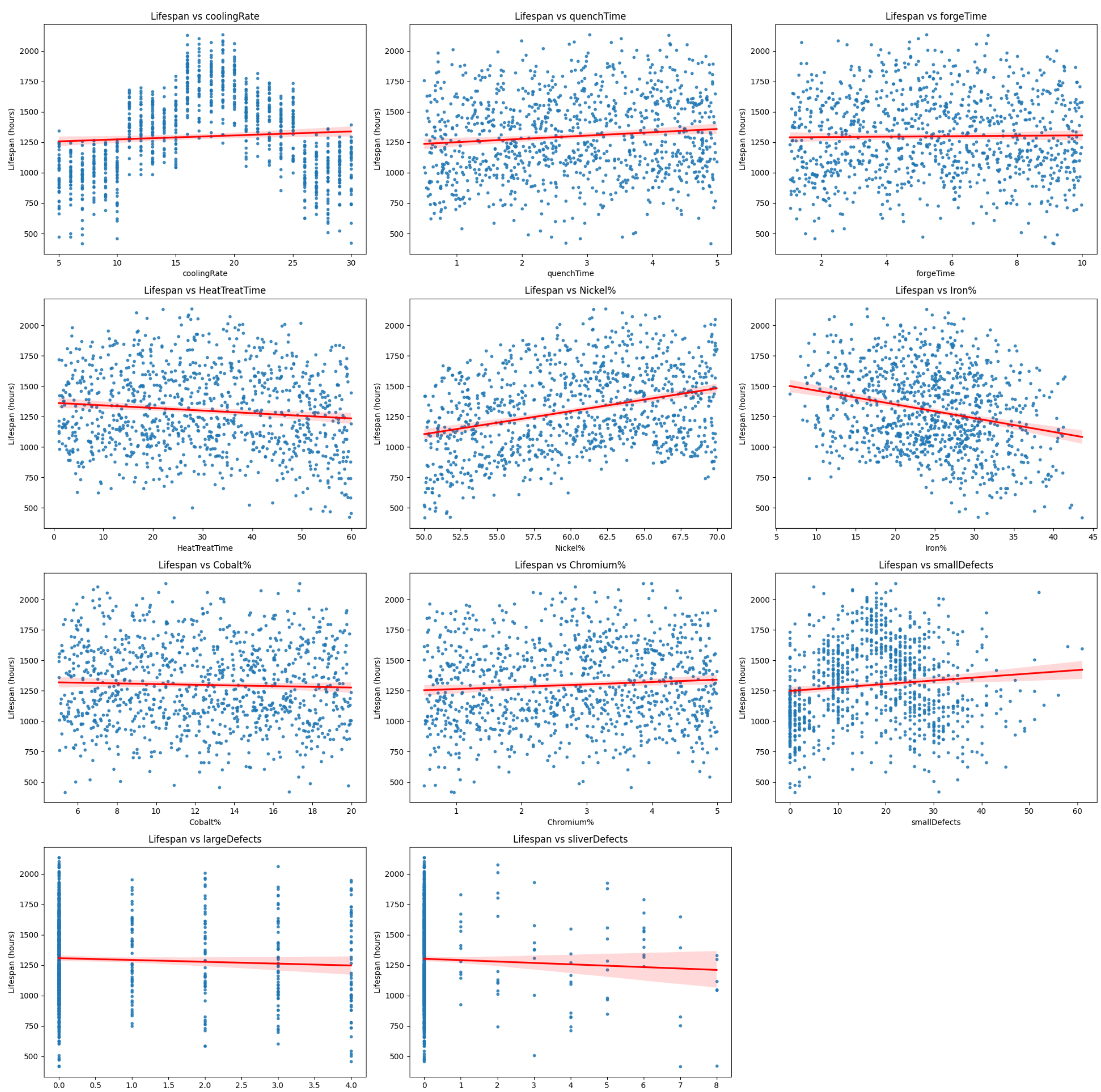


1.3 Scatter Plot Analysis of Lifespan

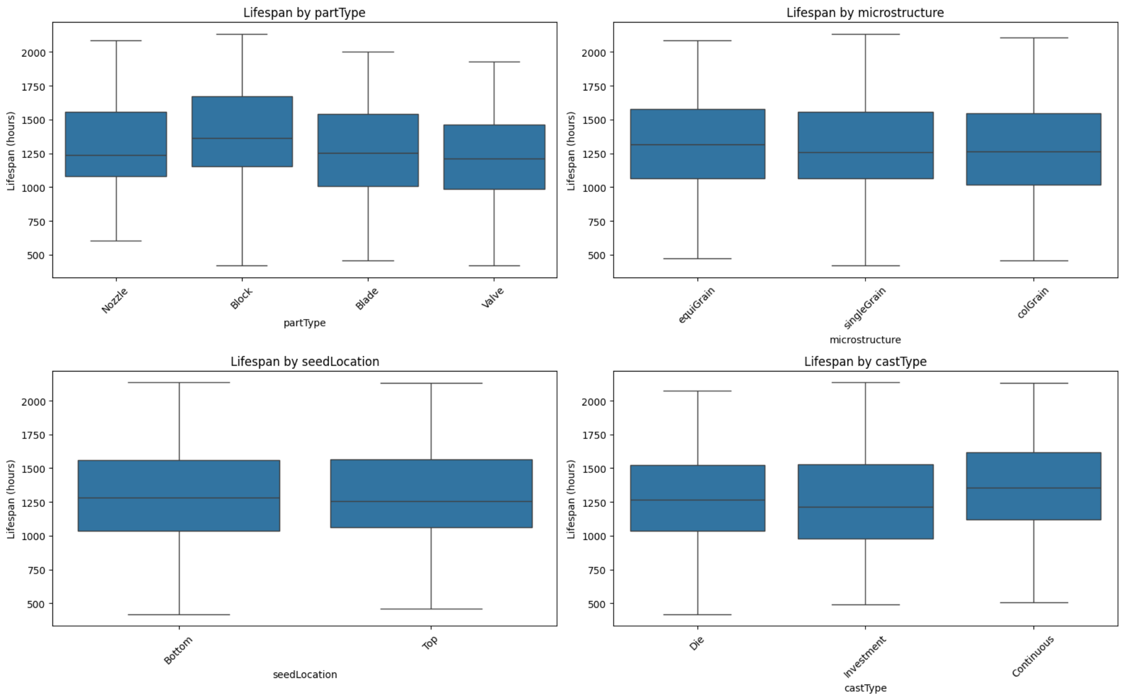
[32]:
```
# List of numerical columns excluding 'Lifespan'
numerical_cols = ['coolingRate', 'quenchTime', 'forgeTime', 'HeatTreatTime',
                  'Nickel%', 'Iron%', 'Cobalt%', 'Chromium%',
                  'smallDefects', 'largeDefects', 'sliverDefects']
```

