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Design and VLSI Implementation of DIP Based Rod Quality Inspection

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Abstract— **The inspection of product quality in majority of cases is based on human factor because of complexities of problems of inspection and quality and demands for the changeability during decision about the quality of product. As the product comes from automated production chain to final manufacturing line its surface and edges are inspected by the stuff employed to detect the defects. In order to avoid human errors in the system, complete automation of production is required. Digital image segmentation can be a versatile, reliable and a low-cost tool for the quality identification of materials, with the potential to replace other all other costly techniques. In this paper, select different types of materials like tiles and rods, the images are acquired and calibrated. The image without defect is kept as a reference image. Then the sample which is to be tested is checked by comparing with the reference image by using techniques like Thresholding, Histograms and Spatiogram Similarity and Cell Segmentation in Matlab environment. The variation in the images shows the defect in the material. By using this system can identify the quality of the industrial materials. The same procedure can also be adopted with digital camera for the quality identification of various other industrial materials. The design based on using FPGA for the hardware implementation of the architecture using VHDL. FPGA Spartan 3E starter Kit has been used for the hardware implementation. The proposed method is an improvement over traditional software package based approaches in that of image comparison.**

Index Terms— DIP, FPGA, Rod surface, Threshold value.

I. INTRODUCTION

The various industrial sectors have taken significant advantage of the strong evolution in the world of automation in recent years. All production phases have been addressed through various technical innovations, with the exception of the final stage of the manufacturing process. This is still performed manually and is concerned with visual surface inspection. A new technique to solve these problems is to use Digital Cameras in place of analog sensors. The digital images are taken and continuously transmitted to the operator station. Digital image processing pays way for generating control signals by comparing the just received image with the standard image already stored inside the computer. Photographs are taken through digital cameras of different levels of adulteration they are stored inside the computer as an experimental setup. In the normal checkup the liquid photograph is taken and is compared with the already stored image inside the PC and a signal is generated when it matches the image. This indicates the defect even when it is very small [1]-[3].

In the proposed systems segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics [4]-[5].

The proposed work is photographs (field images) taken through web camera (digital signal) connected to computer. Super imposing of actual images in the mimic diagram. The field images (just received) are compared with the Standard images already stored in the computer. Identification action is initiated when both images matches. Slowly analog transducer can come to a halt. The emerging DIP technologies will revolutise the present control system.

This paper discusses the VLSI Implementation of DIP Based Rod Quality Identification. In Section II, VLSI Based Proposed Systems is presented. In Section III, Results and Discussions are discussed. In Section IV, conclusions are drawn.

II. VLSI BASED PROPOSED SYSTEMS

The general hardware setup of the proposed system is Camera is placed 20 cm altitude from the bottom of the stand. The intensity of light source is 10 candelas and maintained the room temperature. The bottom surface color is white. The samples are placed at glass on the white surface. First, Cross sectional view of Steel Rod Surface Reference image is taken by camera and converted in to bit file format then stored in Field Programmable Gate Array (FPGA). Next, various level of human eyes are can't identify the crack in the Cross sectional view of Steel Rod Surface Sample image is taken by camera and converted in to bit file format provide to FPGA. Finally, Cross sectional view of Steel Rod Surface Reference image is compared to Cross sectional view of Steel Rod

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Surface Sample image by using distance vector matrix algorithm. This algorithm execution is based on pixel by pixel comparison in FPGA. While comparing two images, whether the difference is occurring the steel rod crack is identified otherwise crack is not present in the steel rod.

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A. *Distance Matrix Algorithm*

$$\delta = \sqrt{\sum_{i=1}^{N}(yi - fi)^2} \quad (1)$$

Where

δ=Difference,
Y_i=Standard Image,
F_i=Field Image.

