

# Measurement of warpage of injection moulded Plastic components using image processing

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**Abstract:** The present work focuses on measurement of warpage of injection moulded plastic components through image processing technique. For this, a fixture has been prepared to hold digital camera in a fixed plane to capture the images of plastic components which help to get more accurate warpage results using image processing. This work has been done for measurement of warpage of Forward and Reverse lever (FR lever). The images of components are captured by using high resolution digital camera which are fixed in the fixture. The high resolution captured images of FR lever, are processed using MATLAB-Image Processing Tool and warpage is measured by comparing with image of standard component.

**Keywords:** Injection moulded plastic components, Warpage, FR lever, Image processing

## I. INTRODUCTION

Injection molding is used to produce thin-walled plastic parts for a wide variety of applications, one of the most common being plastic housings. Warpage can be defined as a dimensional distortion in a moulded product after it is ejected from the mould at the end of the injection moulding process. Warpage is a form of distortion that can occur in some materials, such as wood or plastic. This usually results from uneven stresses that can be internal or external to the material being warped. Warping can also be caused due to non-uniform mould temperatures or cooling rates as shown in Fig 1.

Measurement of warpage is of great concern in injection moulding operations because warpage affects the surface qualities and dimensional accuracy of the moulded components. Several techniques have been developed for monitoring of warpage. The applications of image analysis (vision systems) have proved to be very efficient for warpage detection. In the last decade, many researches are trying to eliminate the costly trial-and-error process.

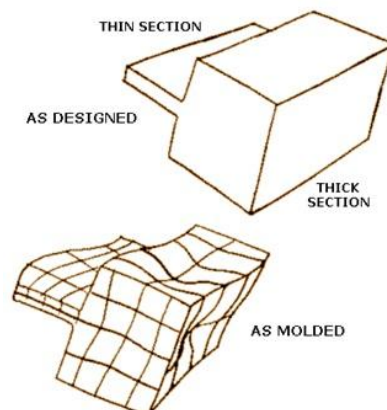


Fig 1 Warpage caused by non uniform wall thickness

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**Huang** pointed out that the most influential parameter on warpage was packing pressure, and the warpage was only slightly influenced by the gate dimension and the filling time in thin shell injection moulding; they also discussed the optimum values of the processing parameters to decrease the warpage[1]. **Ozcelik** also found that packing pressure was the most influential parameter on the warpage of PC/ABS material by using Taguchi experimental method and CAE software Mold flow Plastic Insight 4.0[2]. The warpage analysis was performed in terms of melt temperature, mould temperature, packing pressure and packing time. **Kong** studied the effect of several important parameters, including processing parameters, package geometry and materials on the warpage. Results indicated that the warpage can be reduced significantly with a lower moulding temperature and a smaller coefficient of thermal expansion[3]. **Kurtaran** chose a bus ceiling lamp base as the research model. The optimum values of processing parameters to reach minimum warpage were found by using the neural network model and genetic algorithm[4]. **Gao** developed an effective optimization method by using the Kriging model to minimize the warpage in PIM. The experimental method has been widely used by many researchers for optimization of injection moulding process to control defects[5].

**Patel and Mallick** used firstorder response surface methodology (RSM)-based on DOE to reduce defects (the sink index was chosen as optimum response) in plastics injection moulding[6]. **Mathivanan and Parthasarathy** designed a simple generic model to investigate the effects of parameters on the defect (sink mark depth)[7,8]. In their studies, the most influential parameter was screened and a nonlinear mathematical model was established to predict the sink mark depth. **Wang** in their study used Taguchi experimental design to optimize the processing parameters during injection moulding to minimize the warpage of the front panel of a large LCD TV[9]. Literature review reveals that, different researchers followed their own methods for the measurement of warpage. Objective of the present work is measurement of warpage by image processing tool of MATLAB.

## II CAPTURING OF IMAGES OF INJECTION MOULDED COMPONENT

A separate setup is prepared and the setup consists of a digital camera which is fixed on a flat top plate at a fixed distance and the specimen is placed on the bottom plate. In the top plate a hole is made to fix the camera. This is a flexible image capturing setup made of thermo coal as shown in Fig 2 and the specifications of digital camera are shown in Table 1.

Considerations for image processing method are

- The images of Standard component and specimen component are captured using the setup at the same position.
- The background of image must be white and hence it is prepared with thermocoal.



