In [ ]:
```
!pip install kaggle
```

In [2]:
```
from google.colab import files
files.upload()
```

Choose Files No file chosen

Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving kaggle.json to kaggle.json
```

Out[2]:
```
{'kaggle.json': b'{"username":"vishalmoreai","key":"3d0aec857c464c4d356
c24632f5f7e14"}'}
```

In [3]:
```
!mkdir -p ~/.kaggle
!mv kaggle.json ~/.kaggle/
!chmod 600 ~/.kaggle/kaggle.json
```

In [4]:
```
!kaggle datasets download -d endofnight17j03/industry-defect-dataset
```

```
Downloading industry-defect-dataset.zip to /content
 97% 131M/135M [00:04<00:00, 26.2MB/s]
100% 135M/135M [00:04<00:00, 29.9MB/s]
```

In [ ]:
```
!unzip industry-defect-dataset.zip
```

In [7]:
```
!pip install kerastuner
```

```
ERROR: Could not find a version that satisfies the requirement kerastun
er (from versions: none)
ERROR: No matching distribution found for kerastuner
```

In [8]:

```
import os
import numpy as np
from PIL import Image
from sklearn.model_selection import train_test_split
import tensorflow.keras as keras
import tensorflow.keras.layers as layers
from sklearn.metrics import accuracy_score, precision_score, recall_score
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.metrics import roc_curve, auc, precision_recall_curve
from sklearn.calibration import calibration_curve
from keras.callbacks import EarlyStopping
from keras.models import Model
import matplotlib.pyplot as plt
from tensorflow.keras.utils import plot_model
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
import pandas as pd
```

In [9]:

```
base_path = '/content/Industrial-Equipment/'
```

In [10]:

```
defected_path = os.path.join(base_path, "Defected")
non_defected_path = os.path.join(base_path, "Non-Defected")
```

In [11]:

```
def load_and_resize_images(folder_path, label, target_size=(100, 100), gr
    images = []
    labels = []
    for filename in os.listdir(folder_path):
        if filename.endswith('.jpg') or filename.endswith(".png") or file
            try:
                image = Image.open(os.path.join(folder_path, filename))
                # Resize the image to the target size
                image_resized = image.resize(target_size)
                # Convert the image to grayscale if specified
                if grayscale:
                    image_resized = image_resized.convert('L')
                # Convert the image to a numpy array
                image_array = np.array(image_resized)
                # Add the image and label to the lists
                images.append(image_array)
                labels.append(label)
            except Exception as e:
                print(f"Error processing {filename}: {str(e)}")
    return images, labels
```

In [12]:

```
# Load and resize images from Defected folder
defected_images, defected_labels = load_and_resize_images(defected_path,

# Load and resize images from Non-Defected folder
non_defected_images, non_defected_labels = load_and_resize_images(non_de

# Check the number of images in each category
print("Number of defected images:", len(defected_images))
print("Number of non-defected images:", len(non_defected_images))
```

```
Number of defected images: 2574
Number of non-defected images: 1827
```

In [13]:

```
# Concatenate defected and non-defected images and labels
image_data = np.concatenate((defected_images, non_defected_images), axis
label_data = np.concatenate((defected_labels, non_defected_labels), axis
```

In [14]:

```
combined_data = list(zip(image_data, label_data))
np.random.shuffle(combined_data)
shuffled_image_data, shuffled_label_data = zip(*combined_data)

# Convert to NumPy arrays
shuffled_image_data = np.array(shuffled_image_data)
shuffled_label_data = np.array(shuffled_label_data)

# Check the shape of the shuffled data
print("Shuffled image data shape:", shuffled_image_data.shape)
print("Shuffled label data shape:", shuffled_label_data.shape)
```

```
Shuffled image data shape: (4401, 100, 100)
Shuffled label data shape: (4401,)
```

In [15]:

```
train_images, val_images, train_labels, val_labels = train_test_split(shu
```

In [16]:

```
train_images = train_images / 255.0
val_images = val_images / 255.0
```

In [17]:
```
def build_model(hp):
    model = keras.Sequential()

    # Tune the number of convolutional layers
    num_conv_layers = hp.Int('num_conv_layers', min_value=1, max_value=3,
    for i in range(num_conv_layers):
        model.add(layers.Conv2D(filters=hp.Int(f'conv_{i}_filter', min_va
                                kernel_size=(3, 3),
                                padding='same',
                                activation='relu',
                                input_shape=(100, 100, 1)))  # Add input
        model.add(layers.MaxPool2D(pool_size=(2, 2)))

    model.add(layers.Flatten())

