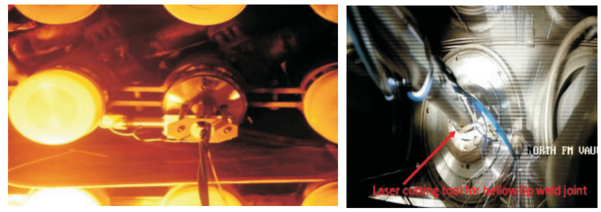
L.1: Laser cutting technology for removal of single selected coolant channel of 540 MWe TAPS-3&4 reactors

Indian nuclear power reactors TAPS-3&4, each of 540 MWe capacity, started commercial operation in 2005. As per *in-situ* inspection plan, BARC Inspection System was carried out in 2017. During volumetric examination of coolant channels, L-8 channel of TAPS-4 was observed to have some flaws in pressure tube (PT) main body. Regulatory clearance for power operation of TAPS-4 recommended that channel L-8 should be removed at the earliest for Post Irradiation Examination (PIE).

Earlier, laser cutting technology for *in-situ* removal of single selected coolant channel of 220 MWe from a matrix of 306 coolant channels under severe space restrictions was developed and successfully deployed at KAPS-1, KAPS-2, RAPS-4 and KGS-1 reactors during past few years. However, 540 MWe nuclear power plant has 392 coolant channels and design of coolant channel is different as compared to 220 MWe reactors. Further, bellow weld joint is also of different type as it is welded with lattice tube. As nearby space of the channel was obstructed by six feeder pipes from top and bottom along with yoke assembly of nearby channel, so it was not possible to approach directly for cutting of bellow weld joint to remove this channel. In view of obstructions and narrow space, remotely operable laser cutting technology for liner tube, end fitting, bellow weld joint with lattice tube and bellow ring detachment from bellow was developed along with tools and fixtures. It has been successfully used for *in-situ* removal of L-8 coolant channel of TAPS-4 reactor.

Indigenously developed fiber coupled pulsed Nd:YAG laser of 250 W average power and 5 kW peak power was utilized for *in-situ* laser cutting operation. Four different type of tools were designed and developed for laser cutting of liner tube and end fitting, bellow lip cutting, bellow ring detachment and PT stub cutting. Laser cutting of liner tube (4.2 mm thick SS304) was carried out at 1560 mm from E-face and end fitting (13 mm thick SS410) was carried out at 1520 mm from E-face. After removal of outboard end fitting, bellow weld joint with lattice tube was cut using laser and separated from lattice tube. Further, ring attached with bellow was also detached by laser cutting using a 45° bending compact laser cutting nozzle. After this cutting, inboard end fitting and pressure tube were removed. Figure L.1.1 shows laser cutting tool for liner tube and end fitting. Figure L.1.2(a) and Figure L.1.2(b) show *in-situ* laser cutting of end fitting and bellow lip weld joints, respectively.

Fig. L.1.1: Laser cutting tool for liner tube and end fitting of 540 MWe TAPS-4 reactor.



(a) (b)

Fig. L.1.2: In-situ laser cutting of (a) end fitting, and, (b) bellow joint of L-8 coolant channel of TAPS-4 reactor.

After laser based removal of coolant channel, it was also required to retrieve PT stubs from both the ends of end fittings for PIE studies. It was challenging task due to (a) high radiation field from end fitting of ~1000 Rad/hr. and (b) risk of airborne activity during underwater laser cutting and PT stub retrieval process. As compared to 220 MWe reactor PT (ID 82 mm, thickness 3.6 mm), 540 MWe PT has a larger inner diameter and larger thickness (ID 103.4 mm, thickness 4.3 mm). Further, in the case of 220 MWe reactor, outboard and inboard end fittings are welded and HEPA filter is connected with feeder coupling hub of outboard end fitting. However, in the case of 540 MWe reactor, due to much longer length of end fitting, PT stub retrieval was performed without welding of outboard end fitting with inboard end fitting. Thus, a new laser cutting tool of ~1.5 m length along with controller and cutting process was developed and tool locking was done from ID of inboard end fitting. In this case, a vent was provided through laser cutting tool for connection with HEPA filter to filter air released from water during underwater laser cutting process. Each PT stub was ~125 mm long and four circumferential cuts were carried out. Total laser cutting time for each PT stub was ~3 hrs. There is no alternate technique for retrieval of PT stubs except underwater laser cutting. Further, non-contact nature of laser cutting helps in retaining stress properties of PT after long irradiation and underwater laser cutting also minimizes heat affected zone, which are vital for analyzing irradiated PT stubs for life extension studies. This laser technology was successfully deployed at TAPS-4 for removal of L-8 coolant channel for PIE studies on pressure tube and PT stubs without any radiation hazard. After safe removal of L-8 coolant channel, reactor was started again for power generation.

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