Fig 2 Image Capturing Setup with Camera

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Digital Camera name	SONY
Pixel	14 Mega pixels
Zoom	5x optical zoom

Table 1 Specifications of digital camera

The standard component is placed on the bottom plate below the camera and image is captured. After, the specimen component is placed in the same location of standard component and image is captured without changing the camera position. To avoid the errors while capturing, a timer is switched on in the camera for 10 seconds and hence the camera can capture the image automatically. These images are given as input to image processing tool to measure warpage.

### III MEASUREMENT OF WARPAGE

#### III A: Processing of images in Photoshop:

The image processing tool in MATLAB cannot read the images captured by digital camera directly because the image is too big in memory, unsuitable image format. To avoid these problems PHOTOSHOP is used with following STEPS.

**STEP 1:** First change the background to white using the tools. Select the required image using quick selection tool. Invert the selection and fill selection with white colour in the background.

**STEP 2:** The image size is too big to read and display. So, the image size is reduced to the width and height 300×225 pixels. Fig 3 shows selection of image size option.

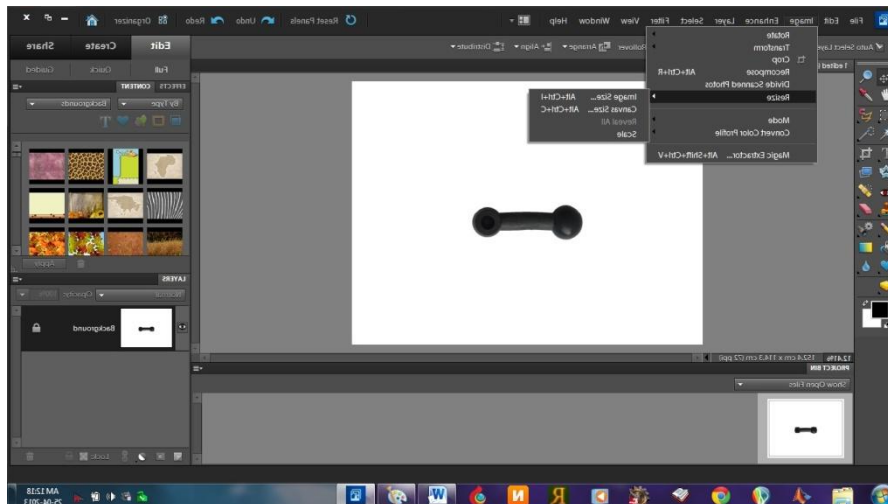


Fig 3 Select image size option with white colour

**STEP 3:** The format of image captured using Digital camera is jpeg, this format is not suitable to process in MATLAB. So the image is converted to tiff image format.

#### III B: Measuring warpage of Specimen with Standard component:

**STEP 1:** Read the image of captured standard component shown in Fig 4 and convert a true color image to a gray scale image. 'One' is the name of image. It is an image of a Forward and Return lever (FR LEVER) which is used in conventional machine as on/off switch.

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Fig 4 Standard component

```
A = imread('one.tif');
B=rgb2gray(A);
imshow(B);
```

**STEP 2:** Get information about variables in the workspace by calling the whos command. The command window showing image sizes is shown in Fig 5.

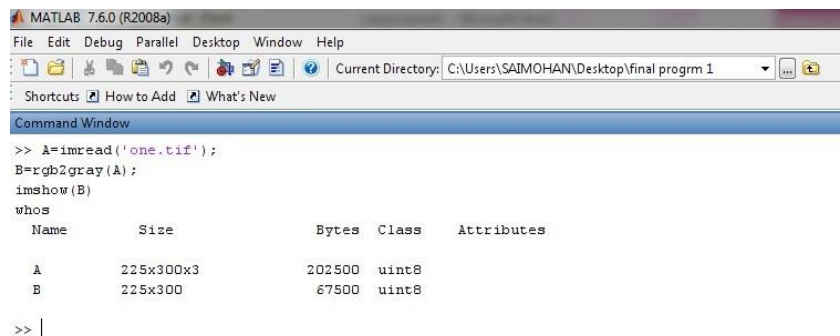


Fig 5 Size of images A,B

**STEP 3:** Name the x and y limits.

```
C=xlim
D=yylim
>> C=xlim      D=yylim
           C= 0      1
           D= 0      1
```

