Self Case Study-2_Severstal: Steel Defect Detection - Can you detect and classify defects in steel?

Section-I

1. Business Problem

Steel is one of the most important building materials of modern times. Steel buildings are resistant to natural and man-made wear which has made the material popular around the world. The quality control of steel manufacturing is vital as it will affect the end-product quality. Identifying the defects present in the steel is a tedious repetition task for humans. Manual inspection of steel defects could lead to delay in the manufacturing process, and it is not an efficient way to warranty defect-free for steel manufacturing. Furthermore, if the undetected defects of steels are released to the end-users or customers, this could potentially lead to a bad reputation for the company.

To help make production of steel more efficient, this Kaggle competition will help identify defects.

‘Severstal’ is leading the charge in efficient steel mining and production. They believe the future of metallurgy requires development across the economic, ecological, and social aspects of the industry and they take corporate responsibility seriously. The company recently created the country’s largest industrial data lake, with petabytes of data that were previously discarded. Severstal is now looking to machine learning to improve automation, increase efficiency, and maintain high quality in their production. In this competition, we will be helping engineers improve the algorithm by localizing and classifying surface defects on a steel sheet.

2. Mapping the real-world problem to an ML problem

2.1 Description

In this competition we will be predicting the location and type of defects found in steel manufacturing. The images are named with a unique image ID. We have to segment and classify the defects in the test set.Each image may have no defects, a defect of a single class, or defects of multiple classes. For each image, we have to segment defects of each class (Class ID= [1,2,3,4]).

This is clearly a Multiclass problem. Given an image with some defect pixels, the task is to classify the defect pixels into their correct type and also to identify the non-defect pixels as well.Hence, the above problem can be posed as an image segmentation or Semantic segmentation task as the classification is at the pixel level.

2.2 Data Source

The data is available on kaggle.com and the same can be downloaded from the link:[https://www.kaggle.com/competitions/severstal-steel-defect-detection/data (https://www.kaggle.com/competitions/severstal-steel-defect-detection/data)](https://www.kaggle.com/competitions/severstal-steel-defect-detection/data)

• train_images/ - folder of training images

• test_images/ - folder of test images (We will be segmenting and classifying these images)

• train.csv - training annotations which provide segments for defects (Class ID= [1,2,3,4]).

• sample_submission.csv - a sample submission file in the correct format.

3 Exploratory Data Analysis

3.1 Importing dependencies

In [1]:
```
#importing usefull library
import pandas as pd
import numpy as np
import os
import cv2
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
warnings.filterwarnings("ignore")
import pandas_profiling as pp
```

3.2 Reading Data

3.2.1 Reading Data from train.csv

In [2]:
```
os.chdir('C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2')
os.getcwd()
```

Out[2]:
```
'C:\\Users\\Vikrant Mohite\\Desktop\\Applied AI\\Case Study-2'
```

In [4]:
```
pd.options.display.max_columns=50
train_df = pd.read_csv("train.csv")
train_df.shape
```

Out[4]:
```
(7095, 3)
```

In [5]:
```
train_df.head(5)
```

Out[5]:

	ImageId	ClassId	EncodedPixels
0	0002cc93b.jpg	1	29102 12 29346 24 29602 24 29858 24 30114 24 3...
1	0007a71bf.jpg	3	18661 28 18863 82 19091 110 19347 110 19603 11...
2	000a4bcdd.jpg	1	37607 3 37858 8 38108 14 38359 20 38610 25 388...
3	000f6bf48.jpg	4	131973 1 132228 4 132483 6 132738 8 132993 11 ...
4	0014fce06.jpg	3	229501 11 229741 33 229981 55 230221 77 230468...