III. RESULTS AND DISCUSSIONS

A. *Simulated Environment*

Family: Vertex4
Device: XC4VLX15
Synthesis Tool: XST (Verilog/VHDL)
Package: SF363
Simulator: Modelsim SE-VHDL
Image Size: 256*256
RAM size: 2 GB
Processor: Core2Duo

TABLE I
CAMERA PROPERTIES

Property	Value
Dimension	4000 X 3000
Width	4000 pixels
Height	3000 pixels
Horizontal Resolution	300dpi
Vertical Resolution	300dpi
Bit Depth	24
Compression Resolution Unit	2
Color Representation Compressed bit/pixel	sRGB
Camera Maker	nokia
Camera Model	N8-00
F-stop	f/2.8
Exposure-time	1/8 sec
ISO-Speed	ISO-494
Exposure bias Focal length	6mm

B. *Steel Rod Surface Quality Identification Results*

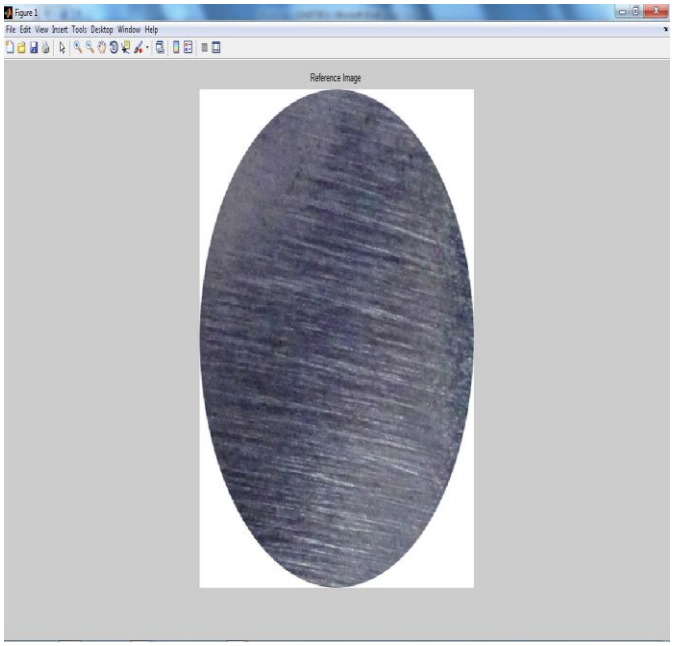

Fig.1 Cross sectional view of Steel Rod Surface Reference image

Figure 1 shows the Cross sectional view of Steel Rod Surface Reference image in *jpg format which is the first input image.

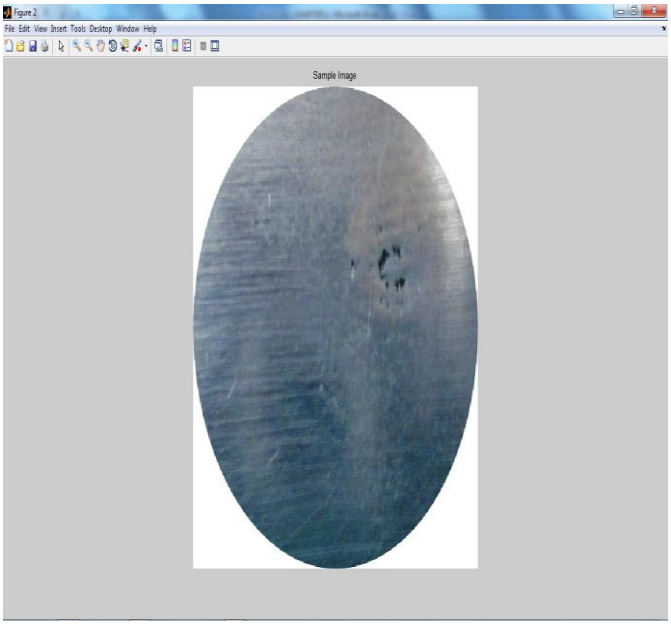

Fig.2 Cross sectional view of Steel Rod Surface Sample image

Figure 2 shows the Cross sectional view of Steel Rod Surface Sample image with some defects in it which is the second input image. Figure 3 is the resized image of the reference rod with 512x512 resolutions. Only the cropped image is used for testing to achieve equal border size that could set with the fixed resolution.