    # Tune the number of dense layers
    num_dense_layers = hp.Int('num_dense_layers', min_value=1, max_value=
    for i in range(num_dense_layers):
        model.add(layers.Dense(units=hp.Int(f'dense_{i}_unit', min_value=
                                activation='relu'))

    model.add(layers.Dense(1, activation='sigmoid'))

    # Tune the learning rate
    hp_learning_rate = hp.Choice('learning_rate', values=[1e-2, 1e-3, 1e-
    model.compile(optimizer=keras.optimizers.Adam(learning_rate=hp_learni
                  loss=keras.losses.binary_crossentropy,
                  metrics=['accuracy'])
    return model
```

In [ ]:
```
!pip install keras-tuner
```

In [20]:
```
import keras_tuner as kt
tuner = kt.RandomSearch(build_model,
                         objective='val_accuracy',
                         max_trials=5,
                         directory="/content/working_folder/",
                         project_name='Industry-Defect')
```

In [21]:
```
early_stopping = keras.callbacks.EarlyStopping(monitor='val_loss', patien
```

In [22]:
```
tuner.search(train_images, train_labels, epochs=100, validation_data=(val
```

```
Trial 5 Complete [00h 00m 27s]
val_accuracy: 0.8354142904281616

Best val_accuracy So Far: 0.8592508435249329
Total elapsed time: 00h 01m 51s
```

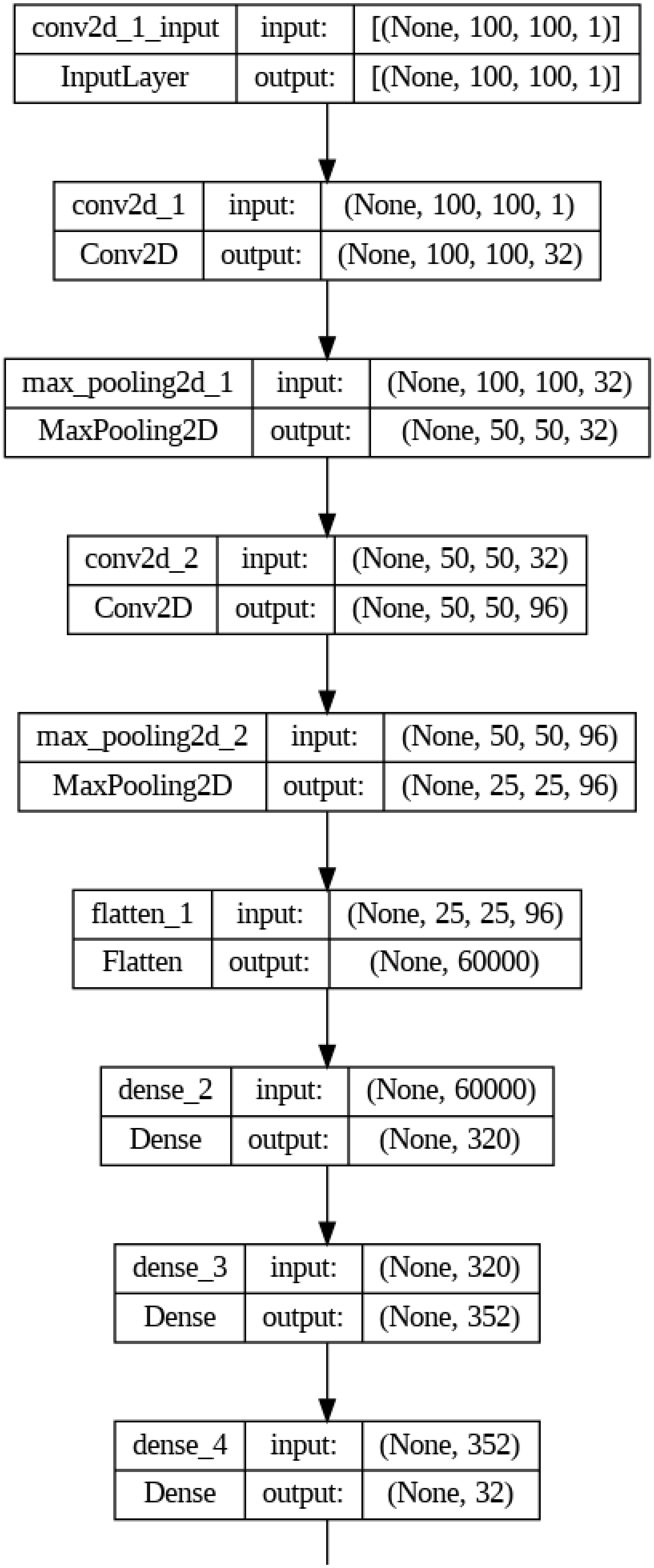
In [23]:
```
# Get the best hyperparameters
best_hps=tuner.get_best_hyperparameters(num_trials=1)[0]