In [6]:
```
train_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7095 entries, 0 to 7094
Data columns (total 3 columns):
 #   Column         Non-Null Count  Dtype 
---  ------         --------------  ----- 
 0   ImageId        7095 non-null   object
 1   ClassId        7095 non-null   int64 
 2   EncodedPixels  7095 non-null   object
dtypes: int64(1), object(2)
memory usage: 166.4+ KB
```

In [7]:
```
train_df.ImageId.value_counts()
```

Out[7]:
```
ef24da2ba.jpg    3
db4867ee8.jpg    3
84865746c.jpg    2
5665ada1b.jpg    2
eb44ad79d.jpg    2
                ..
59ce36e8a.jpg    1
59c00ad1f.jpg    1
59bcf1693.jpg    1
59bc9997f.jpg    1
ffffd67df.jpg    1
Name: ImageId, Length: 6666, dtype: int64
```

In [8]:
```
train_df.nunique()
```

Out[8]:
```
ImageId          6666
ClassId             4
EncodedPixels    7095
dtype: int64
```

In [9]:
```
train_df.ImageId.nunique()
```

Out[9]:
```
6666
```

In [10]:
```
train_df.ClassId.value_counts()
```

Out[10]:
```
3    5150
1     897
4     801
2     247
Name: ClassId, dtype: int64
```

3.2.2 Reading Data from the folder 'train_images'

In [11]:
```
train_images = os.listdir("C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images")
len(train_images)
```

Out[11]: 12568

In [12]:
```
train_images_df = pd.DataFrame(train_images,columns =['ImageId'])
train_images_df.head()
```

Out[12]:

	ImageId
0	0002cc93b.jpg
1	00031f466.jpg
2	000418bfc.jpg
3	000789191.jpg
4	0007a71bf.jpg

3.2.3 Mearging the data from train.csv of defective images with images in the folder train_images

In [13]:
```
train_df_mearged = pd.merge(train_df,train_images_df,how = 'outer',on = ['ImageId','ImageId'])
train_df_mearged.head(5)
```

Out[13]:

	ImageId	ClassId	EncodedPixels
0	0002cc93b.jpg	1.0	29102 12 29346 24 29602 24 29858 24 30114 24 3...
1	0007a71bf.jpg	3.0	18661 28 18863 82 19091 110 19347 110 19603 11...
2	000a4bcdd.jpg	1.0	37607 3 37858 8 38108 14 38359 20 38610 25 388...
3	000f6bf48.jpg	4.0	131973 1 132228 4 132483 6 132738 8 132993 11 ...
4	0014fce06.jpg	3.0	229501 11 229741 33 229981 55 230221 77 230468...

In [14]:
```
train_df_mearged.shape
```

Out[14]: (12997, 3)

In [15]:
```
train_df_mearged.tail()
```

Out[15]:

	ImageId	ClassId	EncodedPixels
12992	ffa8210a1.jpg	NaN	NaN
12993	ffaa05016.jpg	NaN	NaN
12994	ffd0223a7.jpg	NaN	NaN
12995	ffe93442c.jpg	NaN	NaN
12996	fff0295e1.jpg	NaN	NaN

In [16]:
```
train_df_mearged.isnull().sum()
```

Out[16]:
```
ImageId             0
ClassId          5902
EncodedPixels    5902
dtype: int64
```

In [23]:
```
7095+5902
```

Out[23]:
```
12997
```

3.2.4 Visualization of mearged data with panda profiling library

In [17]:
```
pp.ProfileReport(train_df_mearged)
```

Summarize dataset: 100% 19/19 [00:19<00:00, 1.28it/s, Completed]

Generate report structure: 100% 1/1 [00:02<00:00, 2.30s/it]

Render HTML: 100% 1/1 [00:01<00:00, 1.14s/it]

In [18]:
```
train_df_mearged.groupby(['ClassId']).size()
```

Out[18]:
```
ClassId
1.0     897
2.0     247
3.0    5150
4.0     801
dtype: int64
```

In [19]:
```
# replacing 'NaN' values if class ID of non-defective images with '0'
train_df_mearged['ClassId'].fillna(value=0,inplace=True)
train_df_mearged.head()
```

Out[19]:

	ImageId	ClassId	EncodedPixels
0	0002cc93b.jpg	1.0	29102 12 29346 24 29602 24 29858 24 30114 24 3...
1	0007a71bf.jpg	3.0	18661 28 18863 82 19091 110 19347 110 19603 11...
2	000a4bcdd.jpg	1.0	37607 3 37858 8 38108 14 38359 20 38610 25 388...
3	000f6bf48.jpg	4.0	131973 1 132228 4 132483 6 132738 8 132993 11 ...
4	0014fce06.jpg	3.0	229501 11 229741 33 229981 55 230221 77 230468...