[33]:
```
# Determine the number of rows and columns for the subplots
num_cols = len(numerical_cols)
nrows = num_cols // 3 + (num_cols % 3 > 0)  # Set up for 3 columns per row

# Create the subplots
fig, axes = plt.subplots(nrows=nrows, ncols=3, figsize=(20, nrows * 5))
axes = axes.flatten()  # Flatten to easily iterate over

# Plot each scatterplot with a regression trend line in a different subplot
```

```
for i, col in enumerate(numerical_cols):
    sns.regplot(ax=axes[i], data=df, x=col, y='Lifespan', scatter_kws={'s': 10}, line_kws={'color': 'red'})
    axes[i].set_title(f'Lifespan vs {col}')
    axes[i].set_xlabel(col)
    axes[i].set_ylabel('Lifespan (hours)')

# Remove any empty subplots if the number of features is not perfectly divisible by 3
for j in range(len(numerical_cols), len(axes)):
    fig.delaxes(axes[j])

# Adjust layout for better visualization
plt.tight_layout()
plt.show()
```



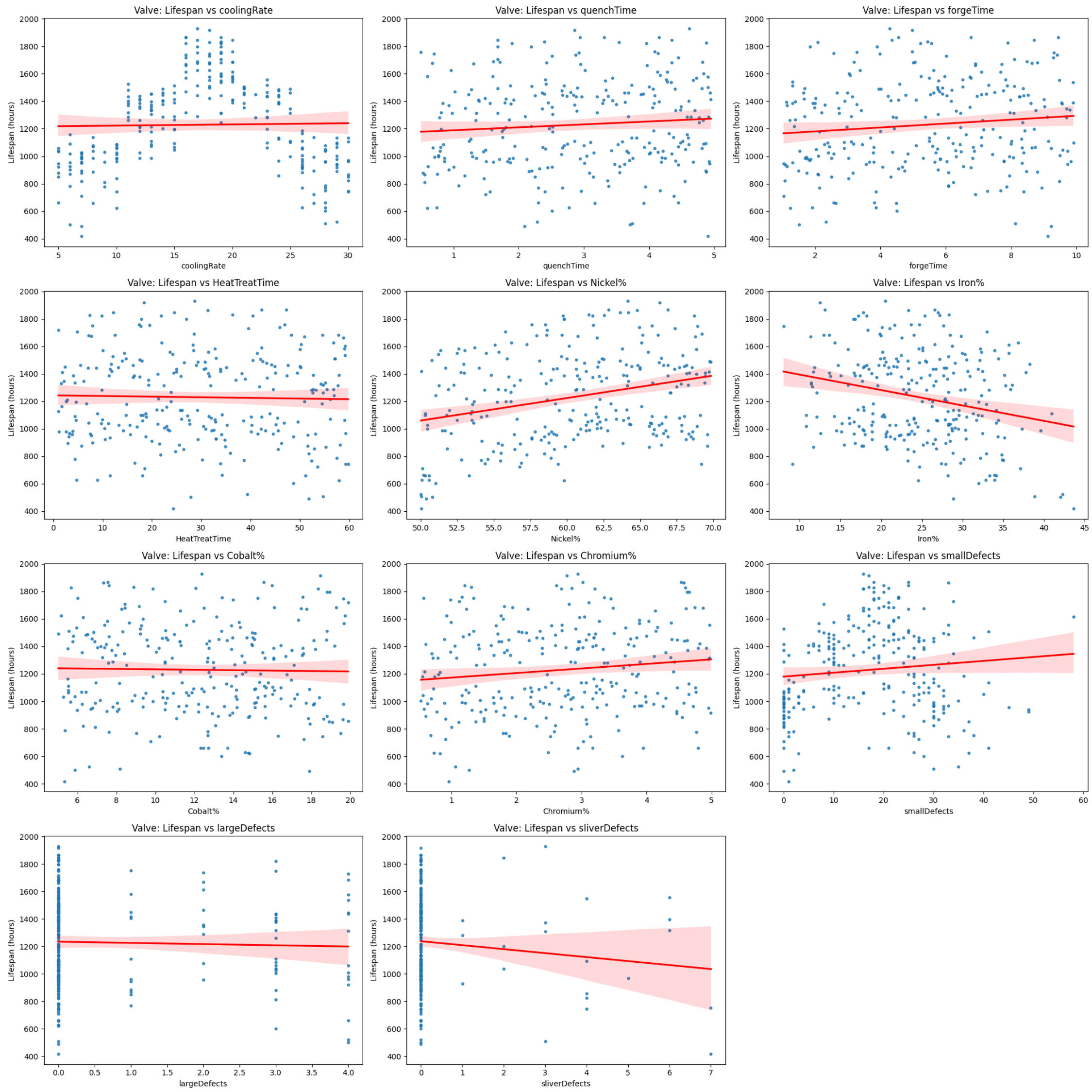
[38]:
```python
# List of categorical columns to include in the box plots
categorical_cols = ['partType', 'microstructure', 'seedLocation', 'castType']

# Determine the number of rows and columns for the subplots
num_cols = len(categorical_cols)
nrows = num_cols // 2 + (num_cols % 2 > 0)  # Set up for 2 columns per row for
↪better readability

# Create the subplots
fig, axes = plt.subplots(nrows=nrows, ncols=2, figsize=(16, nrows * 5))
axes = axes.flatten()  # Flatten the axes array to easily iterate over

# Plot each boxplot in a different subplot
for i, col in enumerate(categorical_cols):
    sns.boxplot(ax=axes[i], x=col, y='Lifespan', data=df)
    axes[i].set_title(f'Lifespan by {col}')
    axes[i].set_xlabel(col)
    axes[i].set_ylabel('Lifespan (hours)')
    axes[i].tick_params(axis='x', rotation=45)

# Remove any empty subplots if the number of features is odd
for j in range(len(categorical_cols), len(axes)):
    fig.delaxes(axes[j])

# Adjust layout for better visualization
plt.tight_layout()
plt.show()
```