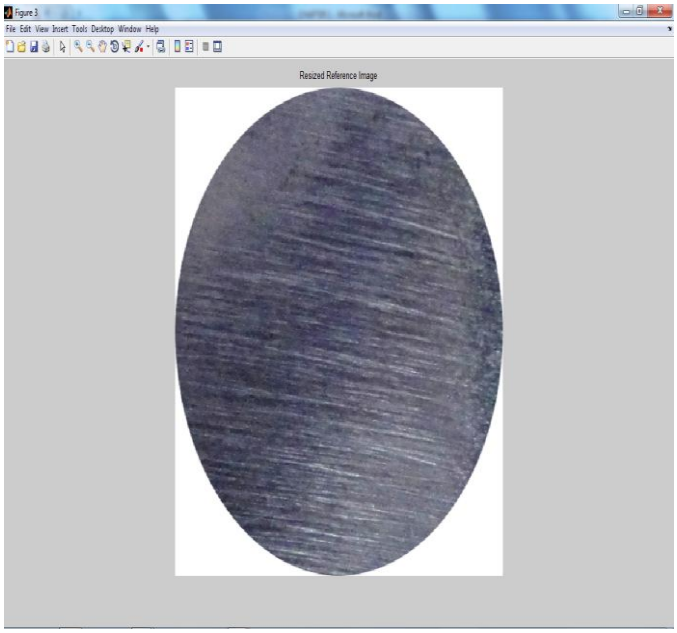

Fig.3 Resized Reference image of Rod

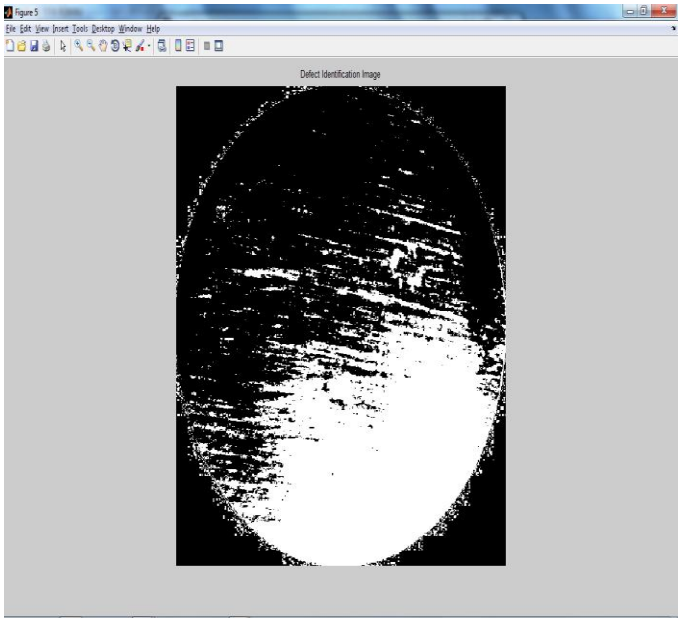

Fig. 5 Defect Identification Image of Rod

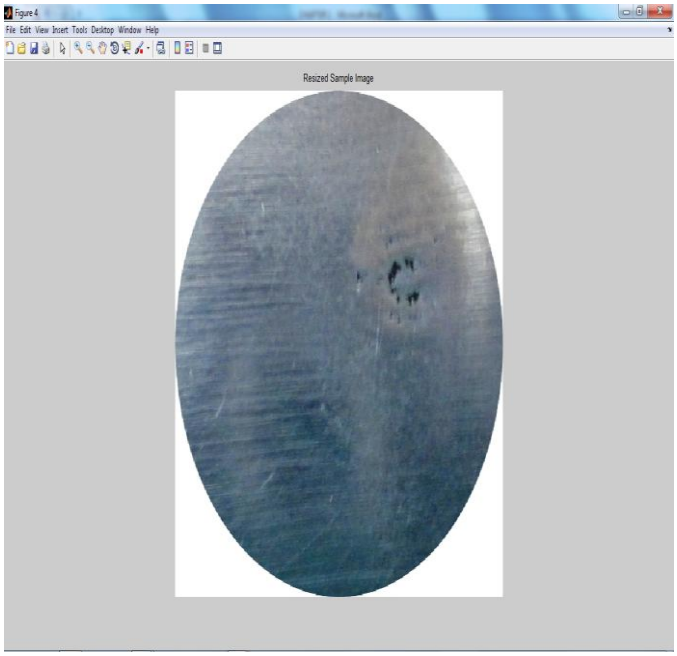

Fig. 4 Resized Sample image of Rod

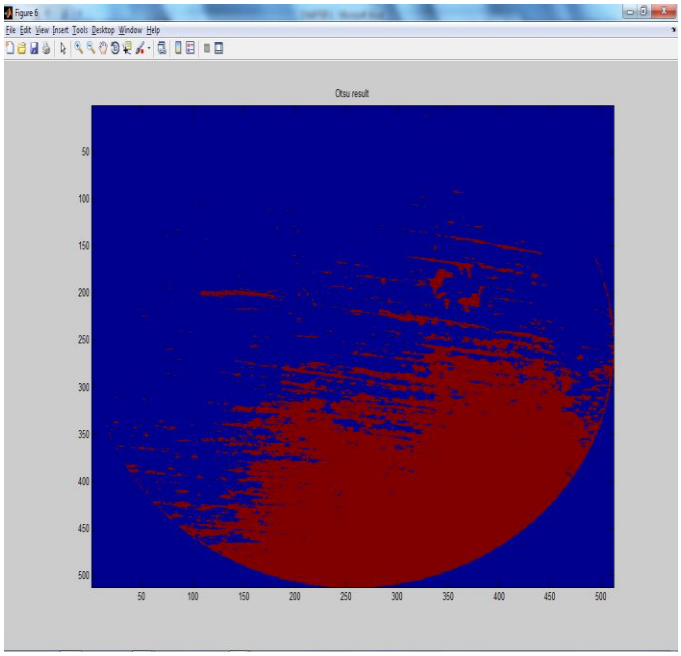

Fig. 6 Otsu Result of Rod

Figure 4 is the resized image of the sample rod with 512x512 resolutions. Only the cropped image is used for testing to achieve equal border size that could set with the fixed resolution. Figure 5 shows the defect in rod by the difference image. First, the reference image is subtracted with sample image. Then the sum of the array elements is added with a scalar value.

Figure 6 shows the Otsu result of the difference image by using the Otsu threshold value. This is one method of histogram shape based thresholding to find the defect in rod. This is a thresholding result based on entropy. This maximizes class entropies to obtain maximum information between the two classes. Figure 6 shows the Figure 7 Kapur Result of the difference image by using the Kapur threshold value.

