

# Geometric Verification of Gears Using Image Processing Technique

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## ABSTRACT

*Gear is a widely used mechanical component whose primary use is to transmit power from one shaft to other. These gears are of many types namely spur gear, helical gears, worm gears Rack gear etc. Gear drives are used to various kinds of machines like automobiles, metal cutting tools, material handling equipment, rolling mills, marine power plants etc. The friction and other losses in this type of power transmission equipment is comparatively very low. In this work we use a software called "MATLAB" to determine gear parameters. MATLAB is extensively used for scientific & research purposes. It is accurate & also having a number of built in functions which makes it versatile. In the industries that require gears the filtering and classification of gears is very important and is done by human labour, precisely human labour is limited to its way of working and the time, cost required. Classification can be done with the use of imaging devices, Cameras and scanners with developing an algorithm that describes what to accept and reject.*

## 1. INTRODUCTION

A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine.

Gear drives or gearboxes are used in various kinds of machines mainly contributing to machines in automobiles, metal cutting tools, material handling equipment, rolling mills, marine power plants etc. The friction and other losses in this type of power transmission equipment is comparatively very low. Manufacturing of gears are done by net shape moulding which includes either powder metallurgy or plastic. Many gears are done when they leave the mould, but powdered metal gears require sintering or investment castings require gear cutting or other machining to finish them. The most common form of gear cutting is hobbing, but gear shaping, milling, and broaching also exist. It is necessary to check each and every gear so that the dimensions of gear produced is

under tolerance limit or not. To do so we have made an experimental setup which will ease out the quality checking of gears done by human force in any small industries.

In this work we have used a software called “MATLAB” to determine gear parameters. MATLAB is extensively used for scientific as well as research purposes. It is accurate and having a number of built in functions which makes it versatile. The programming done here is user friendly, when executed it asks for the inputs and performs the necessary design calculations, giving necessary outputs.

In this world of fast paced computation where resources with time and money/capital are very important the activities in manufacturing and processing industries are day by day being performed by computers, algorithms and computing agents replacing human or semi-human intervention. Here in the industries that require gears the filtering and classification of gears is very important and is done by human labour, precisely human labour is limited to its way of working and the time, cost required. Classification can be done with the use of imaging devices, Cameras and scanners with developing an algorithm that describes what to accept and reject.

Computer science image processing technology is gradually becoming a part of our daily life as it continues to get excellent results while promoting the technological advancement and development. As the key role of technology that presents gear size and measurement and guides to do research and develop more advanced computer technologies, such as DSP (digital signal processing) technology, and DIP (digital image processing) technology. We will measure the image object features easily by using these technologies.

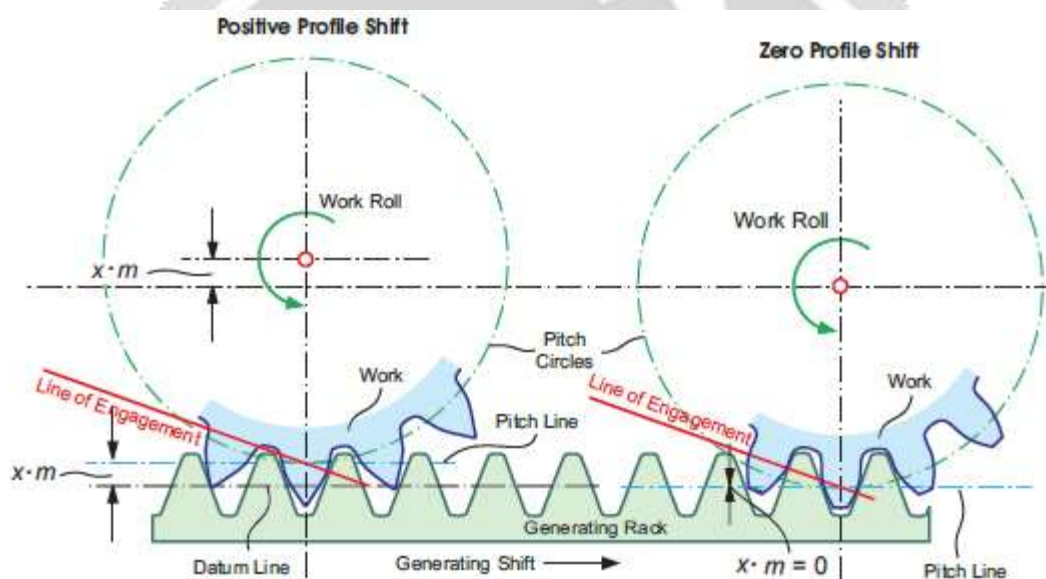


Figure 1 Generating principle of involute gearing.

