ABSTRACT

The brewing industry is amongst industries that fall under health legislation. Progressively legislation has become more stringent in terms of bacterial load limits and process options. In addition water has become a scarce resource, now supplied from municipal, not private sources. The aim of the study was to consider methods that would assist clean-in-place (CIP) process in controlling and/or eliminating biofilms formed on pipes and process vessels in the brewing industry.

In the brewing industry CIP is the current method of choice to control biofilms, however, it both uses large quantities of water and does not seem to be fully meeting the required purpose. An increase in cases of material failures and product contamination caused by microbiologically influenced corrosion (MIC) and spoilage bacteria is evident in the sector. The current research addressed the possibility of the use of low-frequency ultrasound waves (power ultrasound) to assist the CIP process in “hot spot” contamination areas, so reducing the CIP need, saving water and improving performance using an environmentally-friendly process.

Pilot studies showed that sonication (cavitation in liquid) at 24 kHz reduced simulated *E. coli* biofilms grown onto 316L stainless steel coupons with different weld treatments with disinfection efficiencies of ≥ 80%. The second part of the study involved real biofilms formed on a small experimental rig. The rig was made up from interconnected lengths of 60 mm OD, schedule 40 316L stainless steel pipes. These were subjected to different welding preparations and post welding treatments. Municipal water was circulated through the setup

for two sets of five week experiments, each at different flow velocities to enable the growth of biofilm.

It was demonstrated that water supported biofilm growth and its treatment is of utmost importance. In addition, it was shown that ultrasound waves could pass through metal surfaces and clean the inside surfaces but the efficiency of the process ranged between 10 and 100% with regards to removal of biofilm because the thicknesses were high (3.91 mm for SS pipes and 3 mm for SS coupon plates), the clamping device used was heavy (1001 g) and also the device had to be under water for effective cooling during operation.

There was increased concentration of biofilm on and around weld areas include heat affected zones (HAZs) and it was difficult to control biofilms around such areas due to increased roughness. This was because welding introduces rough surfaces, geometrical difficulties (over-penetration and under-penetration), and gave wrought structures (formation of iron oxide or separation on grain boundaries). From the study it was observed that using 316L fillers resulted in better biofilm control than using 904L fillers (even though 904L welds had copper as a biocide) except when the welds were pickled and passivated. In this case 904L fillers resulted in lower intensities than 316L fillers. It was also observed that welding in the presence of argon gave better welds that resulted in reduced biofilm formation.

On top of that, flow direction and pipe position influenced biofilm formation, its control and the CIP process. This led to the conclusion that the CIP process to date was observed to be ineffective against biofilms and it became less effective with continuous use of pipes and process vessels. It was observed that the CIP process became less effective along pipe lengths and process vessels i.e. the further, the pipe or vessel from the CIP source, the less effective was the process.

The test for ultrasound was done by applying ultrasound waves indirectly to pipe walls in a water bath by clamping the sonication device to the pipe walls. This was so because in practice internal access results in non-sterile and impractical situation in a production environment.

The knowledge gained further enhanced the likely success of using ultrasound waves as one of the future methods for biofilm control in the food and beverage industry as it is easy to apply, and is an environmentally-friendly operation.