**STEP 4:** The histogram of the image B is shown in Fig 6.  
figure,imhist(B)

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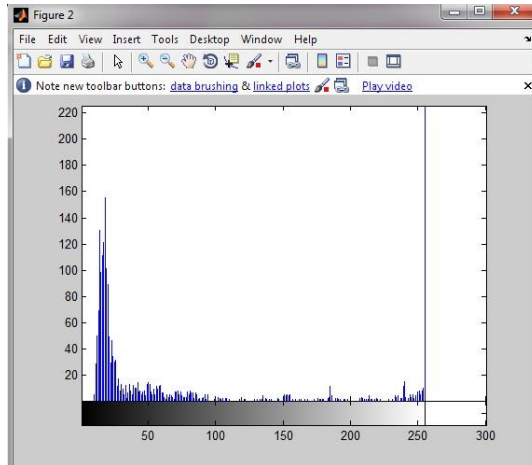


Fig 6 Histogram for the tool

**STEP 5:** Display of x and y limit values is shown in Fig 7

```
xlim(C)
ylim(D)
```



Fig 7 X and Y limits of standard component

**STEP 6:** Create a Binary Version of the Image.

```
level = graythresh(B);
bw = im2bw(B,level);
```

**STEP 7:** Fig 8 shows the image after changing the Display Colors of a Binary Image .

```
imtool(~bw)
```

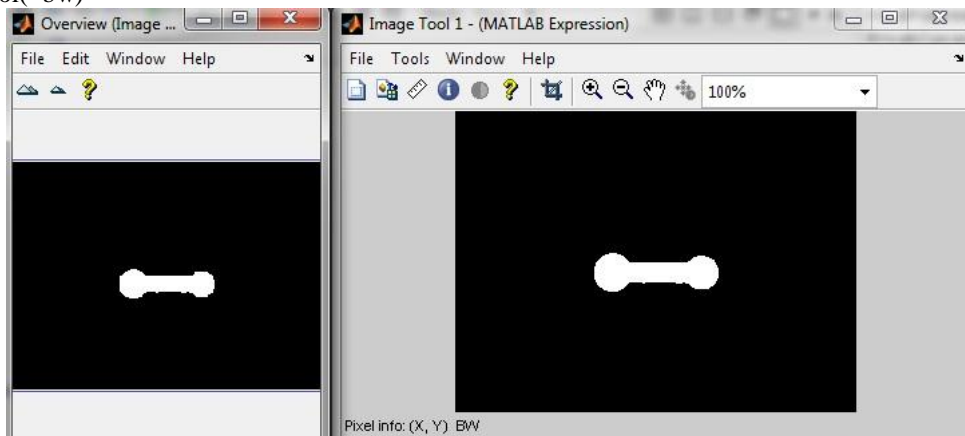


Fig 8 Image after changing the display colours

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**STEP 8:**Name the binary image after changing the display colours.

```
E = (~bw)
```

**STEP 9:**Determine the Number of Objects in the Image. No of objects is shown in Fig 9.

```
[labeled,numObjects] = bwlabel(~bw,4);  
numObjects
```

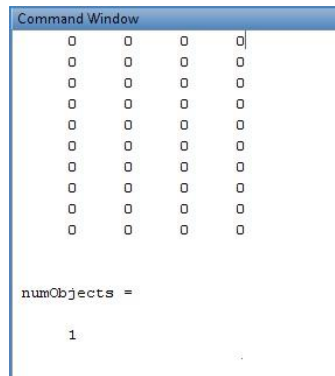


Fig 9 No of objects in the standard component

**STEP 10:** Examine the Label Matrix. Pixel region of standard component is shown in Fig 10.

```
figure, imshow(labeled);  
impixelregion
```