In [20]:
```
train_df_mearged.tail()
```

Out[20]:

	ImageId	ClassId	EncodedPixels
12992	ffa8210a1.jpg	0.0	NaN
12993	ffaa05016.jpg	0.0	NaN
12994	ffd0223a7.jpg	0.0	NaN
12995	ffe93442c.jpg	0.0	NaN
12996	fff0295e1.jpg	0.0	NaN

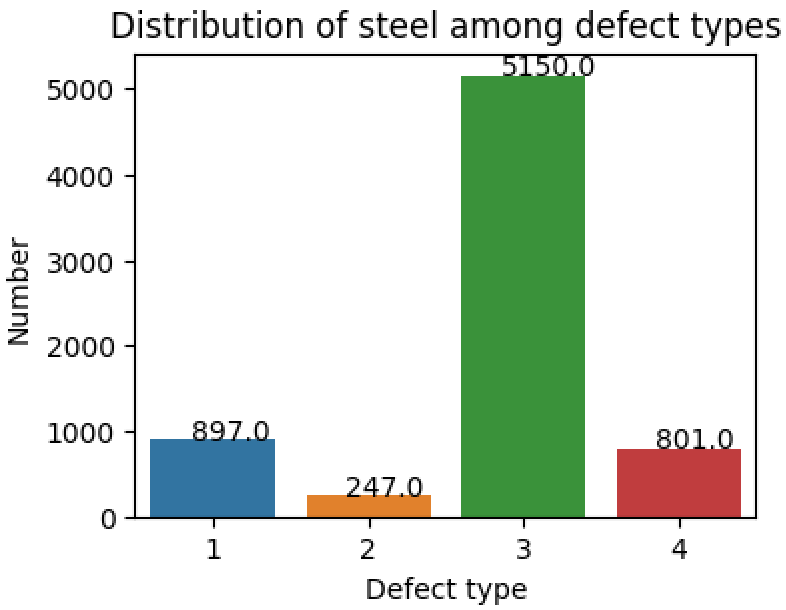
3.2.5 Visualization of distribution of class IDs

In [21]:
```
plt.figure(figsize=(4,3))
ax = sns.countplot(x="ClassId", data=train_df)

plt.title('Distribution of steel among defect types')
plt.xlabel('Defect type')
plt.ylabel('Number')

for p in ax.patches:
   ax.annotate('{:.1f}'.format(p.get_height()), (p.get_x()+0.25, p.get_height()+0.01))

plt.show()
```

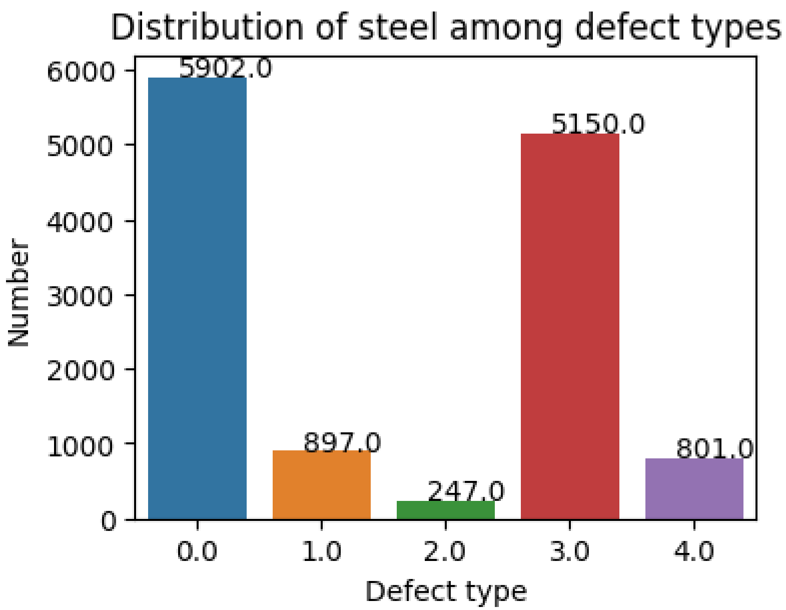


In [22]:
```
plt.figure(figsize=(4,3))
ax =sns.countplot(x="ClassId", data=train_df_mearged)

plt.title('Distribution of steel among defect types')
plt.xlabel('Defect type')
plt.ylabel('Number')

for p in ax.patches:
   ax.annotate('{:.1f}'.format(p.get_height()), (p.get_x()+0.25, p.get_height()+0.01))

plt.show()
```