The measurement is essential task to limit the gear at specific size. By using image processing the fundamental work has been carried out to measure following things which are its most important features.

- To calculate outer diameter (Addendum diameter).
- To calculate inner diameter (Dedendum diameter).
- To count the number of teeth in gear image object.
- To calculate tooth height.
- To calculate PCD of gear.
- To calculate module of gear

In this regard we have converted the original gear image object into grayscale, and then grey scale of original gear image goes from steps to count the teeth of the gear. It means by using programming code, we measure the gear teeth in respect of teeth counted through image processing.

The gears are used in machinery and we know that gear transmissions can be used to alter a machine motion property, although it ensures the modification in the motion through linear and rotary development of gear. It is an old technology and gear transmission was invented having complexity.

In light of gear teeth count and to measure the parameter of the gear object complexity of transmission. The geometry is used to measure the gear transmissions for commercial vehicles. Here it presents a technical exposure of gear basics. On the other hand, for appropriate use of gear and design of gear that is necessary to have a minimum know how about the gear.

The research shows that special tooth callipers could be used to measure the Gear teeth. There are different types of gears in market according to need that can be used. It means gears have different profiles. Hence these are in different size and having odd or even number of teeth. The gear may be odd number of teeth profile and also it may be even number of teeth profile. Hence the gear parameters measurement will be more simple, fast and less time consuming.

## 2. LITERATURE REVIEW

[1] Haque Nawaz and Himat Ali did a research on Gear Measurement using MATLAB that has been carried out by focusing two features of gear image object. The gear Area calculated and teeth counted by using image processing in the MATLAB tool. This paper having the five gear image objects which are processed from developed MATLAB code, all gear image objects found having different value of area and varying teeth with another. These have been measured through the same developed MATLAB code. In this paper each experimental work figure of different gear objects measured with the help of MATLAB tool by using image processing.

The measurement is essential task to limit the gear at specific size. By using image processing the fundamental work has been carried out to measure two things which are its most important features.

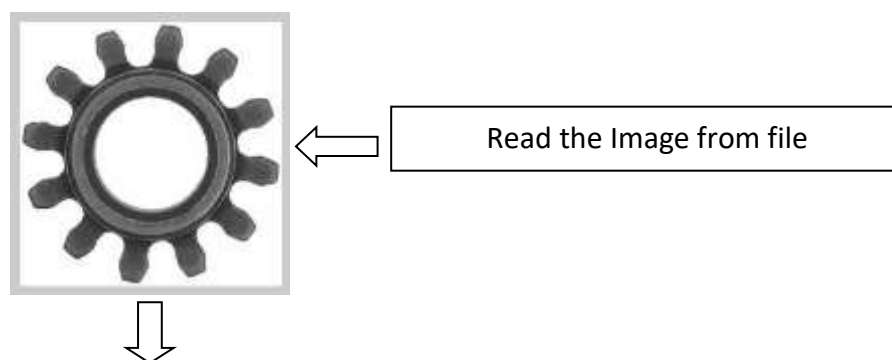
- a. To measure the Area of the gear image object
- b. To count the number of teeth in gear image object.

[2] Cheng Pengfei and Feng Changyong Henan research on MATLAB is a kind of high-level computer language, it has a powerful data processing ability that has a wide range of applications in digital image processing. This paper takes advantage of MATLAB image processing for gear defect detection. Gear shows different defect forms during the using process. Corrosive pitting and attrition are the most important types. Different defect forms will create different image characteristics. This research can effectively distinguish and decide the defect type through these image characteristics.