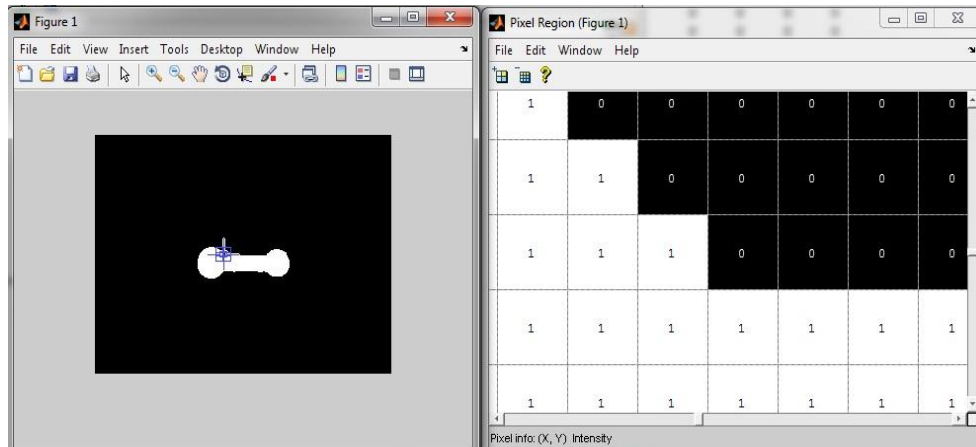


Figure 10 Pixel region of standard component

**STEP 11:** Read the image of second component shown in Figure 11

```
F=imread('two.tif');
```

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Fig 11 Image of specimen component

**STEP 12:** Same procedures from Step 2 to Step 10 is repeated for specimen component.

**STEP 13:** `warpage.tif = xor(E, J)` performs an exclusive OR operation on the corresponding elements of arrays E and J. The resulting element `warpage.tif (i,j,...)` is logical true (1) if `E(i,j,...)` or `I(i,j,...)`, but not both, is nonzero, which displays the image of tool wear.  
`warpage.tif=xor(E,J)`

**STEP 14:** Name the image as K.  
`K=toolwear.tif`

**STEP 15:** To see where either E or J has a nonzero element and the other matrix does not.  
Fig12 shows number of non zero elements.  
`spy(xor(E,J))`

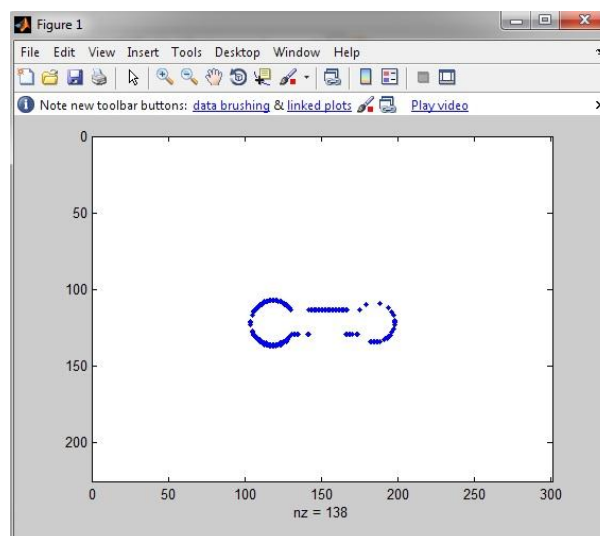


Fig 12 No. of non-zero elements

**STEP 16:** Display the image. Tool wear is shown in Fig 13.  
`figure,imshow(K)`

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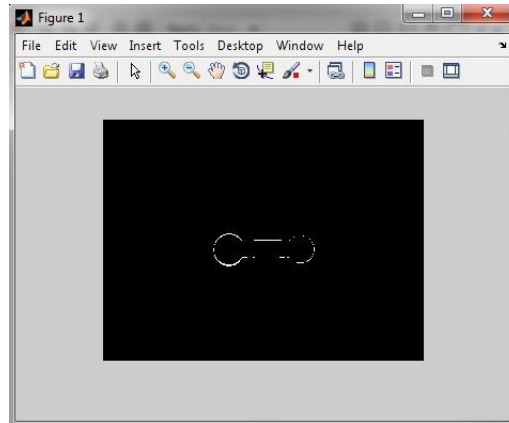


Fig 13 Warpage image

**STEP 17:** Write the image. The image written in directory is shown in Fig 14.

```
imwrite(K,'toolwear.tif');
```

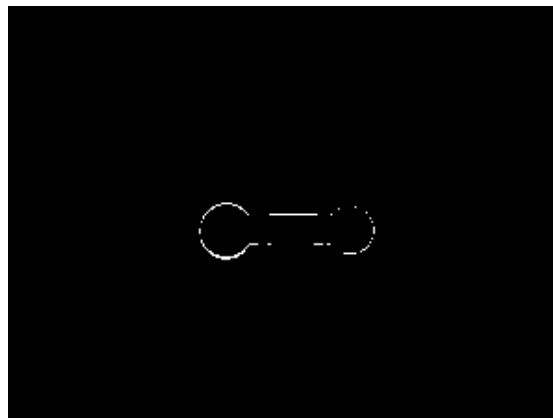


Fig 14 Image written in directory

**STEP 18:** Determine the number of objects. No of objects in tool wear image is shown in Fig 15.

```
[labeled,numObjects] = bwlabel(J,4);  
numObjects
```