In [37]:
```
train_df.groupby(['ImageId']).size().value_counts()
```

Out[37]:
```
1    6239
2     425
3       2
dtype: int64
```

In [23]:
```
df = train_df.groupby(['ImageId']).size().value_counts()
iamagecount_df = pd.DataFrame(df)
iamagecount_df
```

Out[23]:

	0
1	6239
2	425
3	2

In [24]:
```
iamagecount_df['index'] = iamagecount_df.index
iamagecount_df.columns = ['count', 'no._of_defects']
iamagecount_df
```

Out[24]:

	count	no._of_defects
1	6239	1
2	425	2
3	2	3

3.3 Further analysis of images present in the dataset

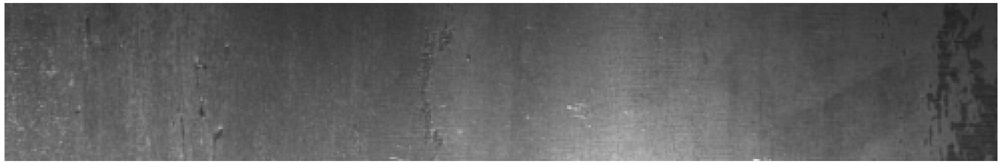
In [25]:
```
# The below function creates the dataframe of path of the images
def return_file_names_df(root_dir):
    lst1 = []
    for path, dirc, files in os.walk(root_dir):
        for name in files:
            if name.endswith('jpg'):
                lst1.append(path + '/' + name)
    data_df = pd.DataFrame((lst1), columns = ["image_path"])
    pd.set_option('display.max_colwidth', None)
    pd.set_option("display.max_rows", None)
    return data_df
```

In [26]:
```
train_images_path = "C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images"
return_file_names_df(train_images_path)
```

Out[26]:

	image_path
0	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/0002cc93b.jpg
1	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/00031f466.jpg
2	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/000418bfc.jpg
3	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/000789191.jpg
4	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/0007a71bf.jpg
5	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/000a4bcdd.jpg
6	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/000f6bf48.jpg
7	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/0014fce06.jpg
8	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/001982b08.jpg
9	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/001d1b355.jpg
10	C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/001d3d093.jpg

In [28]:
```
#reading a sample image
import cv2
img1 = cv2.imread('C:/Users/Vikrant Mohite/Desktop/Applied AI/Case Study-2/train_images/0002cc93b.jpg')
plt.imshow(img1)
plt.axis("off")
plt.show()
```