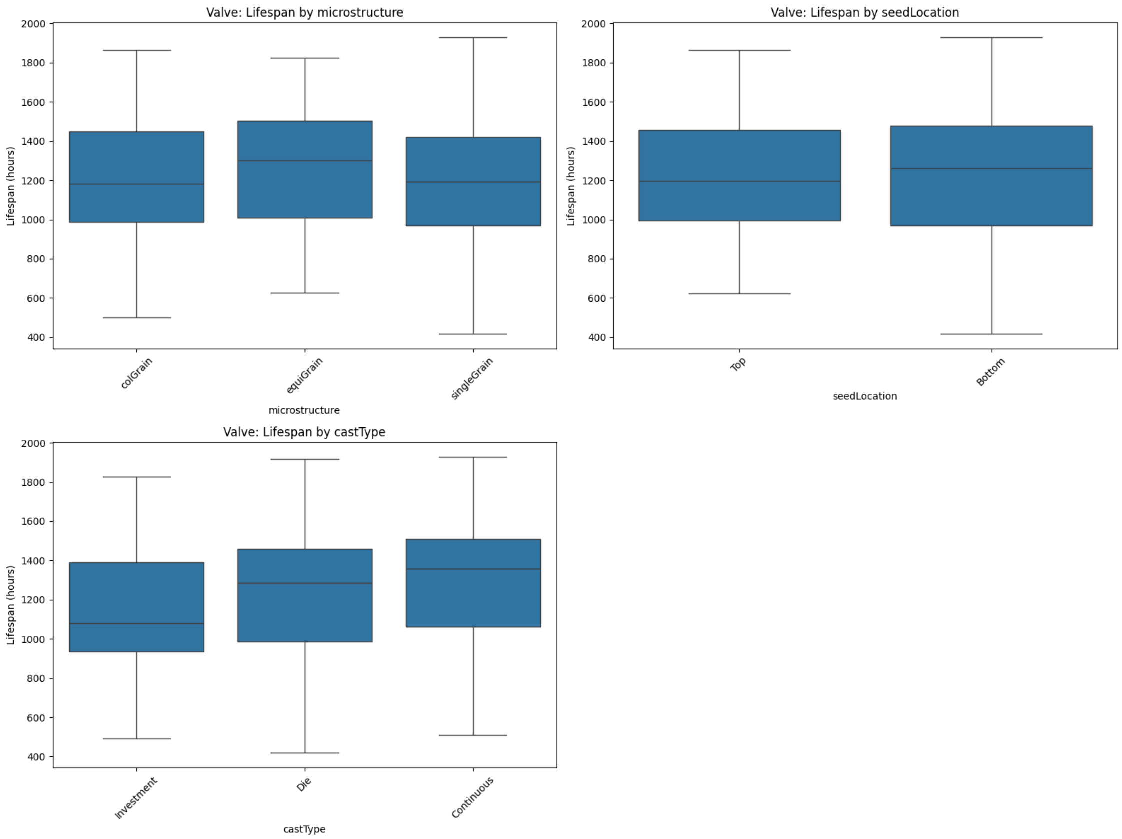
1.4 Analysing the data based on Part Type

1.4.1 Valve

[34]:
```
# 1. Scatter Plots for Valve
valve_data = df[df['partType'] == 'Valve']
fig, axes = plt.subplots(nrows=4, ncols=3, figsize=(20, 20))
axes = axes.flatten()
for i, col in enumerate(numerical_cols):
    sns.regplot(ax=axes[i], data=valve_data, x=col, y='Lifespan',␣
 ↪scatter_kws={'s': 10}, line_kws={'color': 'red'})
    axes[i].set_title(f'Valve: Lifespan vs {col}')
    axes[i].set_xlabel(col)
    axes[i].set_ylabel('Lifespan (hours)')
for j in range(len(numerical_cols), len(axes)):
    fig.delaxes(axes[j])
plt.tight_layout()
plt.show()
```