# Build the model with the best hyperparameters
model = tuner.hypermodel.build(best_hps)
```

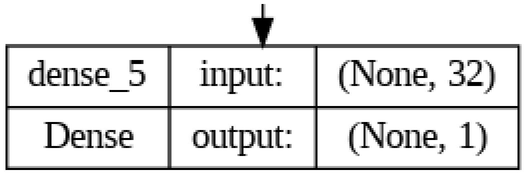
In [24]:
```
model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_1 (Conv2D)           (None, 100, 100, 32)      320

 max_pooling2d_1 (MaxPoolin  (None, 50, 50, 32)        0
 g2D)

 conv2d_2 (Conv2D)           (None, 50, 50, 96)        27744

 max_pooling2d_2 (MaxPoolin  (None, 25, 25, 96)        0
 g2D)

 flatten_1 (Flatten)         (None, 60000)             0

 dense_2 (Dense)             (None, 320)               19200320

 dense_3 (Dense)             (None, 352)               112992

 dense_4 (Dense)             (None, 32)                11296

 dense_5 (Dense)             (None, 1)                 33

=================================================================
Total params: 19352705 (73.82 MB)
Trainable params: 19352705 (73.82 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [25]:
```
plot_model(model, to_file='model_plot.png', show_shapes=True, show_layer_
```

Out[25]:


conv2d_1_input | input: | [(None, 100, 100, 1)]
InputLayer | output: | [(None, 100, 100, 1)]
conv2d_1 | input: | (None, 100, 100, 1)
Conv2D | output: | (None, 100, 100, 32)
max_pooling2d_1 | input: | (None, 100, 100, 32)
MaxPooling2D | output: | (None, 50, 50, 32)
conv2d_2 | input: | (None, 50, 50, 32)
Conv2D | output: | (None, 50, 50, 96)
max_pooling2d_2 | input: | (None, 50, 50, 96)
MaxPooling2D | output: | (None, 25, 25, 96)
flatten_1 | input: | (None, 25, 25, 96)
Flatten | output: | (None, 60000)
dense_2 | input: | (None, 60000)
Dense | output: | (None, 320)
dense_3 | input: | (None, 320)
Dense | output: | (None, 352)
dense_4 | input: | (None, 352)
Dense | output: | (None, 32)



In [26]:

```
# Train the model
history = model.fit(train_images, train_labels, epochs=100, validation_da
```

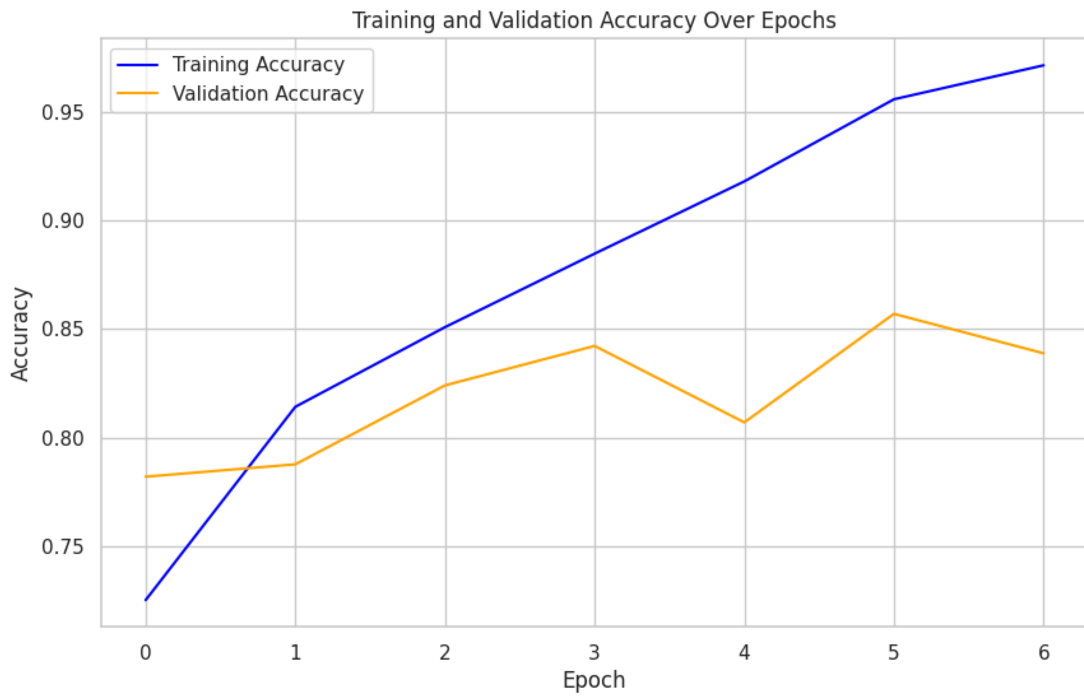
```
Epoch 1/100
110/110 [==============================] - 4s 23ms/step - loss: 0.5483
- accuracy: 0.7253 - val_loss: 0.4194 - val_accuracy: 0.7821
Epoch 2/100
110/110 [==============================] - 2s 20ms/step - loss: 0.3692
- accuracy: 0.8142 - val_loss: 0.4162 - val_accuracy: 0.7877
Epoch 3/100
110/110 [==============================] - 2s 21ms/step - loss: 0.3052
- accuracy: 0.8509 - val_loss: 0.4067 - val_accuracy: 0.8241
Epoch 4/100
110/110 [==============================] - 2s 19ms/step - loss: 0.2377
- accuracy: 0.8847 - val_loss: 0.3819 - val_accuracy: 0.8422
Epoch 5/100
110/110 [==============================] - 2s 18ms/step - loss: 0.1780
- accuracy: 0.9179 - val_loss: 0.6123 - val_accuracy: 0.8070
Epoch 6/100
110/110 [==============================] - 2s 19ms/step - loss: 0.1129
- accuracy: 0.9557 - val_loss: 0.4874 - val_accuracy: 0.8570
Epoch 7/100
110/110 [==============================] - 2s 20ms/step - loss: 0.0753
- accuracy: 0.9713 - val_loss: 0.4937 - val_accuracy: 0.8388
```