[3] Zhang Jing's research on the method is to gain the image of tooth profile and contact spot by using digital camera, to reconstruct diametrically the contact spot of hypoid gear through the computer graphics techniques, to make sure of the relative position on the edges between tooth surface and spot, and to evaluate the size, position and direction of contact spot, in order to provide foundation for in-line inspection of gear.

## 3. PROPOSED METHOD

In figure, the original gear image is read by tool and converted into grayscale then threshold it, after that the area of gear image calculated and highlighted the interested region for to count the teeth, then teeth of the gear counted as shown in below steps.



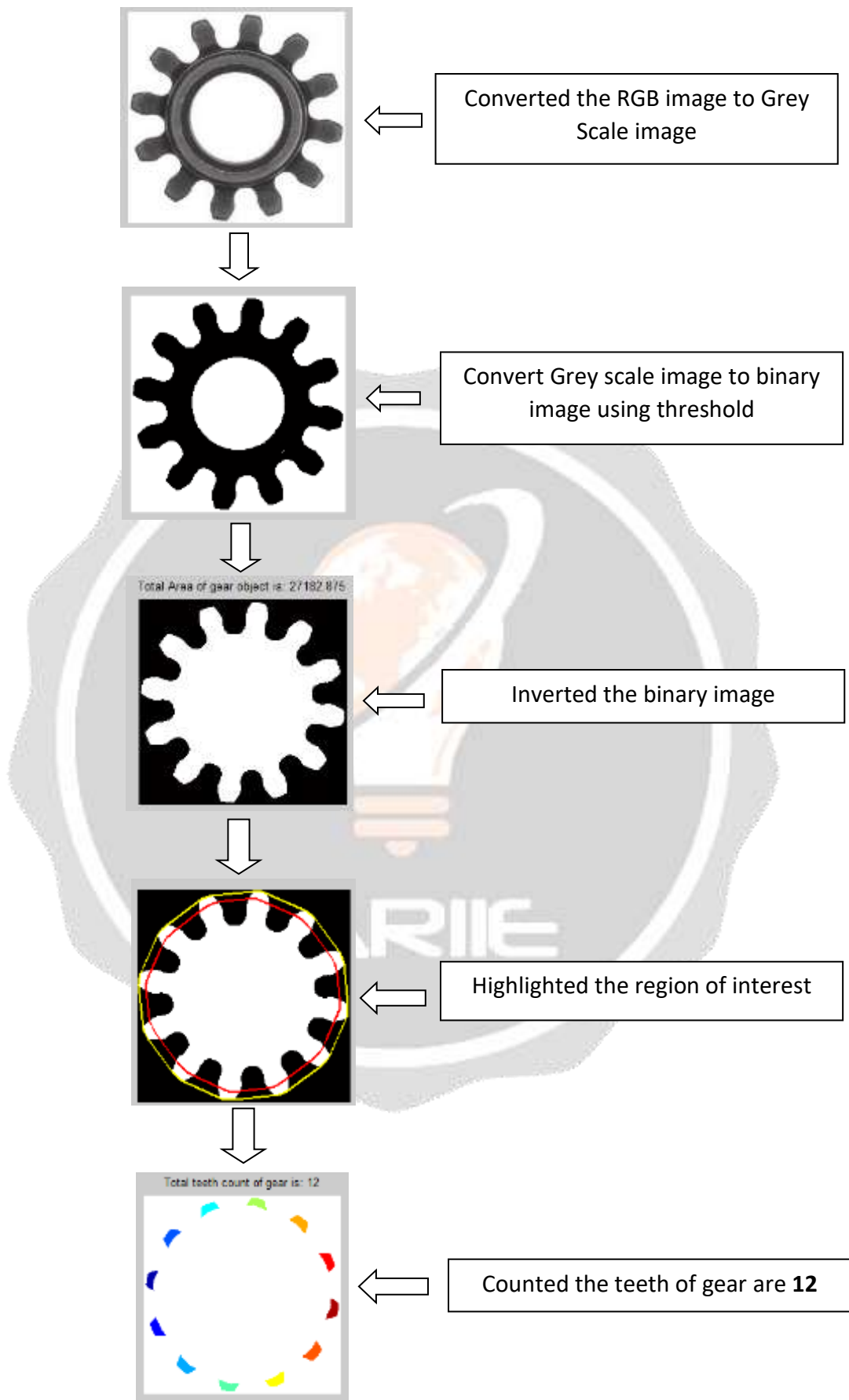


Figure 2 Methodology of Image Processing

### 3.1. Image Processing Algorithm:

```
function main
%% input image
clc;
closeall;
clear all;
vid = videoinput('winvideo',1);
preview(vid);
fori = 1:5
snapshot = getsnapshot(vid);
imagesc(snapshot);
end
imwrite(snapshot,'E:\Gear_Parameter_detection_Final.jpg');
inp = imread('E:\Gear_Parameter_detection_Final.jpg');
if size(inp,3) > 1
inp = rgb2gray(inp);
end
figure,
subplot(1,2,1);
imshow(inp,[]);
title('input image');
%% preprocessing
dimg = medianfilter(inp);
subplot(1,2,2);
imshow(dimg,[]);
title('denoised image');
%% segmentation
seg_f = otsu(dimg);
figure,
subplot(1,2,1);
imshow(seg_f);
title('Otsu image');
```



```

[imgcnt] = bwlabel(double(seg_f));
stats = regionprops(img,'all');
fori = 1:cnt
ar = stats(i).Area;
if ar <= 500
img(img==i)=0;
cnt = cnt-1;
end
end
subplot(1,2,2);
imshow(img);
title('segmented image');
%% cropping
[imgcnt] = bwlabel(double(img));
fori = 1:cnt
    s = regionprops(img, 'BoundingBox');
rectangle('Position', s(1).BoundingBox,'EdgeColor','r');
end
xmin = round(s(1).BoundingBox(1,1));xmax = round(s(1).BoundingBox(1,1)+s(1).BoundingBox(1,3));