Fig 15 No of objects in the warpage image

**STEP 19:** Examine the Label Matrix. Warpage pixel region is shown in Fig16.

```
figure, imshow(labeled);  
impixelregion
```



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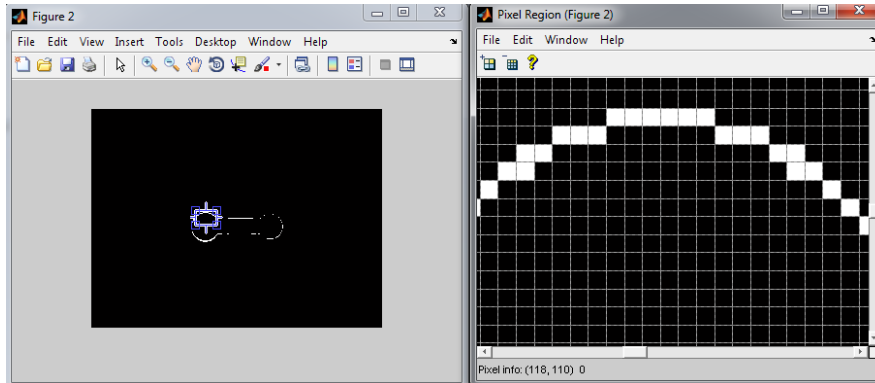


Fig16 Pixel region of warpage image

**STEP 20:** Display the x and y limit values for the limits having pixel values >0. Fig17 shows the row and column wherewarpage occurred.

```
[r,c] = find(bwlabel(K)>0)
rc=[r,c]
```

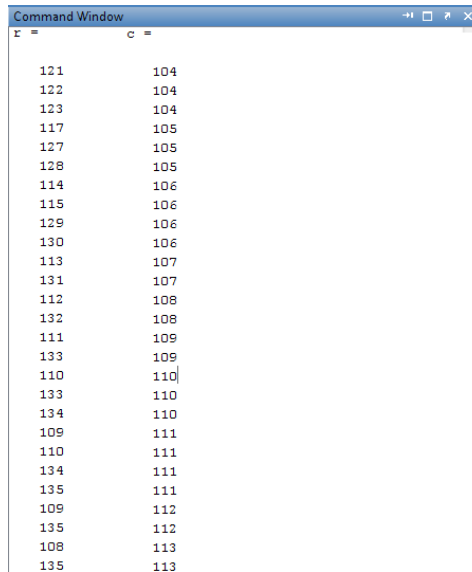


Fig 17 Image showing the no of row and column where warpage occurred

**STEP 21:** The range of row.

```
start_row=1;
end_row=400;
```

**STEP 22:** Giving the distance of each pixel.

```
millimeters_per_pixel = 1;
rows = [start_row millimeters_per_pixel end_row];
```

**STEP 23:** The range of columns.

```
Start_col=1;
end_col=400;
cols = [start_col millimeters_per_pixel end_col];
```

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**STEP 24:** To measure the lengths of component in longitudinal direction first read the standard component image.  
`img = imread('one.tif','PixelRegion',{rows,cols});`

**STEP 25:** ReadCoordinates of the standard component in longitudinal direction from warpage image and specify the position of distance tool on standard component image. The distances between given coordinate points is shown in the below Fig 18.