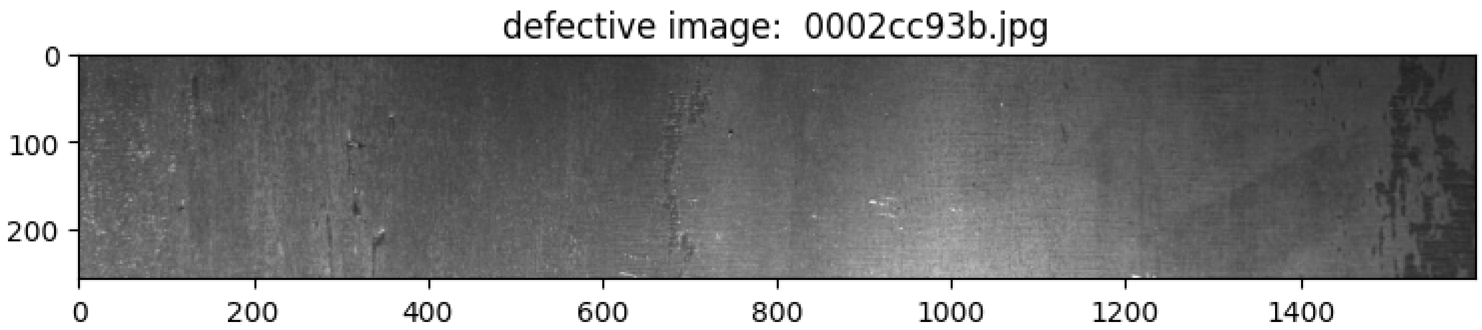


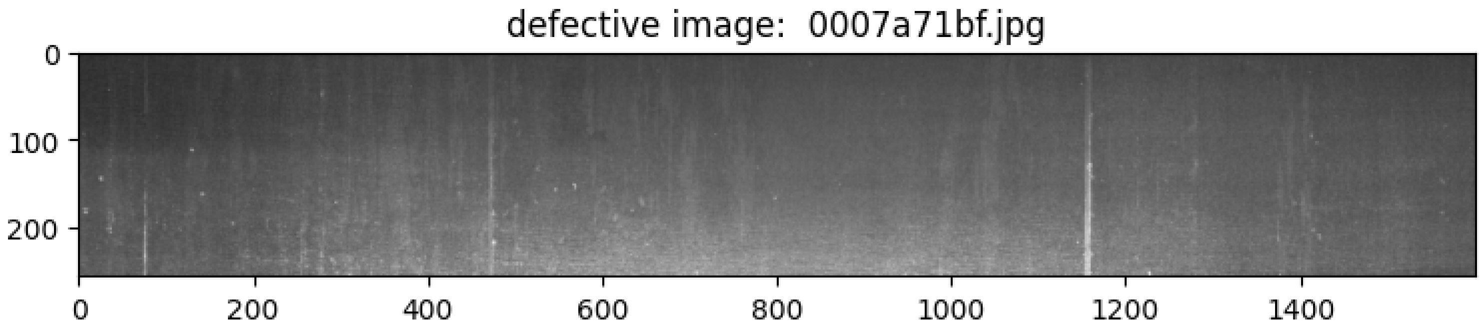
In [29]:
```
# printing shape of image
print("shape of image:", img1.shape)
```

