L.2: Laser surface texturing produces anti-bacterial surface on 304L stainless steel

In nuclear power plants, type 304/304L stainless steel (SS) is used as the condenser material in fresh water cooling systems. During its service, microbes present in the natural water form biofilm and initiate pitting corrosion in the condenser tube. In this regard, corrosion resistance of materials in cooling water systems can be effectively enhanced through development of a surface inhibiting bacterial attachment. The present experimental study, performed in collaboration with LDIAD, RRCAT and CSTD, IGCAR, was taken up with an objective to generate antibacterial surfaces on type 304L SS through laser surface texturing.

Laser surface texturing was performed with a 20 W average power pulsed Nd:YAG laser (λ = 1.064 µm). Two predominant biofilm formers in the fresh water reservoir at Kalpakkam viz. gram-negative *Pseudomonas sp*. and gram-positive *Bacillus flexus* were selected for bacterial exposure studies to evaluate antibacterial activity of the SS surface. The surface sterilized specimens were exposed to bacterial cultures for 6 hours in an incubator at 37 °C. The bacterial density in the biofilms on SS surface was quantified by total viable count (TVC) method as per APHA1989 standards and visualized by epifluorescence microscope. After incubation, bacterial colonies were counted and calculated as colony forming unit (cfu.cm^{-2}).

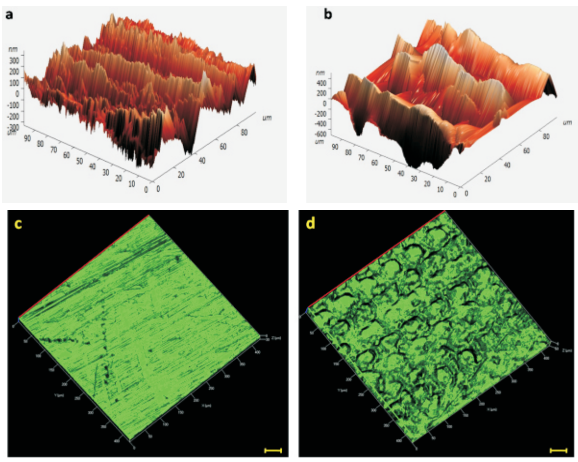

Fig. L.2.1: AFM micrographs of (a) as polished and (b) laser textured surfaces of 304L SS specimens; 3D confocal micrographs (c) as polished and (d) laser textured surfaces. Scale represents 50 µm.

Laser surface texturing brought about an increase in mean surface micro-roughness over untreated (polished) specimens. The mean roughness of as polished 304L SS and laser textured specimens, as determined by AFM were 66 ± 5 nm and 146 ± 7 nm, respectively (Figure L.2.1). With respect

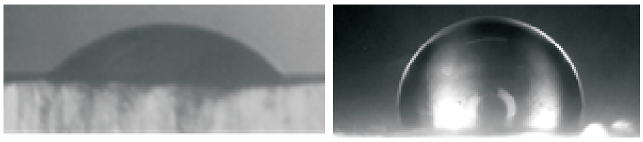

Fig. L.2.2: Profiles of water drop on (left) untreated and (right) laser textured 304L SS surfaces.

to untreated specimen, laser textured surface displayed enhanced hydrophobicity (Figure L.2.2). The contact angles of untreated and laser textured surfaces were 40° and 110°, respectively. With respect to polished surface, laser textured surface displayed two order reduction in the attachment of bacterial cells, thereby confirming good antibacterial activity on laser textured surfaces (Table L.2.1).

Table L.2.1: Results of bacterial exposure study.

Bacterial cultures	As received 304L SS (cfu/cm^2)	Laser textured 304L SS (cfu/cm^2)
Pseudomonas sp.	6.7±0.3 x 10^5	2.4±0.2 x 10^3
Bacillus flexus	2.8±0.1 x 10^5	3.1±0.4 x 10^3

Figure L.2.3 presents epifluorescence micrographs of biofilms of *Pseudomonas sp*. and gram-positive *Bacillus flexus* on untreated and laser textured 304L SS specimens. In this figure orange red fluorescence represents active bacterial cells while green fluorescence represents lesser active cells.

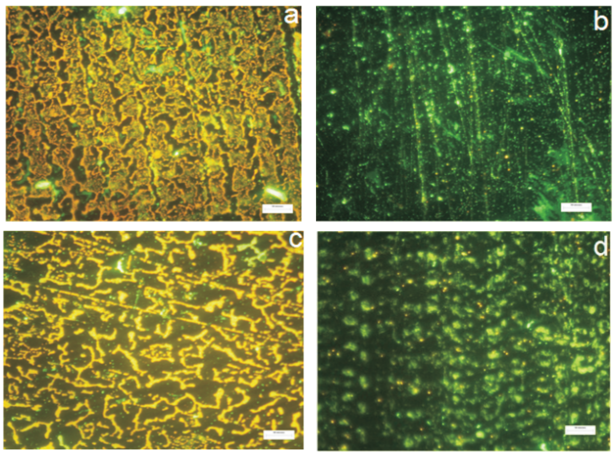

Fig. L.2.3: Epifluoromicrographs of AO stained surfaces with Pseudomonas sp. on (a) as polished and (b) laser textured 304L SS; with Bacillus flexus on (c) as polished and (d) laser textured 304L SS. The scale bar represents 50 µm.

Significant enhancement in antibacterial activity on laser textured surface is contributed by patterning of protrusive structures generated by laser texturing and associated increase in hydrophobicity.

Reported by:
Ram Kishor Gupta (ramgupta@rrcat. gov.in)