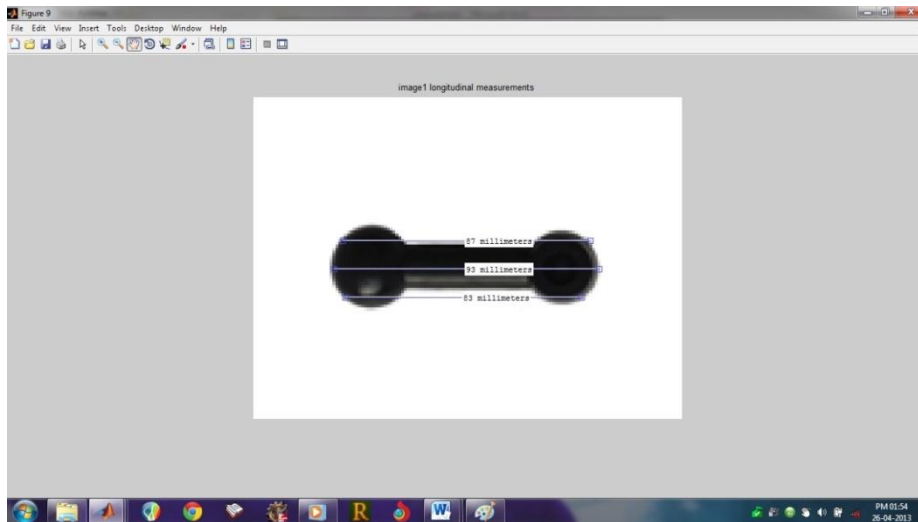


Fig 18 Longitudinal measurements in the standard component

The corresponding distances displays in the command window and it is shown in the Fig 19.

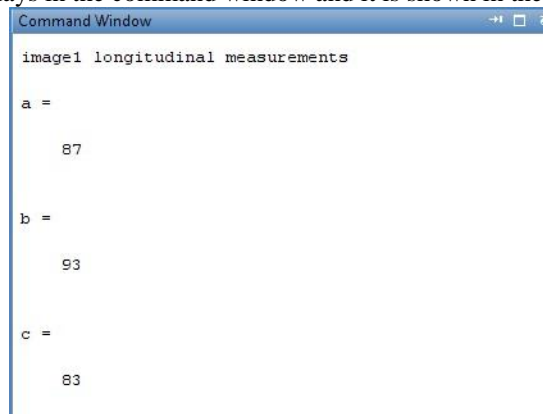


Fig 19 Standard component longitudinal measurements in the command window

**STEP 26:** ReadCoordinates of the specimen component in longitudinal direction from warpage image and specify the position of distance tool on specimen component image. The distances between given coordinate points is shown in the below Fig 20.

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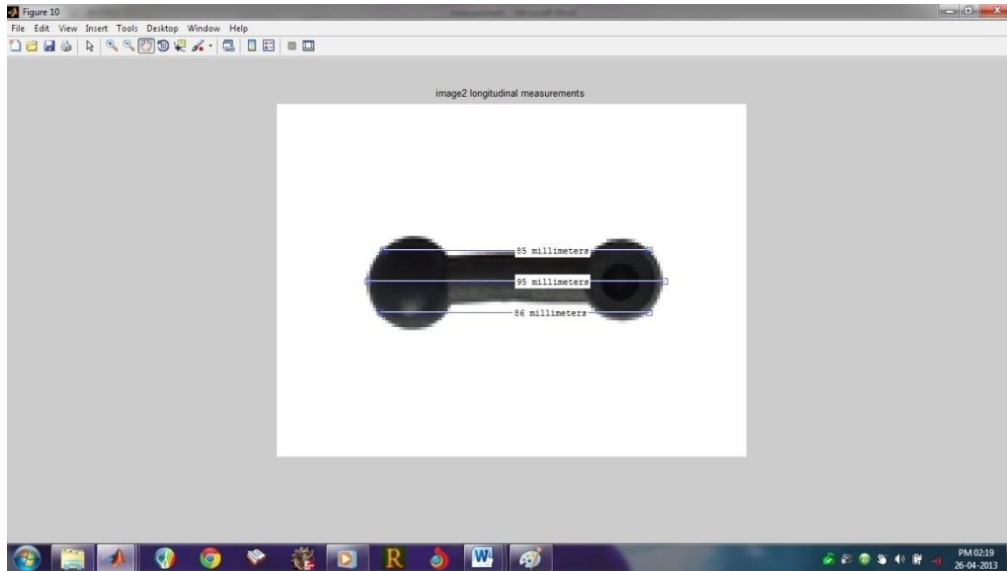


Fig 20 Longitudinal measurements of specimen

The corresponding measurements in the command window is shown in the Fig 21.



Fig 21 Longitudinal measurements of specimen

**STEP 27:** Similarly warpage can be measured later directions as shown in Fig 22. Warpage in both longitudinal and lateral directions is shown in Fig 23.