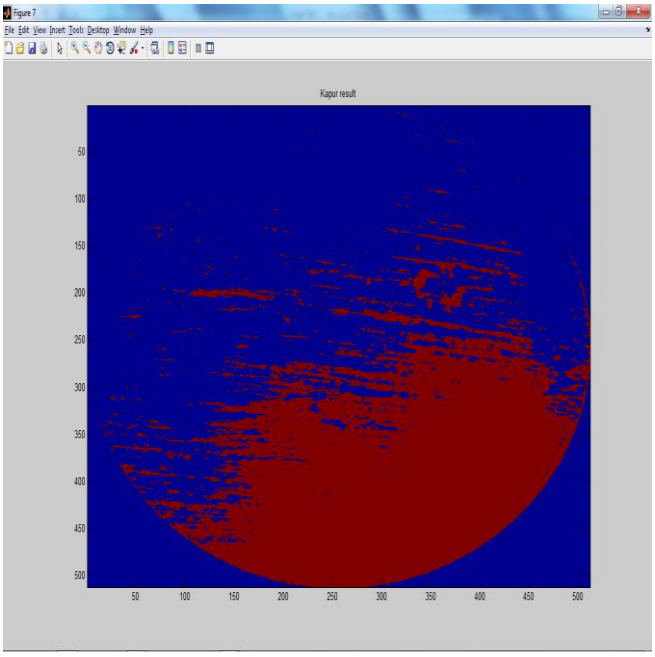

Fig.7 Kapur Result of Rod

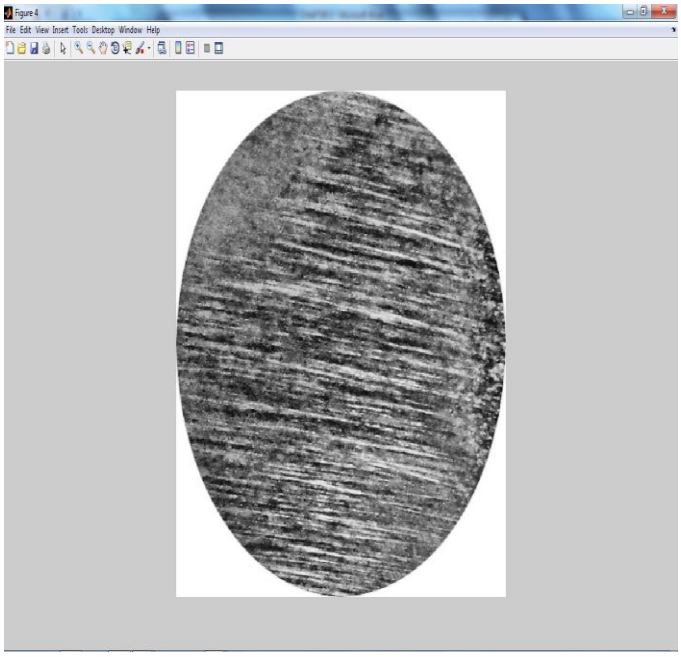

Fig.9 CLAHE image of Reference Rod

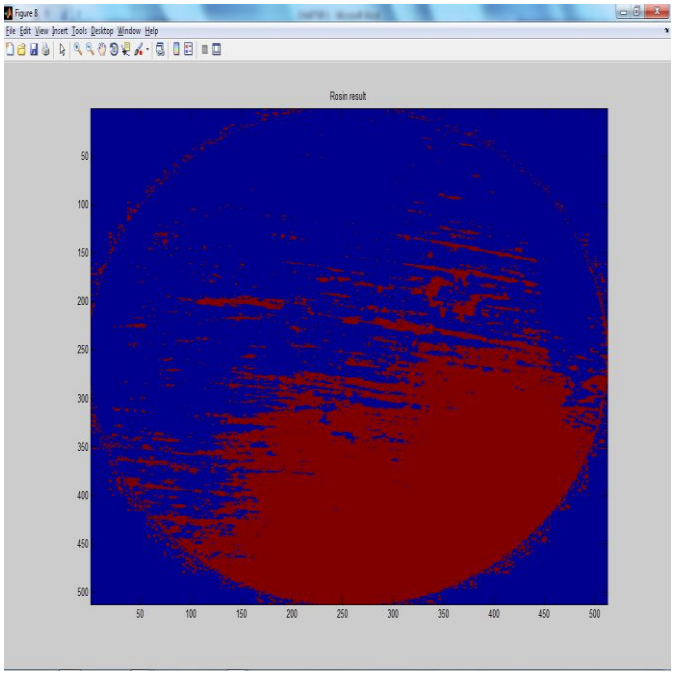

Fig. 8 Rosin Result of Rod

Figure 8 shows the Rosin result of the image which determines the threshold value using the information of dominating background class. The different threshold values are used to find out the defects in the rod.

Figure 9 shows the CLAHE image of reference rod. CLAHE is Contrast Limited Adaptive Histogram Equalization. Figure 10 shows the CLAHE image of sample rod which is to be compared with the reference rod.

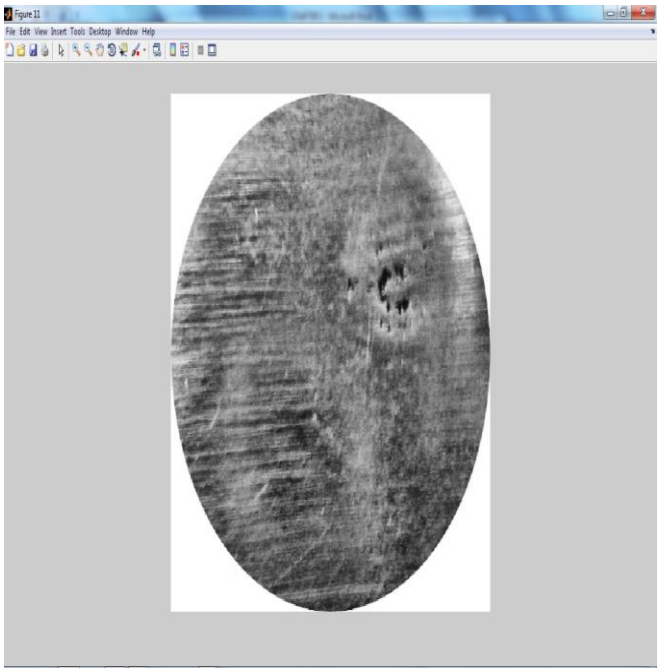

Fig.10 CLAHE image of Sample Rod

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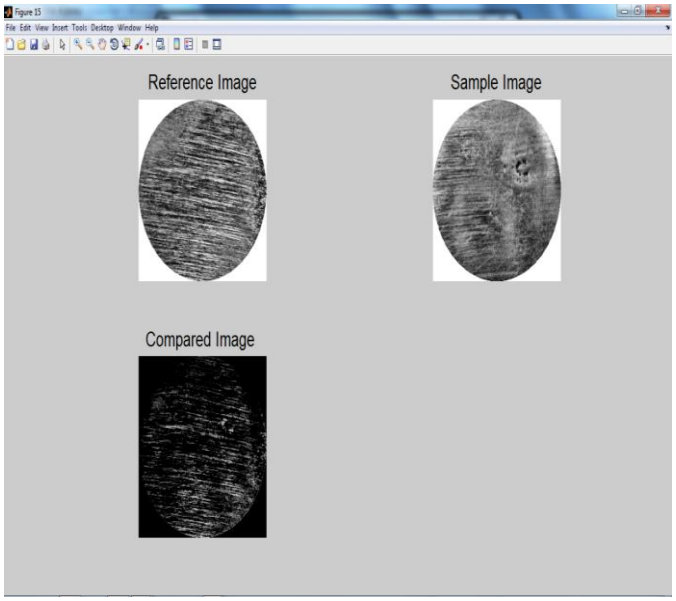

Fig. 11 Compared image of Rod

Figure 11 shows the compared image of the two rods using the cell segmentation. We use morphological tools to detect the defects in a rod. Convert image to binary image, based on threshold. Fill image regions and holes. Morphologically open binary image (remove small objects) that have fewer than P pixels, producing another binary image. Find perimeter of objects in binary image. Create a mask-based image overlay. Computes the extended-maxima transform, which is the regional maxima of the H-maxima transform. Final Step is to compare the reference and sample image. Thus the compared image shows the defect in the material.

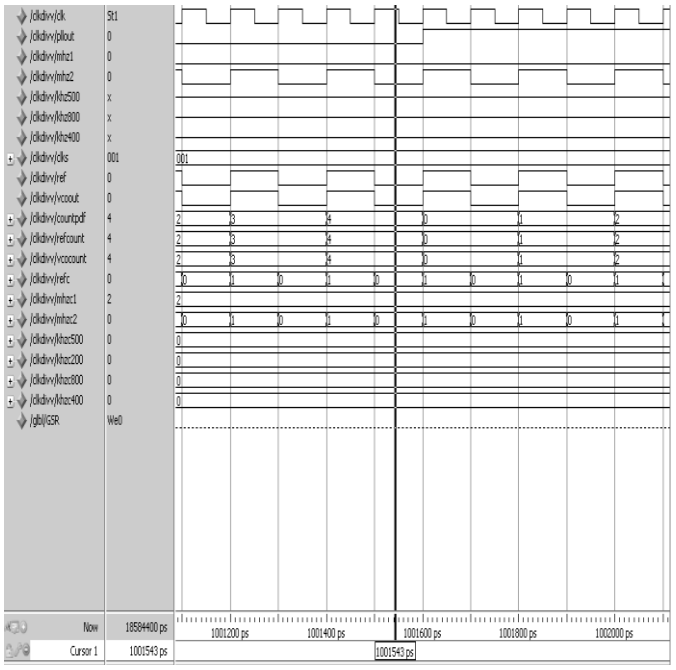

Fig. 12 VHDL Output of Proposed System

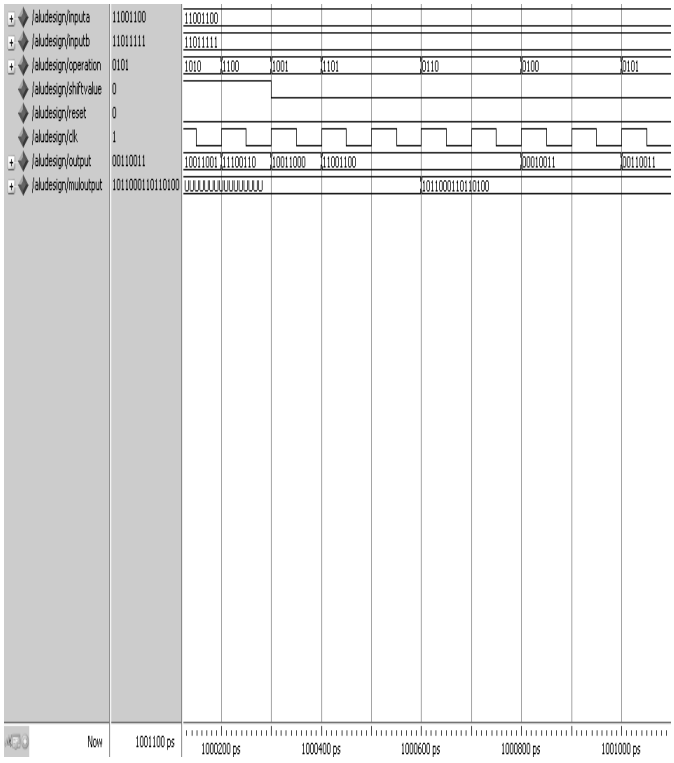

Fig.13 Processing Element Output

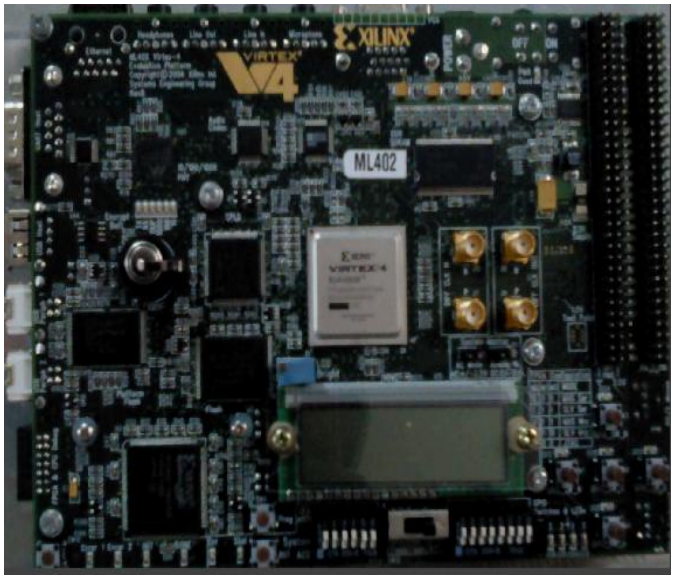

Fig. 14 FPGA Implementation Unit

Figure 12 deals with VHDL Output of Proposed System. Figure 13 has shown Processing Element Output of the proposed system. Finally, Figure 14 shows FPGA Implementation Unit of the proposed system.

TABLE II
IMAGE COMPARISON WITH DIFFERENT ENVIRONMENT

S.No	Platform	Image Comparison Speed (ns)
1	C	11
2	Matlab	06
3	VHDL with FPGA Implementation (Proposed System)	02

Table 1 shows the camera properties of the practical setup and table 2 shows the image comparison with different environment.

IV. CONCLUSION

Thus we have created a system by which we can identify the quality of materials in Industries. This paper uses digital image segmentation and so it can replace all other costly techniques and makes the process very easy for the industries. Here digital camera and a computer to identify the quality of materials. Thus the sample which is to be tested is checked by comparing with the reference image by using techniques like Thresholding, Histograms and Spatiogram Similarity and Cell Segmentation in Matlab environment. The variation in the image shows the defect in the material. This system becomes a faster way of identifying the quality of industrial materials. In this paper presents a new methodology for designing high speed image comparison by using FPGA and reduced the comparison time. If we comparing the image by based on threshold value in MATLAB and other technique it will take more time but our methodology guarantees to reduced the time by comparing the image. This system is based on digital image processing technique, so it can replace the analogue sensors and makes the process very easy for the user. VLSI implementation is helpful for faster way of identifying the quality of the rod. Even though, comparison algorithms are successful at software level, better results can be achieved by implementing in VLSI based hardware.

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