ymin = round(s(1).BoundingBox(1,2));ymax = round(s(1).BoundingBox(1,2)+s(1).BoundingBox(1,4));
out = img(ymin:ymax,xmin:xmax);
figure,
imshow(out,[]);
hold on
stats = regionprops(out,'all');
cen = round(stats.Centroid);
plot(cen(2),cen(1),'r*');
title('cropped image with centroid');
cnt = 0;
fori = cen(2):size(out,1);
if out(i,cen(1))==0
cnt = cnt+1;

```



```

end
end
A = out;
% determine convex hull
B = regionprops(double(A), 'ConvexImage', 'BoundingBox');
% generate mask image
C = zeros(size(A));
C(floor(B.BoundingBox(2))+(1:size(B.ConvexImage,1)),floor(B.BoundingBox(1))+(1:size(B.ConvexImage,2)))=B.ConvexImage;
C = bwmorph(C, 'erode', 2);
% generate teeth image
D = A;
D(C) = 0;
% count teeth
D = bwfill(D,'holes');
[D cnt] = bwlabel(D);
stats = regionprops(D,'all');
for i = 1:cnt
ar = stats(i).Area;
if ar <= 7
D(D==i)=0;
cnt = cnt-1;
end
end
[imgNumTeeth] = bwlabel(D);
%disp(sprintf('Inner Diameter value: %d',cnt));
cnt1=5*cnt;
%out11=2*(size(out,2));
%out11=50+out11;
disp(sprintf('InnerDiameter value:%d mm',(2*(2*cnt1)/10)));
%disp(sprintf('Outer Diameter value: %d',out11));
disp(sprintf('Outer Diameter value: %d mm',floor(round((3.2*size(out,2)/10)))));
disp(sprintf('No of Teeth: %d',NumTeeth));

```

```

disp(sprintf('Tooth Height: %d mm',floor(round((3.2*size(out,2))-(2*cnt1))/100));
cnt2=((6*NumTeeth)/3.1415);
disp(sprintf('PCD: %d mm',cnt2));
cnt3=(cnt2/NumTeeth);
disp(sprintf('Module: %d mm',cnt3));
%if NumTeeth>= 12 &&floor(round(3.2*size(out,2)))>= 200
ifNumTeeth>= 12 && 2*(2*cnt1) >= 200
    s = serial('COM4');
s.baudrate=9600;
fopen(s);
fprintf(s,'K');
fclose(s);
else
    s = serial('COM4');
s.baudrate=9600;
fopen(s);
fprintf(s,'F');
fclose(s);
end
end
functionimg = medianfilter(inp)
% Padarray
c=padarray(inp,[1,1],0,'both');
[R1 C1] = size(c);
%Median filter
fori=2:R1-1
for j=2:C1-1
    temp = [c(i-1,j-1) c(i-1,j) c(i-1,j+1);c(i,j-1) c(i,j) c(i,j+1);c(i+1,j-1) c(i+1,j) c(i+1,j+1)];
    d = temp(:);
    e = sort(d);
    med = e(5,1);