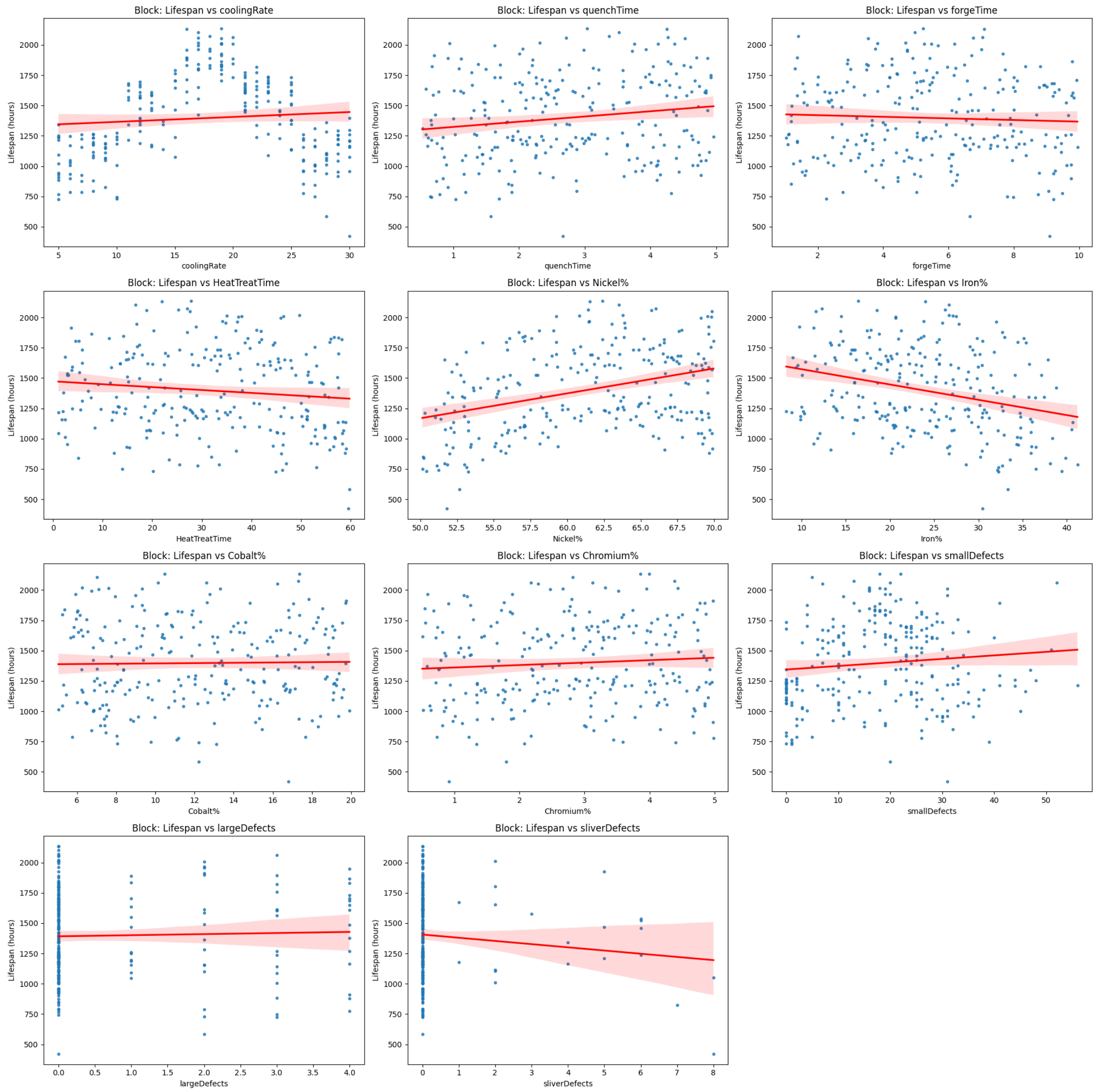


[39]:
```python
# 1. Box Plots for Valve
fig, axes = plt.subplots(nrows=2, ncols=2, figsize=(16, 12))
axes = axes.flatten()
for i, col in enumerate(['microstructure', 'seedLocation', 'castType']):
    sns.boxplot(ax=axes[i], x=col, y='Lifespan', data=valve_data)
    axes[i].set_title(f'Valve: Lifespan by {col}')
    axes[i].set_xlabel(col)
    axes[i].set_ylabel('Lifespan (hours)')
    axes[i].tick_params(axis='x', rotation=45)
for j in range(len(['microstructure', 'seedLocation', 'castType']), len(axes)):
    fig.delaxes(axes[j])
plt.tight_layout()
plt.show()
```

