Project Title: Design and implementation of palm scanner robot for inspection of butt welds using ultrasonic approach

Department:	ICT	***Employer:***	Shahid Mofateh power plant
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Project Necessity:

One of the important issues in stopping the production of electricity in thermal power plants is the leakage or rupture of the pipe in the boiler. If these phenomena occur, the lives of the plant personnel will be endangered, power generation will be stopped, and restarting the boiler will take between 2 and 7 days, which will cause huge financial losses. In addition, each time the boiler is switched off and restarted unintentionally, it will shorten its life and cause further damage to the power plant. These cases highlight the importance of non-destructive inspection of boiler pipes in thermal power plants. Difficult access to the entire surface of the boiler pipes due to their short distances from each other and their special arrangement, along with the necessity of complete rotation of the inspection system around the pipe, makes their non-destructive inspection complex. The distance of the water pipes from each other in some steam units is about 14 mm and this small distance is also covered by the fin.

In general, there are two conventional methods for non-destructive imaging of boiler tubes. The first method is radiography. In this method, first the radioactive source emitting the radiation is placed in a suitable place in relation to the part and then a radioactive film sensitive to the radiation is used on the back of the part. This method results in an image of the boiler tube. But it has several operational drawbacks. First, due to the use of radioactive radiation in this method, the non-destructive area to be inspected must be evacuated to a certain radius of the presence of staff, and therefore disrupt other activities within the area. Second, radiographic films are of lower quality than digital images, and their examination requires high accuracy and expertise. Thirdly, in tube radiography, it is necessary to perform radiation operations from both front and side views to eliminate the effect of increasing the thickness seen by the rays on the sides of the tube. In boiler tubes, due to their arrangement in a special row, radiation from the side is not possible and as a result, the sides of the tubes are not inspected radiographically. Fourth, the appearance of the film does not take place immediately, and there is a delay of one or two days from the time of shooting to the appearance of the image. Fifth, if the captured video is defective for any reason or is not of sufficient quality, it will not be identified until the image appears, and therefore, if there are any defects, the whole process and especially the evacuation of employees must be repeated. Sixth, it is not possible to document this process in the form of computers, and it must be done in the form of the same radiographic films, and their maintenance is done according to certain standards and is costly. Seventh, in some cases, access to the back of the boiler water pipes to place the film is impossible or difficult.

Another method of imaging in non-destructive inspection is phased-array ultrasonic test (PAUT). In this method, the ultrasonic phased-array probe is placed on the surface of the tube which is used to transmit and receive the ultrasonic waves to form the image of the inside of the part. This method benefits from several advantages. First, the risks of using X-rays have been eliminated and there is no need to evacuate the area from staff. Second, the image quality is high. Third, the image is taken immediately and stored in the computer of the device, so the technical inspector can immediately evaluate it. Whenever, the image has not the desired quality, another image is taken quickly. Therefore, inspection and elimination of possible defects are simultaneously and the need to use radiographic films and additional costs are eliminated. In addition, all images are stored as electronic files and the need for physical documentation has been eliminated. Another advantage of this method is that phased-array devices are lighter than radiographic counterparts and are more portable.

Project Goals:

The goal of this project is to design and implementation a boiler pipe inspection system based on the ultrasonic phased-array systems. Moreover, a special scanner is designed and formed for ultrasonic boiler pipe welding inspection. The device provide a high-resolution image of the weld.

Abstract:

Non-destructive inspection of boiler pipes is of great technical and economic importance. However, difficult access to boiler water pipes and problems with the use of conventional radiographic procedures have increased the need for an alternative inspection system. In this project, the design and implementation of a non-destructive inspection device for welding boiler pipes using ultrasonic phased-arrays is explained. The integrated electronic circuits, easy portability, the possibility of inspecting the welding of boiler tubes of power plants with a diameter of 2.5 inches, the ability to rotate completely around the boiler tube without the need to access the back and using the full focus method (TFM) are the most important features. The advantages of this implementation are compared to the previous models, which makes the image noise to be less than the previous models and to provide higher quality images. According to the experimental results, images benefits from high quality when a piece of steel with the holes with a diameter of 0.3 mm with a resolution of 0.05 mm is used for inspection. This device also provides A-scan, B-scan, C-scan images**.**

Steps and Methodologies:

The project is done in the following steps:

- Primary studies

- Design and implementation of hardware

- Hardware and software programming

- Software and hardware integration and troubleshooting

- Consulting with experts and applying the necessary modifications

- Testing inside the laboratory

- Testing on simulated pipes of the power plant inside the laboratory

- Applying the required corrections

Main Results (technical outputs, patents, papers, books, reports, etc.):

The equipment tests in the laboratory and power plant were successful. This equipment exhibits better image quality in contrast to similar models. As a result of this project, 10 papers were published in conferences and journals, while another paper is under review. The 11th article and registering as a patent are also underway. A book of the activities has also been gathered which is under review. Also, the industrialization and commercialization are ongoing.