In [27]:

```
warnings.filterwarnings("ignore", message="use_inf_as_na option is deprec

# Set Seaborn style
sns.set(style="whitegrid")

# Get the training history
train_loss = history.history['loss']
val_loss = history.history['val_loss']
train_accuracy = history.history['accuracy']
val_accuracy = history.history['val_accuracy']
epochs = range(1, len(train_loss) + 1)
```

In [28]:

```
# Plot training and validation accuracy
plt.figure(figsize=(10, 6))
sns.set(style="whitegrid")
plt.plot(history.history['accuracy'], label='Training Accuracy', color='b
plt.plot(history.history['val_accuracy'], label='Validation Accuracy', co
plt.title('Training and Validation Accuracy Over Epochs')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



In [29]:

```
# Plot training and validation accuracy
plt.figure(figsize=(10, 6))
sns.set(style="whitegrid")
plt.plot(history.history['loss'], label='Training Accuracy', color='blue
plt.plot(history.history['val_loss'], label='Validation Accuracy', color=
plt.title('Training and Validation Loss Over Epochs')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.show()
```

In [30]:

```
# Evaluate the model on the validation data
evaluation = model.evaluate(val_images, val_labels)

# Print the evaluation results
print("Evaluation Loss:", evaluation[0])
print("Evaluation Accuracy:", evaluation[1])
```

```
28/28 [==============================] - 0s 8ms/step - loss: 0.3819 - a
ccuracy: 0.8422
Evaluation Loss: 0.3818999230861664
Evaluation Accuracy: 0.8422247171401978
```

In [31]:
```
predictions = model.predict(val_images)

for i in range(min(5, len(val_images))):
    print("Predicted class probabilities for image", i+1, ":", predictio
```

```
28/28 [==============================] - 0s 7ms/step
Predicted class probabilities for image 1 : [0.09564178]
Predicted class probabilities for image 2 : [3.393664e-05]
Predicted class probabilities for image 3 : [0.14038165]
Predicted class probabilities for image 4 : [0.3592586]
Predicted class probabilities for image 5 : [4.5888664e-06]
```

In [32]:
```
predicted_labels = (predictions > 0.5).astype("int32")

