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Design optimization of Cathodic Cage Plasma system via COMSOL for nitriding of AISI 201

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Cathodic Cage-based plasma nitriding (CCPN) is a versatile surface treatment technique that can modify and improve the surface properties of both metallic as well as non-metallic samples for various applications [1]. However, designing a CCPN system is a cumbersome task due to the variation in the ion flux on the sample upon altering the design parameters. Several design factors i.e. size and shape of the cage, height and placement of samples, inter-electrode and electrode-sample separation, etc. alongwith different operating parameters play a vital role in the adherence, porosity, diffusion and hardness of the nitride layer [2].

Austenitic steel AISI 201 is a less expensive non magnetic alloy having lower concentration of expensive Ni content which drastically affects its corrosion resistance. AISI 201 can be a suitable substitute of AISI 301 provided the hardness and wear resistance can be improved. Nitriding, at temperatures around 500°C, has proven to be an effective methodology to increase the hardness and wear resistance of stainless steel of 300 series but the formation of chromium nitride effectively reduces the corrosion resistance[1]

In this work, a cathodic cage plasma system is optimized for various design parameters via COMSOL Multiphysics. Keeping the, chamber size and shape constant, the optimized parameters are used to design a CCPN cage, sample holder, sample-electrode spacer and sample heater to perform nitriding on different substrates. The optimized system is used to perform the nitriding of AISI 201 at temperatures below 500°C. The temperature dependency of the nitride layer is confirmed using XRD, SEM, EDX, microhardness, etc.

References
[1] M. Naeem *et al*, Surface and Coatings Technology, 464, 129542.(2023)
[2] R.R.M. de Sousa *et al,* Vacuum 86,2048(2012)

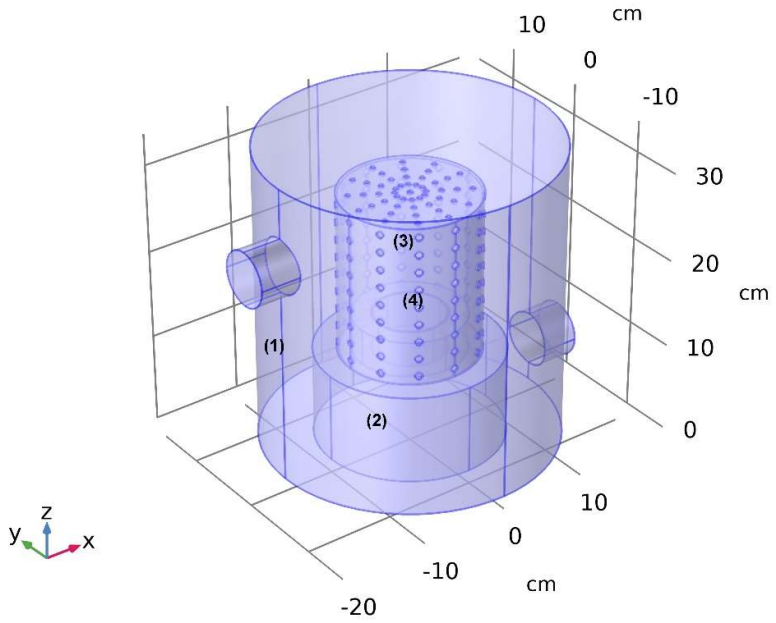

Figure 1. CCPN model used for simulation in COMSOL Multiphysics.