Profilometry of Fuel Rods with the Laser Scan Micrometer

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Abstract

In the hotlaboratory of the Paul Scherrer Institute (PSI) fuel rod inspection for nuclear power plants is performed periodically. The older system, using linear variable displacement transducers, is outperformed regarding accuracy, speed and maintenance effort. It was decided to design a non contact laser scanner. The laser scanning of fuel rods is now fully integrated in the non destructive resarches in the laboratory of material behaviour from PSI.

Keywords: Profilometry of Fuel Rods, Laser Scanning, Laser Scan Micrometer

1. INTRODUCTION

Fuel rod profilometry by non contact laser scanning is performed since this year in the hotlab of the Paul Scherrer Institute.
The design of the new laser scan equipment for fuel rods started in 2005. All tests in 2006 were successful and in 2007 the first fuel rods were measured in the hotcell of the PSI hotlab with the new high speed laser beam equipment. Higher accuracy in measuring the rod diameter over the rod length of about 4 meters including speed up the process is reached.

Boundary conditions:

- Measuring Range : diameters of 15–25mm
- Resolution < 1 micron
- Repeatability: < 1 micron
- fast installation set up and calibration
- compatible with existing hotcell
- high radiation resistance

The dimensions of the PSI hotcell, where laser scanning on the fuel rods is performed are 4800mm (l) x 2500mm (w) x 4100mm (h). The fuel rods are moved along the fix mounted laser scanner into a shielded extension (4650mm) on the backside of the hotcell. Electric connections are led through a lead shielded plug to pass the one meter thick concrete wall.
The Measuring includes the ovality of the rods in the midspan areas, the diameter on position 0 º /180º, 90 º/270 º, 45 º/225 º, 135 º/315 º. To guarantee the quality of the measurements, calibration before and after the process is done.

2. COMPONENTS

Laser Scanner: Mitutoyo LSM 506H
Specifications:

- Measuring Range : 1–60mm
- Resolution 0.05 micron
- Repeatability 0.5 micron
- Focal Point 163mm from Laser Emission Unit
- Display Unit: Mitutoyo LSM-6100

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3. DESIGN

To protect the laser unit against the radiation, the unit is positioned below the fuel rod (see fig 1) behind 50mm lead shielding. The laser beam is mirrored once on the fuel rod and back to the reception unit.

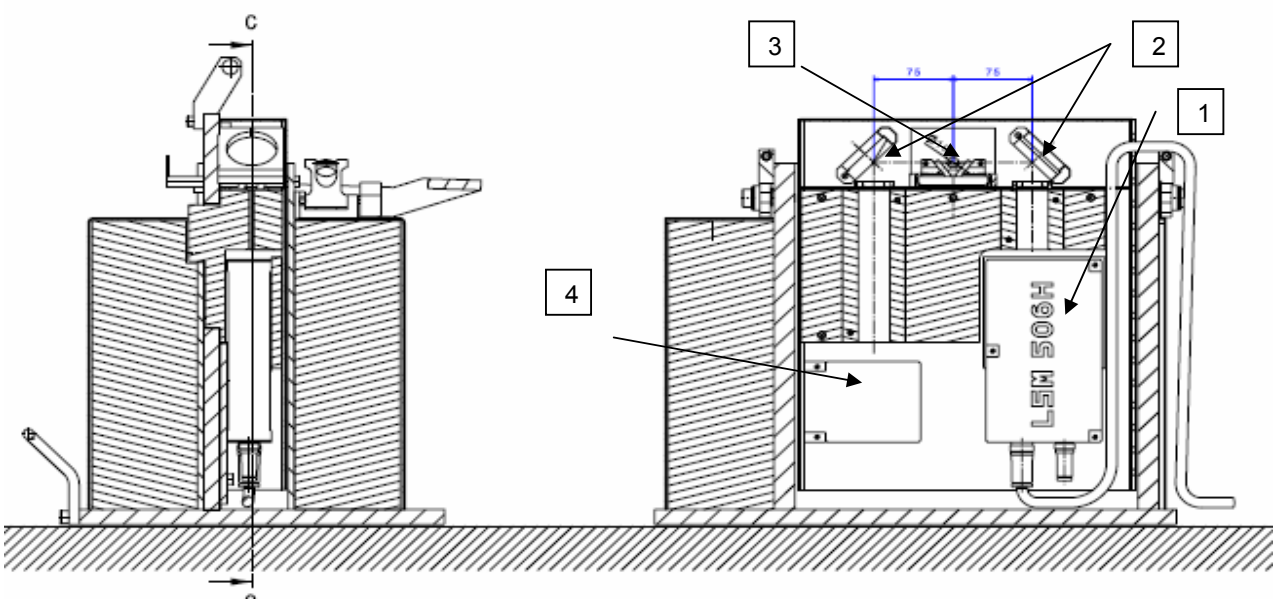

fig.1 Laser Scan Unit with Lead Shielding (1: Emitter; 2: Mirrors; 3: Fuel Rod; 4: Reception Unit

fig.2 Mirrors

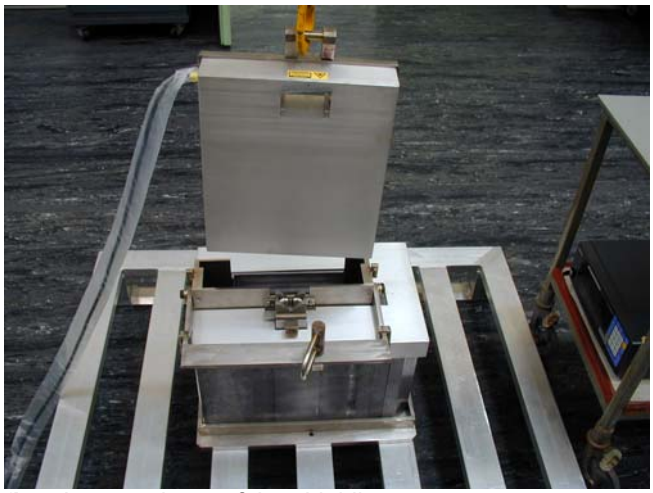

fig.3 Laser unit out of the shielding

4. OPERATION EXPERIENCES

- Set up and calibration is possible within one day
- Measure time for one rod (ovalitiy, diameter 0/180; 90/270; 45/225; 135/315; stepsize 0.5mm) →20hrs
- Accuracy <1micron

5. COSTS

Mitutoyo Laser Scanner	5‘000 Euro
Display Unit	2‘000 Euro
Mirrors	470 Euro
Designing Work	7‘000 Euro
Workshop	15‘000 Euro
Total	29’470 Euro

6. SUMMARY

- The new laser scanner is working well on fuel rods. Shielding is very important to keep a constant signal from the reception unit and keep the laser scanner working for a long time.
- The performance of the non contact laser profilometry is better than the old mechanical equipment, regarding accuracy, speed and maintenance.
- Set up and calibration of the unit within one day, measuring ovality in midspan areas and diameter in positions 0/180; 45/225; 90/270; 135/315 degrees , stepsize 0.5mm, over a length of about 4000mm within 20 hrs
- Accuracy < 1 micron is reached
- Costs about 30’000 Euros