for i in range(min(5, len(val_images))):
    print("Predicted label for image", i+1, ":", predicted_labels[i])
```

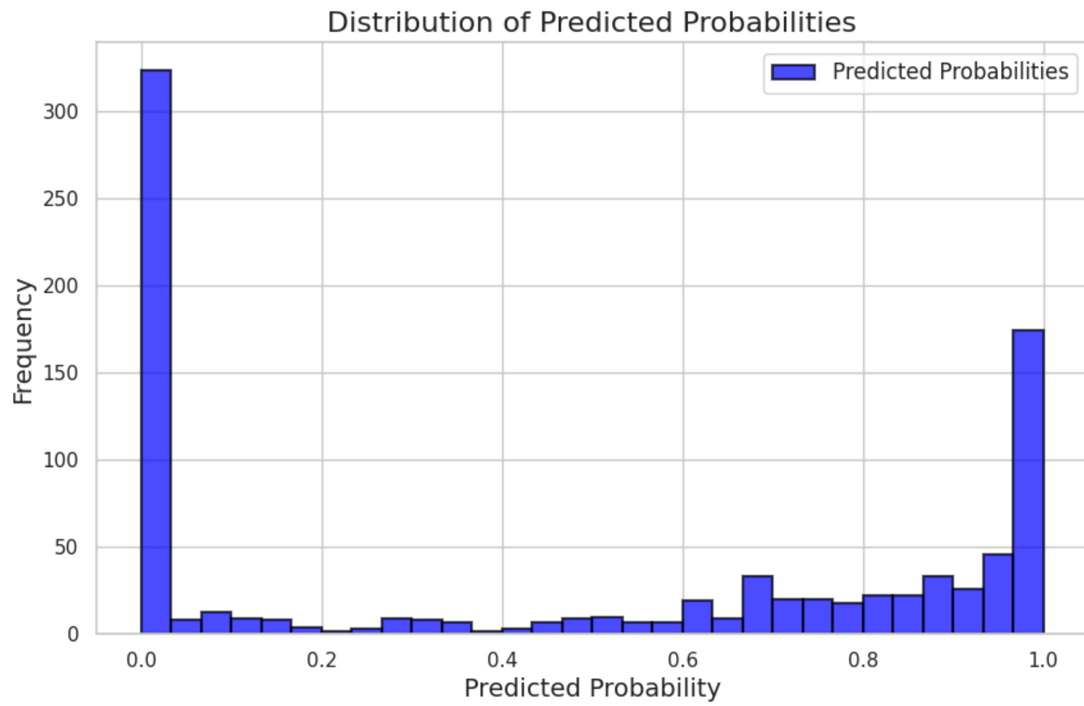
```
Predicted label for image 1 : [0]
Predicted label for image 2 : [0]
Predicted label for image 3 : [0]
Predicted label for image 4 : [0]
Predicted label for image 5 : [0]
```

In [33]:
```
class_mapping = {0: "Defected", 1: "Non-Defected"}
predictions = model.predict(val_images)
predicted_labels = (predictions > 0.5).astype("int32")

actual_labels = [class_mapping[label] for label in val_labels]

additional_data = {
    "Actual Class Name": actual_labels,
    "Predicted Class Name": [class_mapping[label] for label in predicted_
}

data = {
    "Predicted Probabilities": predictions.flatten(),
    "Actual Labels": val_labels,
    "Predicted Labels": predicted_labels.flatten(),
    **additional_data
}

df = pd.DataFrame(data)
```

```
28/28 [==============================] - 0s 9ms/step
```

In [34]:

```
def plot_predicted_probabilities(predicted_probabilities):
    plt.figure(figsize=(10, 6))
    plt.hist(predicted_probabilities, bins=30, alpha=0.7, color='blue', e
    plt.xlabel('Predicted Probability', fontsize=14)
    plt.ylabel('Frequency', fontsize=14)
    plt.title('Distribution of Predicted Probabilities', fontsize=16)
    plt.legend(fontsize=12)
    plt.grid(True)
    plt.show()