```



dimg(i-1,j-1) = med;

end

end

end

### 3.2. CAD MODEL OF SET-UP

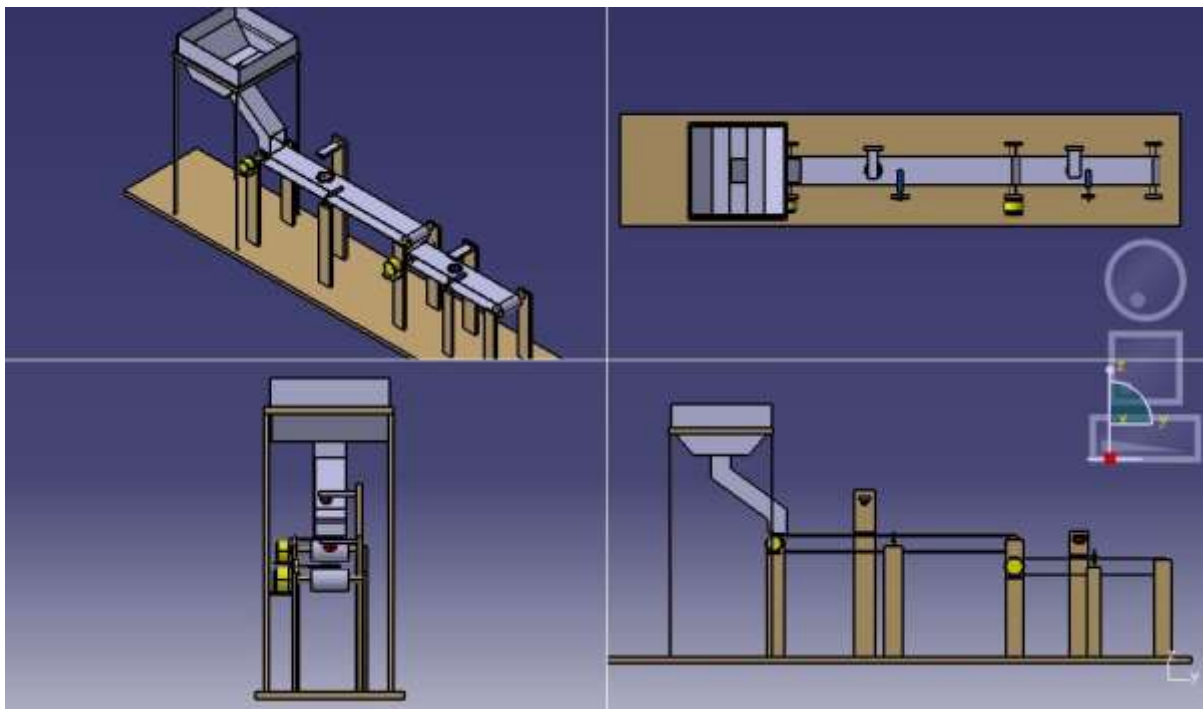


Figure 3 CAD MODEL

### 4. EXPERIMENTAL SET-UP

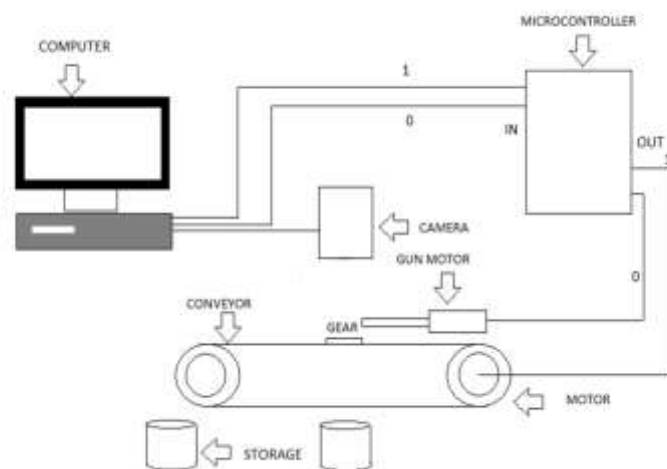


Figure 4 Experimental Setup

- i) The gear parameters are calculated and teeth are counted by using image processing in the MATLAB programming software.
- ii) Computer is the main unit of the project. The I/O devices are connected across the parallel port of computer.
- iii) Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or, a set of characteristics or parameters related to the image.
- iv) Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.
- v) Two rollers are mounted according to the required distance, the belt is mounted on the rollers on which the materials are placed.
- vi) The rollers shaft is coupled with the Motor drive hence when power is supplied to the motor rollers rotate with a certain time delay according to the Motor drive and the belt moves along the rollers. Thus, material handling is carried out.
- vii) With help of the Motor drive the time delay can be achieved.
- viii) Initially Motor conveyor is stationary,
- ix) Gear is kept on conveyor belt and the gear image is captured by the camera which is fixed at the top of the setup.
- x) The captured image is sent to the computer
- xi) MATLAB algorithm read image and processes with the help of image processing and results are displayed on command window of MATLAB.
- xii) Selected piece (right gear) is collected in a separate tray and the rejected piece (wrong gear) is collected in another tray with the help of dc gun motor.
- xiii) A pushing rod is mounted in front of the dc gun with help of hinge and spring arrangement. When the dc gun extends it pushes the plate hence the work piece in front is also pushed and collected in the tray. When the dc gun is retracted the plate also comes back to its position with help of spring.

## 5. FUTURE SCOPE

- Applicable in nut, gear manufacturing industries.
- Applicable in Quality Control departments.
- Industrial applications such as production inspection, sorting.
- Automatic character recognition such as zip code, bar code, license plate recognition etc.
- Computerized photography.
- Space image recognition.
- Ultrasonic sensor can be used for detecting internal flaws.