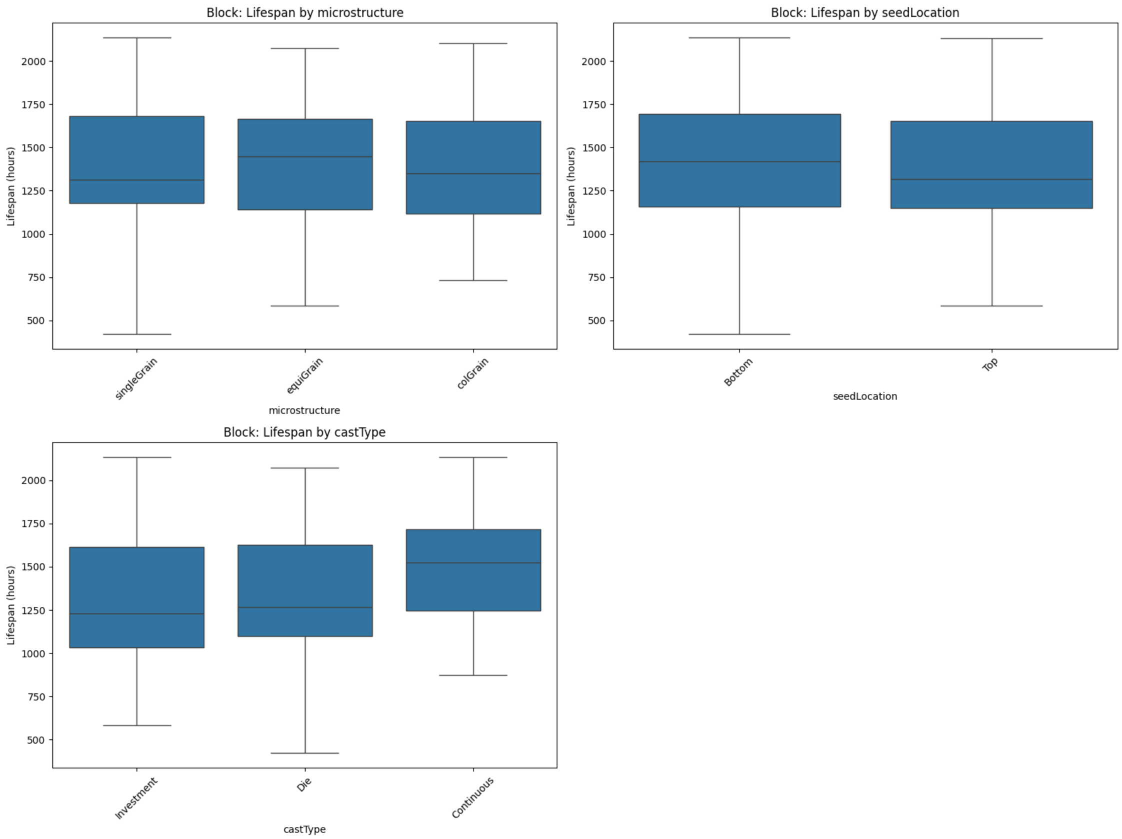


1.4.2 Block

[35]:
```
# 2. Scatter Plots for Block
block_data = df[df['partType'] == 'Block']
fig, axes = plt.subplots(nrows=4, ncols=3, figsize=(20, 20))
axes = axes.flatten()
for i, col in enumerate(numerical_cols):
    sns.regplot(ax=axes[i], data=block_data, x=col, y='Lifespan',␣
↪scatter_kws={'s': 10}, line_kws={'color': 'red'})
    axes[i].set_title(f'Block: Lifespan vs {col}')
    axes[i].set_xlabel(col)
    axes[i].set_ylabel('Lifespan (hours)')
for j in range(len(numerical_cols), len(axes)):
    fig.delaxes(axes[j])
plt.tight_layout()
plt.show()
```

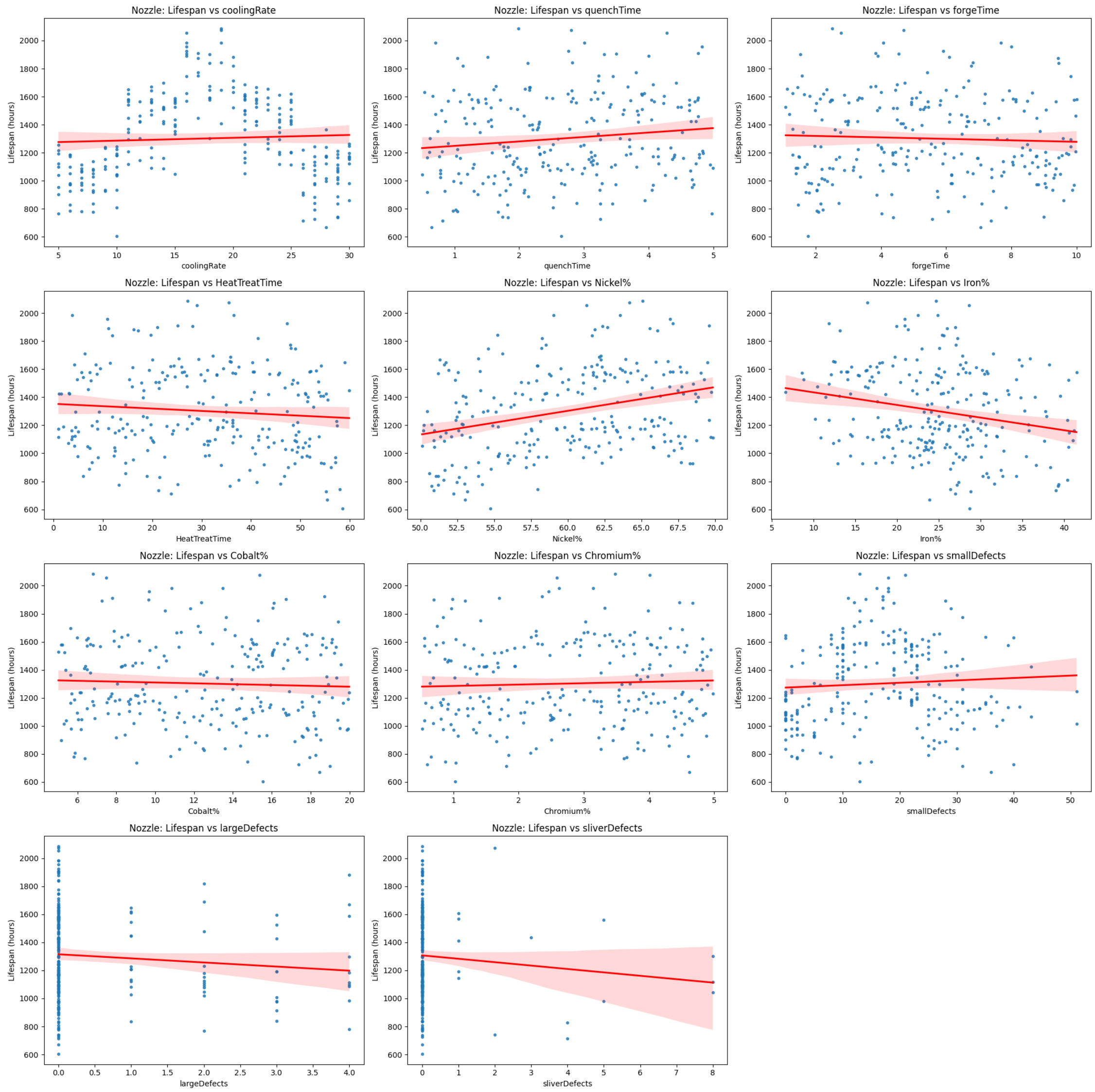


[40]:
```
# 2. Box Plots for Block
fig, axes = plt.subplots(nrows=2, ncols=2, figsize=(16, 12))
axes = axes.flatten()
for i, col in enumerate(['microstructure', 'seedLocation', 'castType']):
    sns.boxplot(ax=axes[i], x=col, y='Lifespan', data=block_data)
    axes[i].set_title(f'Block: Lifespan by {col}')
    axes[i].set_xlabel(col)
    axes[i].set_ylabel('Lifespan (hours)')
    axes[i].tick_params(axis='x', rotation=45)
for j in range(len(['microstructure', 'seedLocation', 'castType']), len(axes)):
    fig.delaxes(axes[j])
plt.tight_layout()
plt.show()
```

