L.1: Machine vision based metrology system for end plates of PHWR fuel bundle

A machine vision based dimensional inspection system based on non-contact shadowgraph technique was designed and developed at RRCAT. The system will be used for measurement of dimensions of end plate. Pressurized heavy water reactor (PHWR) fuel bundle has two end plates welded on both the ends of the bundle. The system measures dimensions of these end plates before welding them on bundle. Dimensional inspection of end plate is an essential step for quality assurance of fuel bundle. Complex geometry of end plate pose challenges in measurement. Machine vision based systems provide non-contact, fast and multi-point measurement of end plate dimensions. These measurements are highly repeatable as compared to the manual measurements.

System consists of three sections: illumination optics, imaging optics and an embedded image processor. End plate placed on glass window is illuminated using LED placed at the focus of telecentric lens. Shadow of an end plate is captured by high resolution digital camera placed on opposite side of glass plate.

Fig. L.1.1: Photograph of machine vision based dimensional inspection system for PHWR fuel bundle end plate.

High quality telecentric optics is used to obtain high contrast and sharp edged shadow of the end plate. Figure L.1.1 shows photograph of machine vision based dimensional inspection system for PHWR fuel bundle end plate.

In-house developed inspection software running on embedded processor, processes this image (shadow of end plate) and then measures various dimensions of the end plate. Software has elaborate graphical user interface (GUI) for operating the system. On startup, validation of calibration using standard slip gauges is mandatory, user cannot by-pass it. Only after successful validation, GUI allows operator to enter in measurement mode. In measurement mode, the operator can enter lot number, batch code and other details. After this, operator can place an end plate in measurement area. The software captures the shadow of the end plate. Using captured image, software measures various dimensions of the end plate at multiple locations and reports its maximum and minimum values. The developed software allows user to perform calibration of the system using supplied calibration standards. Software has in-built diagnostic routine to check health of the system on startup.

All the measured dimensions of sample are displayed on the front panel of GUI with result as “Accepted”, “Rejected” or “Rework”. For authenticated user, software allows to set tolerance values for accept/reject/rework criteria. On request, software generates inspection report of lot/batch. Figure L.1.2 shows screenshot of inspection software for fuel bundle end plate dimensional inspection system.

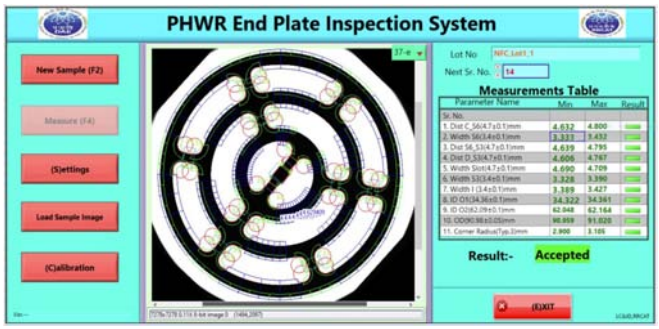

Fig. L.1.2: Screenshot of inspection software for fuel bundle end plate dimensional inspection system.

System has a field of view (FOV) of 100 mm diameter and measures 11 dimensions of end plates with an accuracy of ± 15 µm and repeatability of better than 15 µm. Overall throughput of the system is 3 end plates/minute. User friendly GUI allows operation of system by an un-skilled or semi-skilled operator as well. This system has been commissioned at Nuclear Fuel Complex (NFC), Hyderabad and is being used regularly for Quality Control / Quality Assurance (QC/QA) of end plates.

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