L.1: Removal of coolant channel and cutting of thick end fitting inside lead shielding flask at KAPS-1

KAPS-1 reactor started commercial operation in May 1993 and was made operational again in 2011 after *en-masse* coolant channel replacement (EMCCR) campaign in 2009 using improved pressure tube material of Zr-Nb2.5%. However, in March 2016, one of the pressure tubes (Q-15) leaked leading to shutdown of reactor. Removal of Q-15 coolant channel was required from reactor core for post-irradiation examination (PIE) to study the reasons for failure of pressure tube. It was difficult to remove this channel by conventional mechanical methods due to obstruction from six feeder pipes and yoke assemblies of adjacent coolant channels from top and bottom. In view of high radiation field and restricted approach, an indigenously developed remotely operable laser cutting technique was deployed successfully for cutting of liner tube (4 mm thick) followed by cutting of end fitting (12 mm thick) from inner diameter of the tubes. After removal of outboard end fitting, bellow lip weld joint was cut from outside of the tube to remove inboard end fittings along with ~ 1m length of leaked portion of pressure tube. This in-situ laser cutting operation of Q-15 coolant channel was successfully implemented with minimum radiation dose consumption and in minimum time without any radiation hazard. Laser cutting operation using three different laser cutting fixtures was carried out in the following sequence: a) Cutting of PT using mechanical chip-less cutter by NPCIL from E-face, b) Laser cutting of 4 mm thick liner tube at a distance of 926 mm from E-face and from inside of the tube, then pulling it by 20 mm to create space for inserting laser cutting nozzle for cutting of end fitting, c) Laser cutting of 12 mm thick end fitting at a distance of 905 mm from E-face and from inside of the tube. After this cutting, outboard end fitting was removed and space of this tube got vacated, d) Using the space of outboard end fitting, laser cutting of bellow lip weld joint was performed using a new tool with miniature nozzle of 60 mm length, e) After cutting of bellow lip weld joint, it was separated mechanically and inboard end fitting was also removed.

A home-built 300 W average power pulsed Nd:YAG laser having four time shared fiber ports for beam delivery was deployed for laser cutting operation. This laser provides a maximum pulse energy of 100 J with variation in pulse duration in the range of 2-20 ms and repetition rate in the range of 1-100 Hz. For all the above mentioned operations, three different laser cutting fixtures and nozzles developed at RRCAT were deployed: one for cutting of liner tube, another for cutting of end fitting and third one for cutting of bellow lip. All the fixtures were motor driven and were operated remotely. Time for cutting of liner tubes, end fittings, and bellow lips were 4 minutes, 12 minutes, and 18 minutes, respectively. For cutting of bellow lip, a miniature nozzle of only 60 mm length and 20 mm diameter was used to avoid any obstruction during cutting due to small axial gap of only 75 mm for nozzle rotation.

The total length of inboard end fitting along with PT was large to be handled in hot cell for PIE. Thus, cutting of inboard end-fitting near roll joined area, at a distance of ~1100 mm from its face, where the thickness of end fitting was 18 mm, was required. The tube had a radiation field of about 7000 Rad/hr. and cutting was required to be done from inside the tube, remotely in a closed lead shielding flask blindly. This was a challenging task. Remotely operable laser cutting tools for inboard liner tube and end fitting near rolled joint area was developed along with laser cutting technology for 18 mm thick end fitting in single pass. Online monitoring of cutting from inside of the flask was also developed to visualize the status of cutting operation. This remotely operated laser based cutting technology for cutting of highly radioactive end fitting in shielding flask was deployed successfully for the first time with minimum radiation dose consumption. This laser cutting operation was completed in a very short time span of ~2 hours without any airborne activity or radiation hazard. Debris generated during laser cutting process was passed through a HEPA filter. After this activity, cracked/leaked portion of pressure tube of Q-15 has been sent to BARC for PIE and analysis. Figure L.1.1 shows laser cutting fixture for cutting of 18 mm thick end fitting and Fig. L.1.2 shows laser cutting of 18 mm thick end fitting in lead shielding flask.

Fig. L.1.1: Laser cutting fixture for 18 mm thick end fitting in lead shielding flask

Fig. L.1.2: A view of laser cutting of 18 mm thick end fitting in lead shielding flask

Reported by:
B. N. Upadhyay (bnand@rrcat. gov.in)
on behalf of LDIAD and LED Team