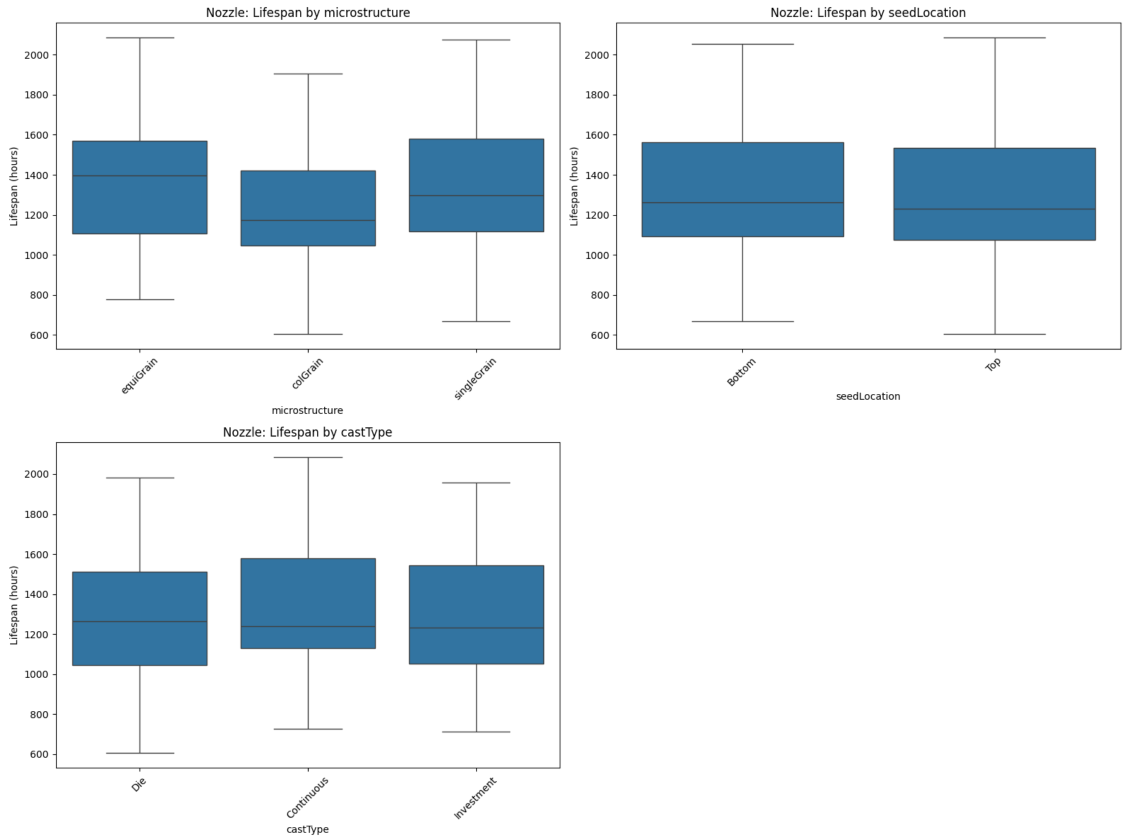


1.4.3 Nozzle

[36]:
```python
# 3. Scatter Plots for Nozzle
nozzle_data = df[df['partType'] == 'Nozzle']
fig, axes = plt.subplots(nrows=4, ncols=3, figsize=(20, 20))
axes = axes.flatten()
for i, col in enumerate(numerical_cols):
    sns.regplot(ax=axes[i], data=nozzle_data, x=col, y='Lifespan', scatter_kws={'s': 10}, line_kws={'color': 'red'})
    axes[i].set_title(f'Nozzle: Lifespan vs {col}')
    axes[i].set_xlabel(col)
    axes[i].set_ylabel('Lifespan (hours)')
for j in range(len(numerical_cols), len(axes)):
    fig.delaxes(axes[j])
plt.tight_layout()
plt.show()
```