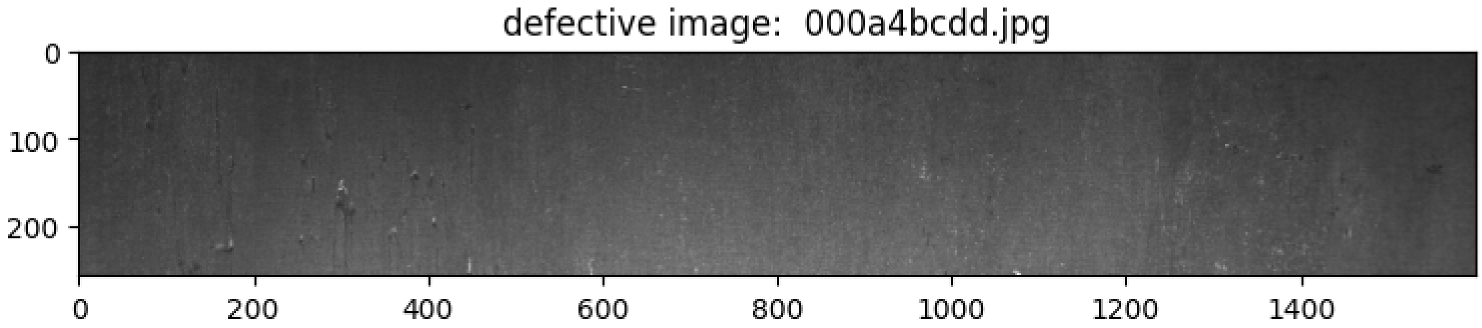
```
shape of image: (256, 1600, 3)
```

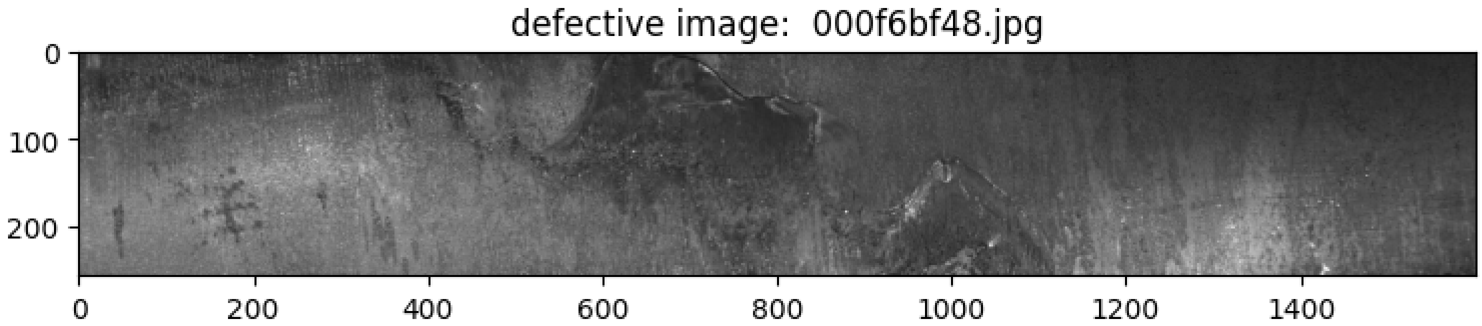
In [30]:
```
# code to print images that have defect
print("Images that have defects:")
for i, j in enumerate(train_df_mearged['ImageId'][train_df_mearged['ClassId']!=0]):
    if i < 5:
        plt.figure(figsize=(9, 3))
        img = cv2.imread(os.path.join(train_images_path , j))
        plt.imshow(img)
        plt.title("defective image:  "+j)
        plt.show()
    else:
        break
```