plot_predicted_probabilities(predictions)
```



In [35]:
```
styled_df = df.sample(30).style.set_properties(**{'text-align': 'center'}
                              .set_caption("Predictions and Actual Labels'
                              .format({"Predicted Probabilities": "{:.4f}'
                              .background_gradient(cmap='viridis', subset=
styled_df
```

Out[35]:

Predictions and Actual Labels

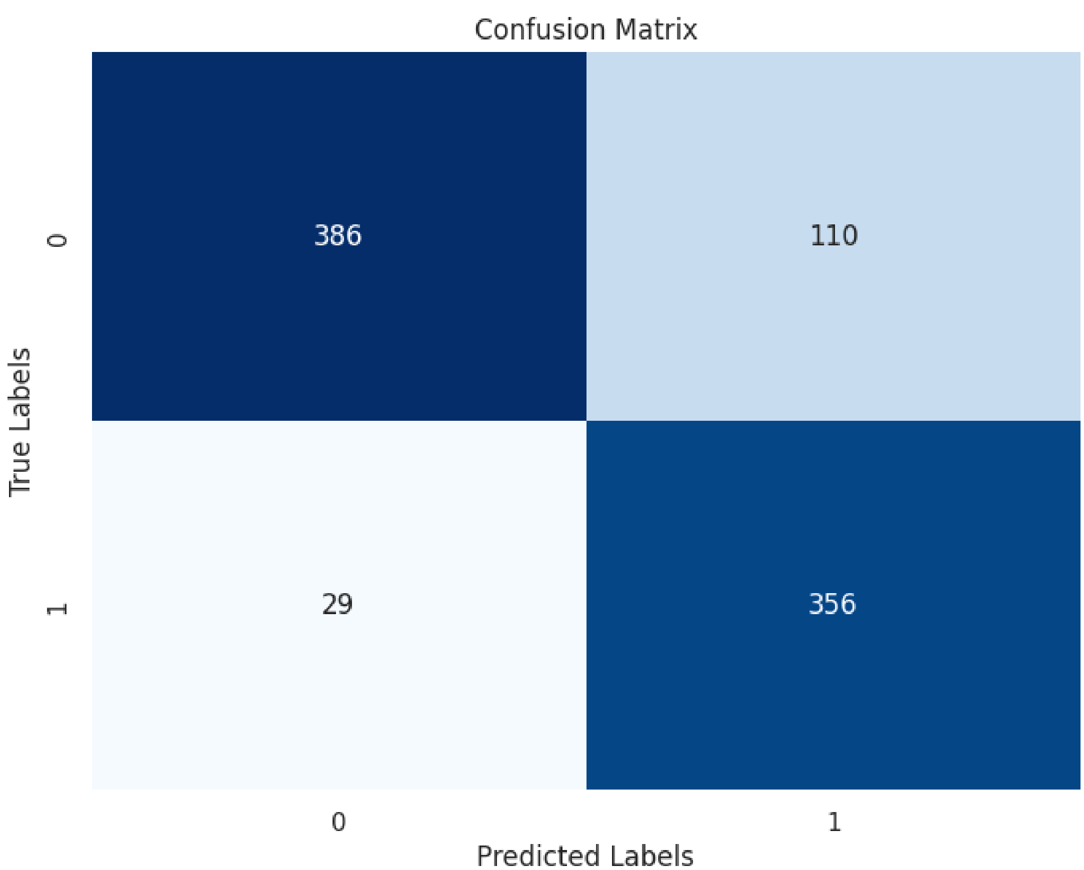
	Predicted Probabilities	Actual Labels	Predicted Labels	Actual Class Name	Predicted Class Name
640	0.9937	1	1	Non-Defected	Non-Defected
726	0.0004	0	0	Defected	Defected
356	0.4608	0	0	Defected	Defected
419	0.8998	1	1	Non-Defected	Non-Defected
179	0.8014	0	1	Defected	Non-Defected
503	0.0033	0	0	Defected	Defected
783	0.8186	1	1	Non-Defected	Non-Defected
596	0.3214	1	0	Non-Defected	Defected
34	0.9592	0	1	Defected	Non-Defected
45	0.5256	1	1	Non-Defected	Non-Defected
243	0.6862	1	1	Non-Defected	Non-Defected
562	0.8143	0	1	Defected	Non-Defected
467	0.9987	1	1	Non-Defected	Non-Defected
249	0.9575	1	1	Non-Defected	Non-Defected
263	0.0000	0	0	Defected	Defected
370	0.0000	0	0	Defected	Defected
53	0.0059	0	0	Defected	Defected
580	0.0000	0	0	Defected	Defected
379	0.0000	0	0	Defected	Defected
790	0.8093	1	1	Non-Defected	Non-Defected
341	0.7752	1	1	Non-Defected	Non-Defected
859	0.8824	1	1	Non-Defected	Non-Defected
82	0.7503	1	1	Non-Defected	Non-Defected
442	0.6571	0	1	Defected	Non-Defected
727	0.9804	1	1	Non-Defected	Non-Defected
397	0.0000	0	0	Defected	Defected
302	0.6904	1	1	Non-Defected	Non-Defected
862	0.4328	0	0	Defected	Defected
313	0.0000	0	0	Defected	Defected
494	0.1643	0	0	Defected	Defected

In [36]:

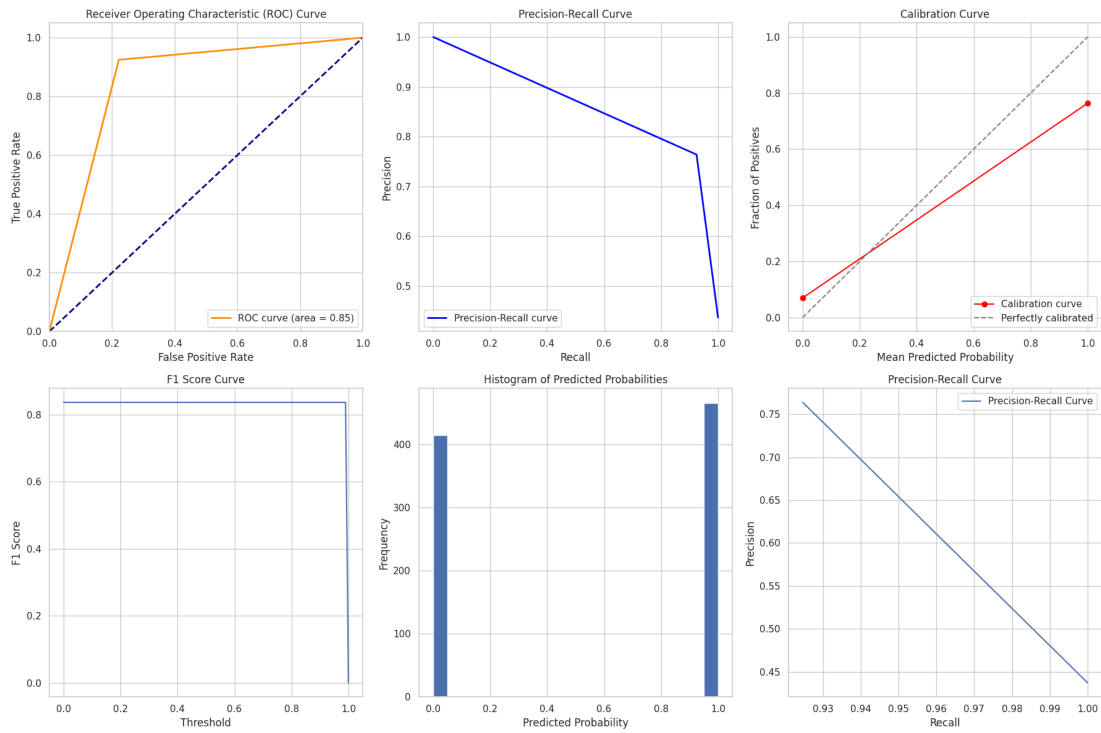