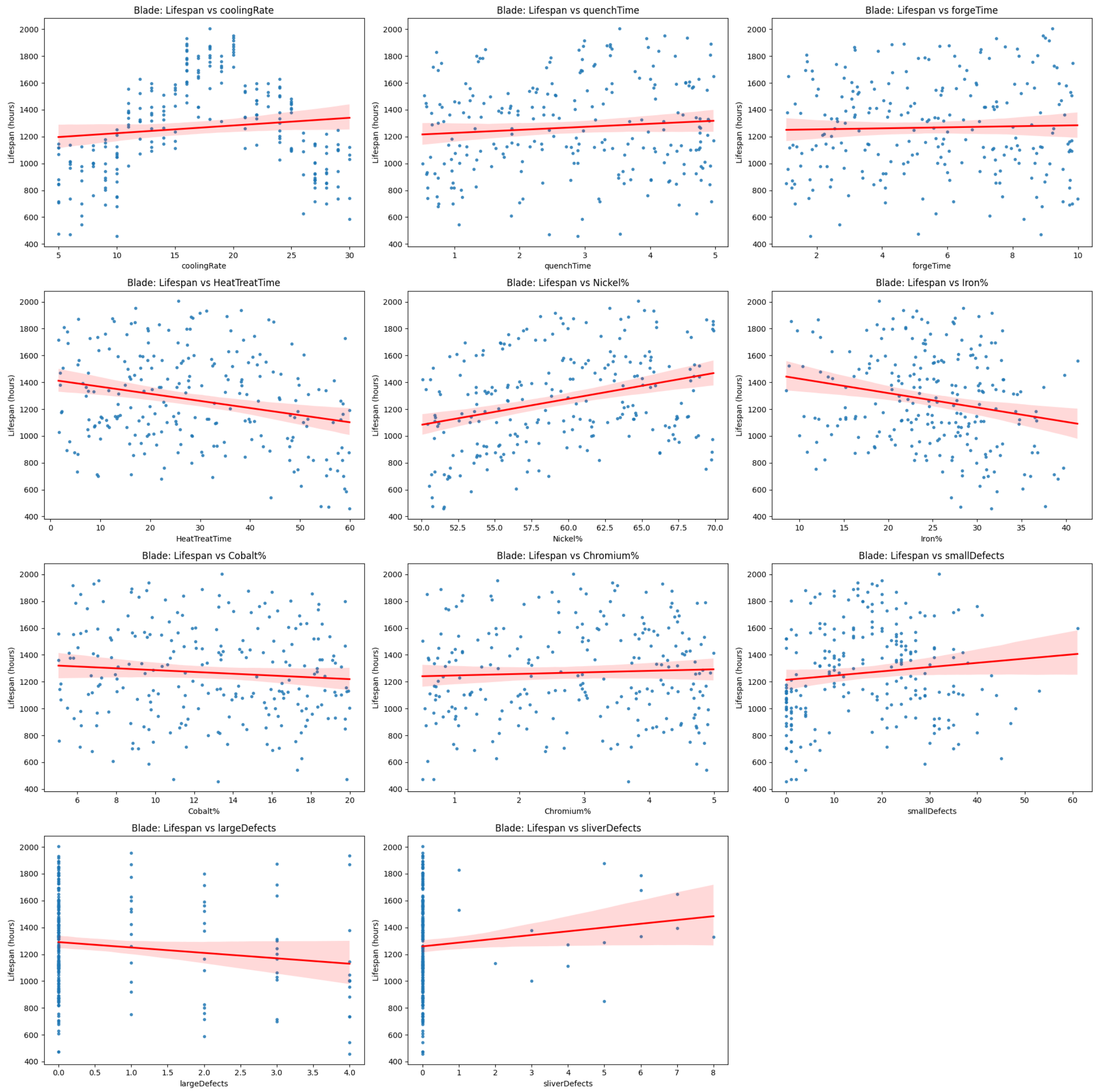


[41]:
```python
# 3. Box Plots for Nozzle
fig, axes = plt.subplots(nrows=2, ncols=2, figsize=(16, 12))
axes = axes.flatten()
for i, col in enumerate(['microstructure', 'seedLocation', 'castType']):
    sns.boxplot(ax=axes[i], x=col, y='Lifespan', data=nozzle_data)
    axes[i].set_title(f'Nozzle: Lifespan by {col}')
    axes[i].set_xlabel(col)
    axes[i].set_ylabel('Lifespan (hours)')
    axes[i].tick_params(axis='x', rotation=45)
for j in range(len(['microstructure', 'seedLocation', 'castType']), len(axes)):
    fig.delaxes(axes[j])
plt.tight_layout()
plt.show()
```

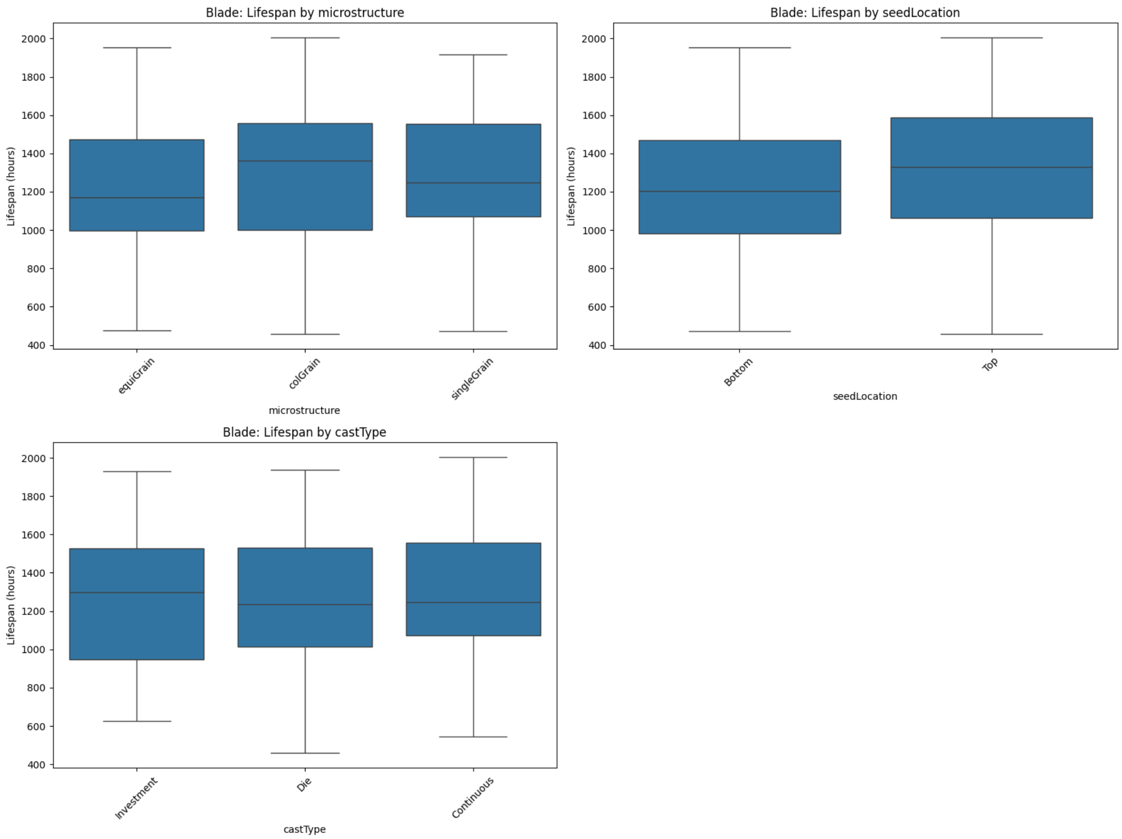


1.4.4 Blade

[37]:
```python
# 4. Scatter Plots for Blade
blade_data = df[df['partType'] == 'Blade']
fig, axes = plt.subplots(nrows=4, ncols=3, figsize=(20, 20))
axes = axes.flatten()
for i, col in enumerate(numerical_cols):
    sns.regplot(ax=axes[i], data=blade_data, x=col, y='Lifespan',␣
 ↪scatter_kws={'s': 10}, line_kws={'color': 'red'})
    axes[i].set_title(f'Blade: Lifespan vs {col}')
    axes[i].set_xlabel(col)
    axes[i].set_ylabel('Lifespan (hours)')
for j in range(len(numerical_cols), len(axes)):
    fig.delaxes(axes[j])
plt.tight_layout()
plt.show()
```