## 6. CONCLUSION

This paper proposes a pre-processing method for the original deviations of tooth profiles according to the characteristics of the outliers from the tooth profiles and the features of the **involute gear profile error detector** model and establishes a model of outlier detection and correction for the deviations of tooth profiles. The conclusions are as follows.

- 1 The inner and outer diameter of the gear and also tooth profile have been checked.
- 2 The involute gear profile error detector model automatically detects the outliers of the deviations obtained from tooth profiles, so it improves the measurement precision of the tooth profiles.
- 3 The analytical outputs and the tooth profile for the Spur Gear were obtained by using MATLAB software and the given outputs also suggest that the designed Spur Gear was either safe or unsafe.
- 4 In fabricating this project, involute profile error checking machine. The project has been properly pre-planned and cost estimated to be completed within the time limits, with less cost to an efficient working condition.
- 5 Finally, we have this project completed successfully at a lower cost using available materials. This machine serves all small-scale gear manufacturing industries that have so far been deprived of getting the benefit of the conventional involute checkers due to its high cost and complexity.
- 6 By measuring the involute profile error and making corrective measures, the gear manufacturers can deliver precision gears, which render good power and torque transmission at constant velocities. It is a

real boon for all of them who strived to achieve perfection in manufacturing high precision spur gear at an unimaginable cheaper cost without any compromise for accuracy.

## 7. REFERENCES

- [1] Haque Nawaz, Himat Ali, "Gear Measurement Using Image Processing in MATLAB", 'International Journal of Innovative Technology and Exploring Engineering (IJITEE)', 2014, Volume-3, PP 43-47.
- [2] Cheng Pengfei and Feng Changyong Henan, "Characteristic Value Extraction of Gear Defect Based on Image Processing", 'Journal of Multimedia', 2013, Volume- 8, PP 198-205.
- [3] Zhang Jing, "The Research on the Application to Digital Image Technology in Hypoid Gear Contact Zone Detection", 'Journal of Computers', 2011, Volume-. 6, PP 1519-1525.