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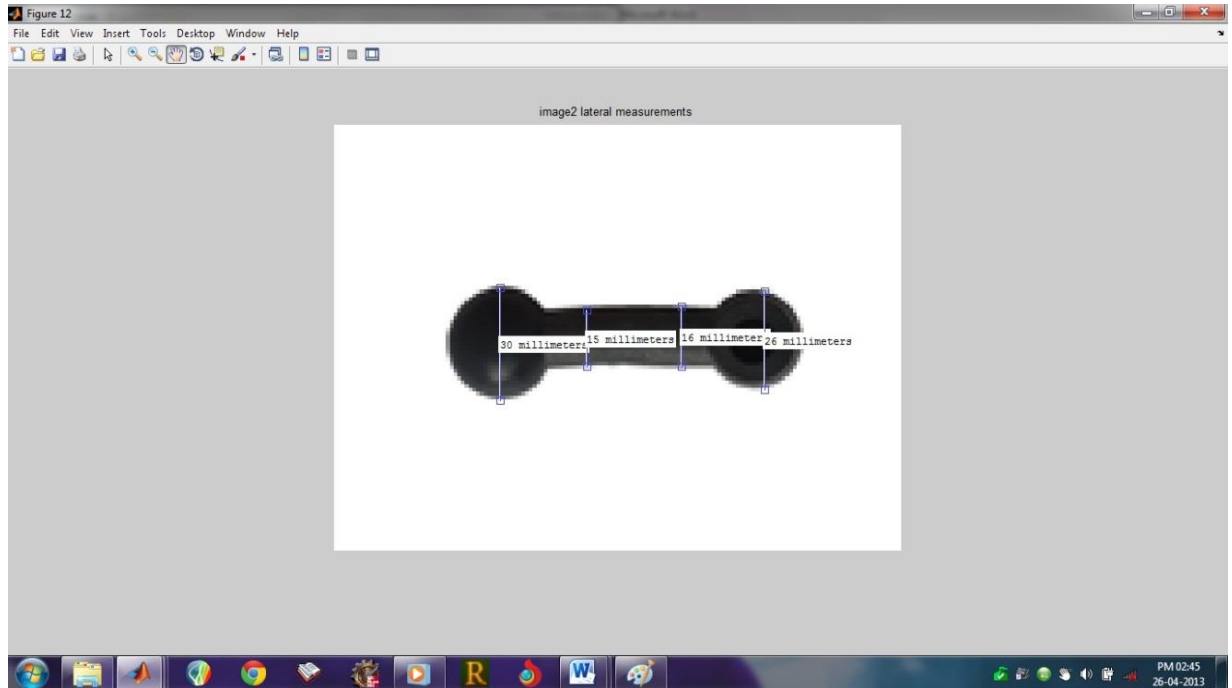


Fig22 Lateral measurements of specimen

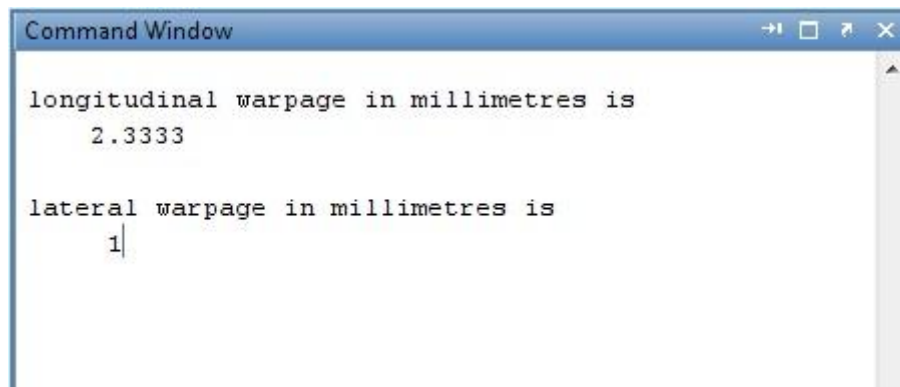


Fig 23 Warpage value of specimen in both directions

## IV CONCLUSIONS

- Measurement of warpage is very important because, if it is above the acceptable limit, suitable process parameters of injection moulding machine such as mould temperature, injection pressure, injection speed, filling time and cooling time can be adjusted to get the better quality of plastic component.
- The MATLAB, image processing tool is very effective and fruitful in the measurement of warpage for complex shaped plastic components.
- This method may also be extend to determine other defects like shrinkage, blow holes, etc in plastic injection moulding components

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