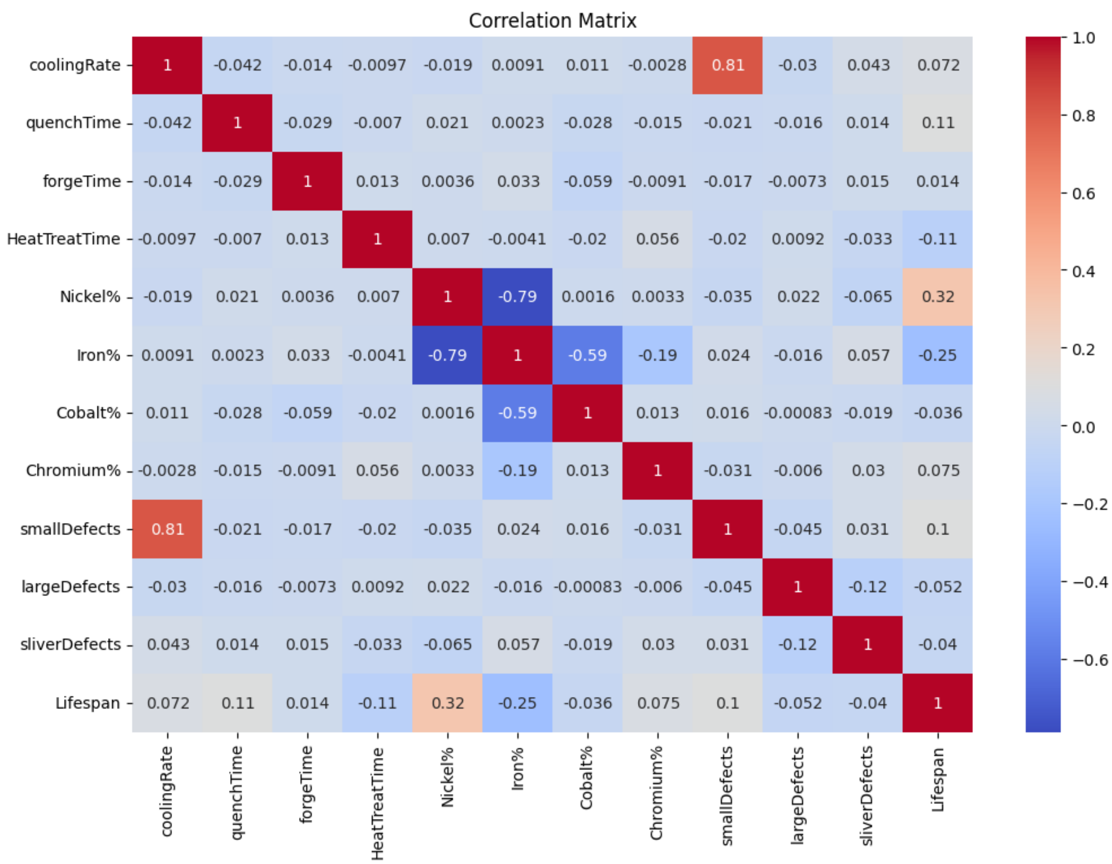


[42]:
```python
# 4. Box Plots for Blade
fig, axes = plt.subplots(nrows=2, ncols=2, figsize=(16, 12))
axes = axes.flatten()
for i, col in enumerate(['microstructure', 'seedLocation', 'castType']):
    sns.boxplot(ax=axes[i], x=col, y='Lifespan', data=blade_data)
    axes[i].set_title(f'Blade: Lifespan by {col}')
    axes[i].set_xlabel(col)
    axes[i].set_ylabel('Lifespan (hours)')
    axes[i].tick_params(axis='x', rotation=45)
for j in range(len(['microstructure', 'seedLocation', 'castType']), len(axes)):
    fig.delaxes(axes[j])
plt.tight_layout()
plt.show()
```



1.5 Correlation Matrix for Combined Lifespan of Metal Parts

[43]:
```
# Include 'Lifespan' in the correlation matrix
numerical_cols_with_target = numerical_cols + ['Lifespan']
corr_matrix = df[numerical_cols_with_target].corr()

# Plot heatmap
plt.figure(figsize=(12, 8))
sns.heatmap(corr_matrix, annot=True, cmap='coolwarm')
plt.title('Correlation Matrix')
plt.show()
```



1.6 Correlation Matrix for Lifespan of Individual Metal Parts

[44]:
```python
# Correlation Matrices for All Metal Parts in Subplots
fig, axes = plt.subplots(nrows=2, ncols=2, figsize=(24, 16))
axes = axes.flatten()

# 1. Correlation Matrix for Valve
valve_corr_matrix = valve_data[numerical_cols + ['Lifespan']].corr()
sns.heatmap(valve_corr_matrix, annot=True, cmap='coolwarm', ax=axes[0])
axes[0].set_title('Correlation Matrix for Valve')

# 2. Correlation Matrix for Block
block_corr_matrix = block_data[numerical_cols + ['Lifespan']].corr()
sns.heatmap(block_corr_matrix, annot=True, cmap='coolwarm', ax=axes[1])
axes[1].set_title('Correlation Matrix for Block')

# 3. Correlation Matrix for Nozzle
nozzle_corr_matrix = nozzle_data[numerical_cols + ['Lifespan']].corr()
sns.heatmap(nozzle_corr_matrix, annot=True, cmap='coolwarm', ax=axes[2])
axes[2].set_title('Correlation Matrix for Nozzle')
```

```python
# 4. Correlation Matrix for Blade
blade_corr_matrix = blade_data[numerical_cols + ['Lifespan']].corr()
sns.heatmap(blade_corr_matrix, annot=True, cmap='coolwarm', ax=axes[3])
axes[3].set_title('Correlation Matrix for Blade')

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