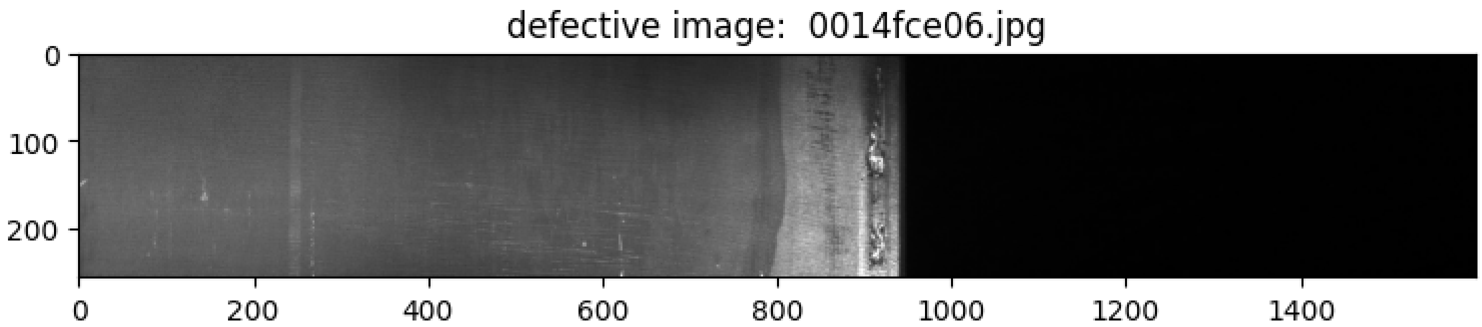
```
Images that have defects:
```



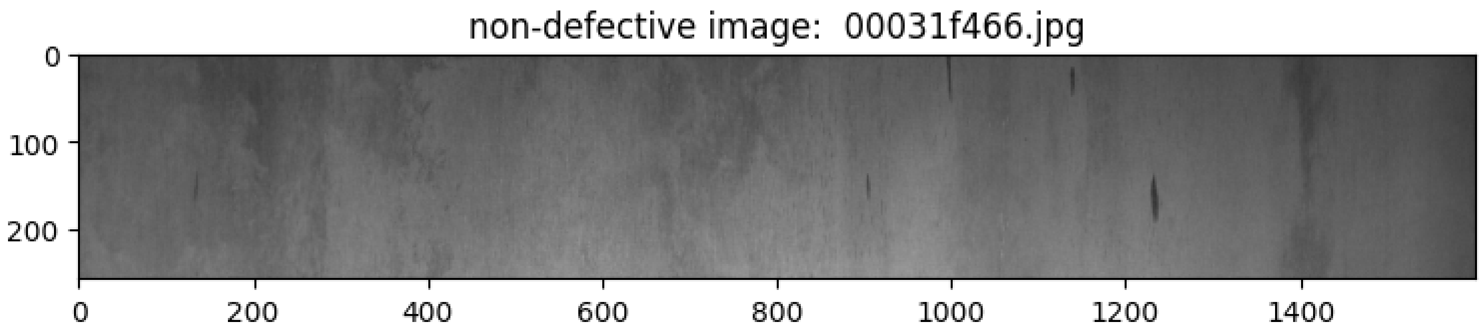


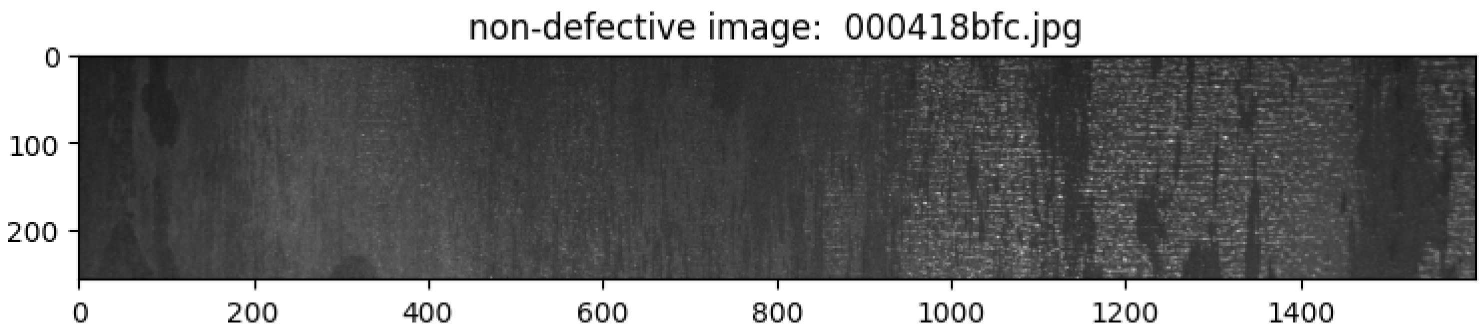

defective image: 000a4bcdd.jpg
0
100
200
0
200
400
600
800
1000
1200
1400

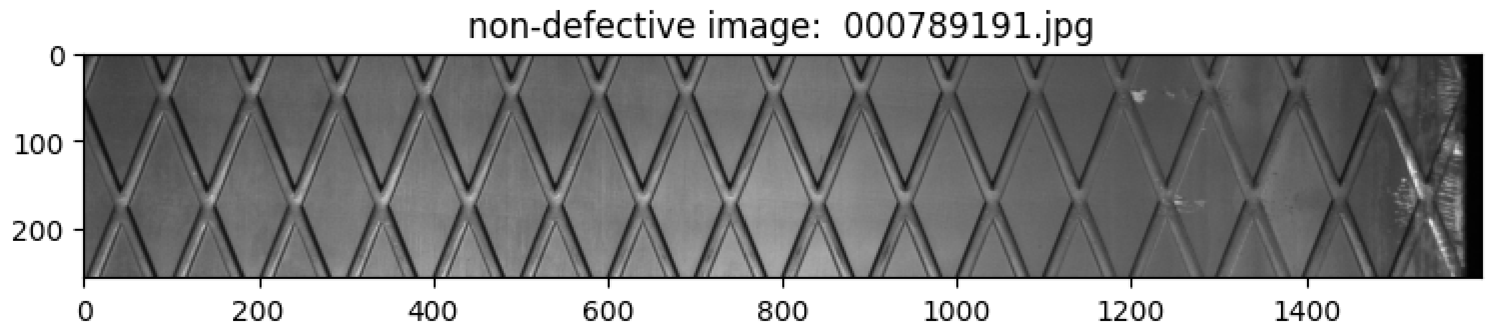

defective image: 000f6bf48.jpg
0
100
200
0
200
400
600
800
1000
1200
1400

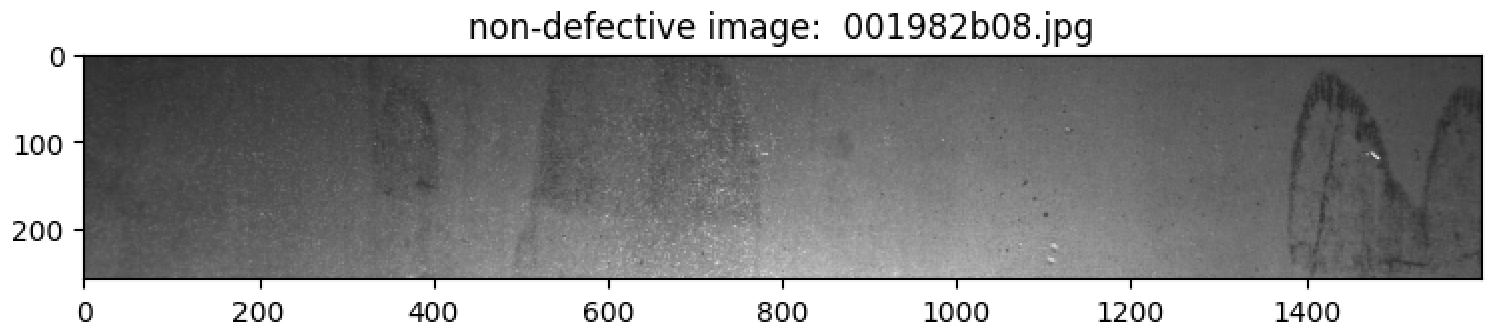

defective image: 0014fce06.jpg
0
100
200
0
200
400
600
800
1000
1200
1400

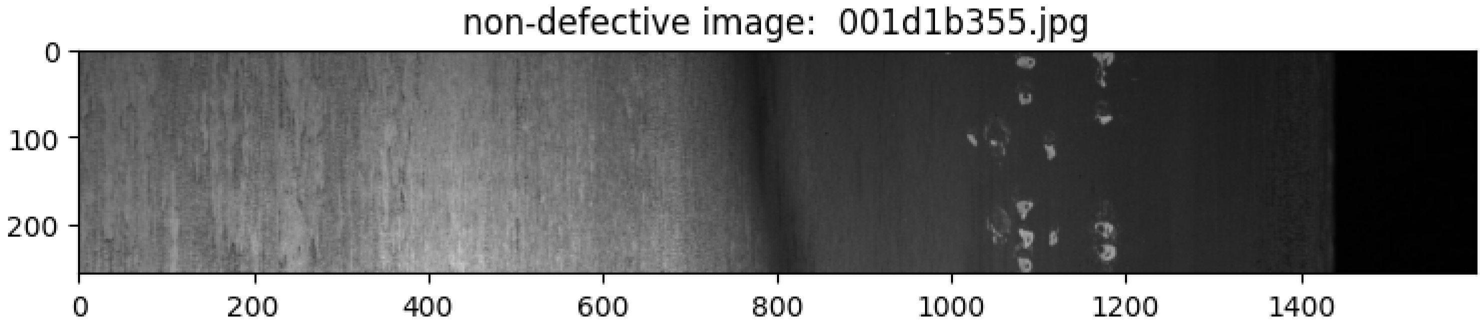
In [31]:
```
# code to print images that do not have any defect
for i, j in enumerate(train_df_mearged['ImageId'][train_df_mearged['ClassId']==0]):
    if i < 5:
        plt.figure(figsize=(9, 3))
        img = cv2.imread(os.path.join(train_images_path , j))
        plt.imshow(img)
        plt.title("non-defective image:  "+j)
        plt.show()
    else:
        break
```






non-defective image: 000789191.jpg
0
100
200
0
200
400
600
800
1000
1200
1400


non-defective image: 001982b08.jpg
0
100
200
0
200
400
600
800
1000
1200
1400



3.4 Observation from the EDA and the analysis of images done above

The Dataset consists of a collection of grayscale steel surface images measuring 1600 x 256 pixels. There are total 12568 images in dataset of which 6666 have defects and 5902 do not have any defects. It is seen that the most of the defective images are having single defect. There are 425 images that have 2 defects each. There are only 2 images that have 3 defects each. It is also found that the class ID ‘3’ has most no. of samples followed by classes ‘1’, ‘4’ and ‘2’. The data is found to be highly imbalanced.

In [ ]: