
U. Sabura Banu

Abstract— In automobiles crank pin plays a major role in connecting off-centre bearings of the crank shaft. The crank undergoes many stages, such as Carbonization, Quenching, tempering and hole drilling. The dimensions of the holes need to be correct for the proper alignment of the pin. The pin is placed in a rotating shaft. The crank pin is caught in a web camera. The holes are detected using ant colony optimization based edge detection techniques. Dimension of the pin holes are estimated. The dimension is checked with the reference. If the pin is found to match the reference, they are blown to the conveyor by an I/P converter and the counter for good pins is incremented by 1. If the pin is found to be faulty, they are blown using another I/P converter and collected in a tray and a separate count for faulty pin is maintained. The crank pin hole dimension detection is automated and tested.

Keywords—Crank Pins, Ant Colony Optimization, I/P converter

I. INTRODUCTION

CRANK pin plays a vital role in the smooth running of the engines. In a reciprocating engine, the crank pins are the bearing journals of the big end bearings and the ends of the connecting rods opposite to the pistons. If the engine has a crankshaft, then the crank pins are the journals of the off-centre bearings of the crankshaft. In a beam engine the single crank pin is mounted on the flywheel; in a steam locomotive the crank pins are often mounted directly on the driving wheels. Big end bearings are commonly plain bearings, but less commonly may be roller bearings. Crank Pin is a high precision item, having round cylindrical shape. It can be of hole or solid type, but must have a high surface finish, to serve as running surface for needle bearings. Three holes are drilled in the crank pin. The dimensions of the holes need to be maintained at a predefined values. At present, hole dimensions are measured manually now. Due to gross error, the position of the holes cannot be detected accurately and the process consumes more time. In the present work, the dimension of the hole is determined using Image Processing Tool of MATLAB.

Image edge detection is a process of locating the edge of an image which is important in finding the approximate absolute gradient magnitude at each point of an input gray scale image. Edge detection is a process of locating an edge of an image. Detection of edges in an image is a very important step towards understanding image features. Edges consist of meaningful features and contained significant information. It’s reduce significantly the amount of the image size and filters out information that may be regarded as less relevant, preserving the important structural properties of an image. Most images contain some amount of redundancies that can sometimes be removed when edges are detected and replaced, when it is reconstructed. Eliminating the redundancy could be done through edge detection. When image edges are detected, every kind of redundancy present in the image is removed. The image quality reflects significant information in the output edge and the size of the image is reduced. This in turn explains further that edge detection is one of the ways of solving the problem of high volume of space images occupy in the computer memory. The problems of storage, transmission over the Internet and bandwidth could be solved when edges are detected (Vincent, 2007). Since edges often occur at image locations representing object boundaries, edge detection is extensively used in image segmentation when images are divided into areas corresponding to different objects.

Ant colony Optimization is an optimization algorithm naturally inspired by the behaviour of ants[1],[2]. Ants deposit pheromone on the ground in order to find the optimal path from nest to food. Dorigo et al. formulated the Ant colony optimization algorithm [3]-[4], followed by Max-Min system [5] and ant colony system [6]. ACO finds a wide spread application [7]-[21]. In the proposed work, edge detection is found using ACO technique by exploiting number of ants which move on the image driven by the local variation of the image’s intensity values to establish a matrix representing the edge information at each pixel location of the image.

Section 2 discusses the crank pin details. Section 3 deals with the details of the edge detection techniques of using conventional techniques. Section 4 briefs about the ant colony optimization based edge detection techniques. Section 5 deals
with the overall process automation of the hole dimension detection of the crank pin.

II. CRANK PIN

Crank Pin is a high precision item, having cylindrical shape. It can be of hole or solid type, but must have a high surface finish, to serve as running surface for needle bearings. The surface must be free from nick marks and must be hard, to bear the normal wear and tear of the vehicle. It is firmly connected to the connecting rod and as such the geometry of the outer diameter as well as side faces play a vital role in fitment and running. Figure 1 shows the crank connected to the piston. Figure 2 shows the sample crank pins.

Figure 1. Crank pin

Figure 2 Sample crank pins placed on a shaft

There are two types of cranks.

- The first type is the continuously rotating crank, such as in engine crankshafts or on bicycles, where the crank can continuously turn more than 360 degrees without having to reverse.
- The second is the partial circle crank, where the entire rotary motion of the main shaft may be 90 degrees or less, as with steering linkages or ventilation damper adjustments.

Figure 3 shows the various processes in the treatment of the crank pin. The crank pins are heat treated and cured. While heat treatment the low level carbons are converted into high level carbons. After that three holes are drilled on the crank pin for the purpose of cooling the engine by allowing the oil to flow through the holes.

Fig. 3 process diagram

The dimensions of these holes in the crank pin are measured manually in that company. During the manual inspection there are several difficulties in measurement.

1. Inaccuracy in the measurement.
2. Gross error because the measurement will vary from person to person.
3. Manual inspection is time consuming.

To overcome these disadvantages, the dimensions of the holes are measured using image processing tool of MATLAB software.

III. EDGE DETECTION OF THE DIGITAL IMAGE USING CONVENTIONAL TECHNIQUES

Edge detection in digital images is computed in three steps outlined below:

- Compute the gradient of the image frame. The gradient gives a measure of the difference in the values amongst neighbouring pixels better characterizing color changes in a localized region.
- Compute the edge strength by taking the magnitude of the gradient. The gradient is more pronounced when the difference amongst adjacent pixel values is larger.
- Threshold the result to identify the image edges. A smaller/larger threshold will detect fewer/greater edges. This “cleans up” the image resulting in a binary result that is easy to process for subsequent image interpretation stages.

There are four different edge detection algorithms. They are Sobel, Prewitt, Robert’s and Canny algorithm. The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial gradient that correspond to edges. Prewitt is a method of edge detection in image processing which calculates the maximum response of a set of convolution kernels to find the local edge orientation for each pixel. The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The Canny operator was designed to be an optimal edge detector (according to particular criteria. It takes as input a grey scale image, and produces as output an image showing the positions of tracked intensity discontinuities.
IV. EDGE DETECTION USING ANT COLONY OPTIMIZATION

The ACO based image edge detection approach aims to utilize a number of ants to move on a 2D image for constructing a pheromone matrix each entry of which represents the edge information at each pixel location of the image. The ant movements are steered by intensity variations. The first step is the initialization process followed by construction, update and decision process. Initially K ants are randomly assigned on an image I with a size of M1 x M2, each pixel of which is viewed as a node. The initial value of the pheromone matrix is set to $\tau$\textsuperscript{init}. At the $n$\textsuperscript{th} construction site, one ant is randomly selected from the above mentioned K ants and this ant will move on the image for L movement steps.

This ant moves from node (l,m) to its neighbouring node (i,j) according to a transition probability that is defined as

$$ t_{ij}^{(n)} = \frac{(\frac{1}{\tau_{ij}^{(n-1)}})^{\alpha} (\eta_{ij}^{(n)})^{\beta}}{\sum_{j \in \Omega_{i}} (\frac{1}{\tau_{ij}^{(n-1)}})^{\alpha} (\eta_{ij}^{(n)})^{\beta}} \text{; if } j \in \Omega_{i} $$

where $\eta_{ij}$ is the pheromone information value of the node (i,j); $\Omega_{(l,m)}$ is the neighbourhood nodes of the node (l,m), $\eta_{ij}$ represents the heuristic information at the node (l,j). The constants $\alpha$ and $\beta$ represent the influence of the pheromone matrix and the heuristic matrix.

The second update is carried out after the movement of all ants within each construction step according to

$$ \tau_{ij}^{(n)} = (1 - \rho) \cdot \tau_{ij}^{(n-1)} + \rho \cdot \eta_{ij} \text{; if } (i,j) \text{ is visited by current } k $$

$$ \tau_{ij}^{(n)} = \Delta_{ij}^{(k)} = \Delta_{ij}^{(k-1)} \cdot \psi $$

where $\rho$ is the evaporation rate, $\Delta_{ij}^{(k)}$ is determined by the heuristic matrix; that is $\Delta_{ij}^{(k)} = 1 \text{ at } (i,j)$

Where, $\psi$ is the pheromone decay coefficient.

Finally, the decision is made at each pixel location to determine where it is edge or not, by applying a threshold $T$ on the final pheromone matrix $\tau^{(N)}$

![Fig 4. Edge of the crank pin detected using Ant colony optimization technique](image)

Area is calculated for the detected hole and compared with the reference area = 5.39 cm$^2$ and decision taken accordingly.

V. AUTOMATION OF HOLE DIMENSION DETECTION OF CRANK PIN

![Fig. 5 Schematic Diagram of the Automatic Hole Dimension Detection](image)

Figure 5 shows the overall schematic diagram of the automatic hole dimension detection process. The process consists of a crank pin placed in a rotating shaft rotated using a DC motor. A drive shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. Figure 6 shows the setup of the overall automatic hole dimension detection process.
The area of the hole is found which is compared with the control the servo pressure and the output pressure. To control pneumatic actuators/operators, pneumatic valves, (3 to 15 psig). Its purpose is to translate the analog output signal (4 to 20 mA) to a proportional linear pneumatic output. A "current to pressure" converter (I/P) converts the analog an I/P converter (accept) which blows the pin to a conveyor. The pin moves in the conveyor and sent to the next stage. If the dimensions do not match with the reference, I/P converter reject is excited which blows the pin to a tray where the faulty pins are collected. The following process was able to identify the good and faulty crank pins with 100% accuracy.

VI. CONCLUSION
The image of the crank pin placed on a shaft is captured using webcam. The dimension of the pin is detected using conventional Edge Detection Technique and Ant Colony optimization techniques. The area of the crank pin hole is computed and compared with the reference area which is 5.39cm². If the area matches, the pin is blown to a conveyor via a tray using a Pneumatic actuator and transported to the next section. If the area doesn’t match, the pin is collected in a tray using a second pneumatic actuator. The process is completely automated reducing the possibility of gross error. Also the time consumption is also very less.

REFERENCES

Fig. 6 Automatic hole dimension detection process setup

**Dr. U. Sabura Banu** has completed her B.E(ICE) in Arulmigu Meenakshi Amman College of Engineering, MS(By Research) (EEE) in Anna University and PhD (EEE) in Anna University, Tamilnadu, India in 1999, 2004, 2009 respectively. She has 10 years of teaching experience and currently holds the post of Professor in the Department of Electronics and Instrumentation in BS Abdur Rahman University. She has published more than 50 research papers in various conferences and journals. She is a member of ISA. Her areas of interest includes Advanced Process Control, Optimal tuning of controllers using Swarm intelligence, Image Processing.