```
print("========================================================================
# Compute accuracy
accuracy = accuracy_score(val_labels, predicted_labels)
print("Accuracy:", accuracy)
print("========================================================================
# Compute precision
precision = precision_score(val_labels, predicted_labels)
print("Precision:", precision)
print("========================================================================
# Compute recall
recall = recall_score(val_labels, predicted_labels)
print("Recall:", recall)
print("========================================================================
# Compute F1-score
f1 = f1_score(val_labels, predicted_labels)
print("F1-score:", f1)
print("========================================================================
# Compute ROC AUC score
roc_auc = roc_auc_score(val_labels, predicted_labels)
print("ROC AUC score:", roc_auc)
# Generate classification report
print("========================================================================
print("Classification Report:")
print(classification_report(val_labels, predicted_labels))
print("========================================================================
# Generate confusion matrix
print("Confusion Matrix:")
conf_matrix = confusion_matrix(val_labels, predicted_labels)
# Plot the heatmap
plt.figure(figsize=(8, 6))
sns.heatmap(conf_matrix, annot=True, fmt="d", cmap="Blues", cbar=False)
plt.xlabel("Predicted Labels")
plt.ylabel("True Labels")
plt.title("Confusion Matrix")
plt.show()
print("========================================================================
# Set up subplots with 2 rows and 3 columns
fig, axes = plt.subplots(2, 3, figsize=(18, 12))

# Compute ROC curve
fpr, tpr, _ = roc_curve(val_labels, predicted_labels)
roc_auc = auc(fpr, tpr)

# Plot ROC curve
axes[0, 0].plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (are
axes[0, 0].plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
axes[0, 0].set_xlim([0.0, 1.0])
axes[0, 0].set_ylim([0.0, 1.05])
axes[0, 0].set_xlabel('False Positive Rate')
axes[0, 0].set_ylabel('True Positive Rate')
axes[0, 0].set_title('Receiver Operating Characteristic (ROC) Curve')
axes[0, 0].legend(loc="lower right")

# Plot precision-recall curve
precision, recall, _ = precision_recall_curve(val_labels, predicted_label
axes[0, 1].plot(recall, precision, color='blue', lw=2, label='Precision-R
axes[0, 1].set_xlabel('Recall')
```

```
axes[0, 1].set_ylabel('Precision')
axes[0, 1].set_title('Precision-Recall Curve')
axes[0, 1].legend(loc="lower left")

# Plot calibration curve
prob_true, prob_pred = calibration_curve(val_labels, predicted_labels, n_
axes[0, 2].plot(prob_pred, prob_true, marker='o', color='red', label='Ca
axes[0, 2].plot([0, 1], [0, 1], linestyle='--', color='gray', label='Per
axes[0, 2].set_xlabel('Mean Predicted Probability')
axes[0, 2].set_ylabel('Fraction of Positives')
axes[0, 2].set_title('Calibration Curve')
axes[0, 2].legend(loc="lower right")

# Plot F1 score curve
thresholds = np.linspace(0, 1, 100)
f1_scores = [f1_score(val_labels, (predicted_labels > t).astype(int)) for
axes[1, 0].plot(thresholds, f1_scores)
axes[1, 0].set_xlabel('Threshold')
axes[1, 0].set_ylabel('F1 Score')
axes[1, 0].set_title('F1 Score Curve')

# Plot histogram of predicted probabilities
axes[1, 1].hist(predicted_labels, bins=20)
axes[1, 1].set_xlabel('Predicted Probability')
axes[1, 1].set_ylabel('Frequency')
axes[1, 1].set_title('Histogram of Predicted Probabilities')

# Show precision-recall curve
axes[1, 2].plot(recall[:-1], precision[:-1], label="Precision-Recall Curv
axes[1, 2].set_xlabel('Recall')
axes[1, 2].set_ylabel('Precision')
axes[1, 2].set_title('Precision-Recall Curve')
axes[1, 2].legend()

# Adjust layout
plt.tight_layout()
plt.show()
```

```
===============================================================================
Accuracy: 0.8422247446083996
===============================================================================
Precision: 0.7639484978540773
===============================================================================
Recall: 0.9246753246753247
===============================================================================
F1-score: 0.8366627497062279
===============================================================================
ROC AUC score: 0.8514505655634687
===============================================================================
Classification Report:
              precision    recall  f1-score   support

           0       0.93      0.78      0.85       496
           1       0.76      0.92      0.84       385

    accuracy                           0.84       881
   macro avg       0.85      0.85      0.84       881
weighted avg       0.86      0.84      0.84       881

===============================================================================
Confusion Matrix:
```



```
===========================================================================
===========
```



In [37]:

```python
model.save('/content/working_folder/saved_model.h5')
model.save('/content/working_folder/model.h5')
model_json = model.to_json()
with open("/content/working_folder/model.json", "w") as json_file:
    json_file.write(model_json)

model.save_weights("/content/working_folder/model_weights.weights.h5")
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/engine/training.py:31
03: UserWarning: You are saving your model as an HDF5 file via `model.s
ave()`. This file format is considered legacy. We recommend using inste
ad the native Keras format, e.g. `model.save('my_model.keras')`.
  saving_api.save_model(
```

In [40]:

```
from PIL import Image
import numpy as np

def load_and_preprocess_image(image_path, target_size=(100, 100), graysca
    # Load image from path
    image = Image.open(image_path)
    # Resize image to target size
    image_resized = image.resize(target_size)
    # Convert image to grayscale if specified
    if grayscale:
        image_resized = image_resized.convert('L')
    # Convert image to numpy array
    image_array = np.array(image_resized)
    # Reshape array to match model's input shape
    image_array = np.expand_dims(image_array, axis=0)
    # Normalize pixel values to range [0, 1]
    image_array = image_array / 255.0
    return image_array

def predict_single_image(model, image_path, threshold=0.5):
    img = load_and_preprocess_image(image_path)
    prediction = model.predict(img)
    class_name = "Defected" if prediction < threshold else "Non-Defected'
    return img, class_name, prediction
def plot_image_with_prediction(image, class_name, prediction):
    plt.imshow(image.squeeze(), cmap='gray')
    plt.axis('off')
    plt.title(f'Prediction: {class_name} (Probability: {prediction})')
    plt.show()

image_path = '/content/Industrial-Equipment/Defected/bearingfailures-1.pr
img, class_name, prediction = predict_single_image(model, image_path)


plot_image_with_prediction(img, class_name, prediction)
```

```
1/1 [==============================] - 0s 17ms/step
```

Prediction: Defected (Probability: [[0.06577594]])

In [41]:

```
image_path = '/content/Industrial-Equipment/Non-Defected/baring.png'
img, class_name, prediction = predict_single_image(model, image_path)


plot_image_with_prediction(img, class_name, prediction)
```

```
1/1 [==============================] - 0s 26ms/step
```

Prediction: Non-Defected (Probability: [[0.9971009]])

In [ ]: