INDIAN WELDING JOURNAL Volume 57 No. 1, January 2024

Artificial Intelligence / Machine Learning in Welding

Surendra Vaidya
Advisor- Technical
Godrej and Boyce Mfg. Co. Ltd
Email: smvgodrej@gmail.com

Welding as you all know is a process where we cast material drop by drop and since material gets heated up requires adequate protection and ensure that it gets fused properly along the joining faces or two of the edges getting joined. Since we melt material and for good fusion, parent material also gets melted and due to conduction, convection and radiation from arc surrounding material also gets heated up. In short, we see melting of material and thermal cycles in the material which are varying across the weld area and keeps on moving as the weld progresses.

Welding engineer must take care of compatible consumables, protection with flux or gas, good joint design which will give accessibility and fusion, cleaning pre- during and post welding, pre heat and post …. While welder must monitor above parameters and while using pre-qualified parameters also manuevre source of heat and consumables in such a way that while welding no defects are developed and joint is fully filled with expected penetration and reinforcement…. For most of the welding where geometries are regular like long seam and circumferential seams and use of manipulators, we often weld in same position, however if position is changing due to some limitations in manufacturing welder needs to weld in different positions and gravitational forces and shielding by gas or flux may also vary and welder needs to be careful.

Experienced welding engineers and welders based on the learning and experiments can specify in WPS and take decision while welding is on. While qualifying PQR or for WPQ on test plate conditions are highly conducive and passing through NDT norms and physical test may not be a big challenge unless metallurgy of base material is not exotic, materials getting joined are not same, properties demanded requires a very narrow band of welding and sometimes demand from preventing distortion or fusion defects are not allowing parameters for certain properties to be achieved. In such cases welding engineer and welder must work cohesively while joining and ensure all properties are met. Second criteria while welding on the job from PQR/ WPQ plates is environment, adequate protection in different positions and geometries like welding nozzles on shell and dish ends, branch pipes, pipelines connecting different vessels, elevation at which we are welding play an important role. Many parameters in such complex conditions or where NDT is very stringent becomes difficult to manage and it gets further aggravated if it is manual welding. While an experienced welder can do miracles in manual welding specially when joint fits are not that good as per WPS due to various fabrication, process constraints, it also gives variation in speed, jerks and variation in arc length… Combination of all these may impact desired results in terms of properties, like impact, corrosion resistance, creep, distortion level, this makes us to think of using latest technology of AI and ML.

As a starting point first, we need to build a data bank, starting from test plates to weld in various possible situations and asking welder or welding engineer to weld using parameters that they will find most appropriate. All the essential and non-essential parameters shall be recorded and tabulated against the NDT results and physical properties. In second step carry of design of experiments and try and achieve defects or varying physical properties (Please note such deliberate attempt of getting different properties is not that easy) and tabulate them. Third step this will indicate 3-5 very critical and must be adhered parameters. Now in forth step got to your library of IoT sensors and start implementing one by one like temp, surge in voltage, video camera, varying Arc Voltage, speed, strain and start measuring by locating them on job or on fixture such that it will not affect ease of welding. In the fifth phase

start converting huge data that will start coming from these sensors to select the best frequency so that data is minimized, in the sixth step, start plotting mathematical model and equation of if this happens this is what is predicted for individual parameters first and then combined parameters, in the seven step run your model for varying parameters and predict what is going to happen and experiment it to check how good is your predication. In the ninth step, correct the minor variations if any or rewrite if predications are far varying. Once you have a confidence in the model and program you developed implement on the job and keep on updating towards perfection.

These ten steps are easy to write down, a welding engineer with his team of welders once understood the importance of skill levels, expertise, and experience and how difficult it is to transfer such tactical data by just writing down few notes or instructions or practically demonstrating it to new team. Like we see dramatic improvements in CNC machines and CMM in inspections, welding also can be converted into AI/ML if welding engineer, welder and fabrication, NDT team will work together. Electronics and sensors if located at the right place and right information is collected can reduce skill, automation or semi automation will be easy and rather than wasting time in rectification which is very expensive can give ROI from above ten steps in the first one or two jobs by delivering on time and reducing defects to less than 0.5% which is working out international norm. Once you are on time, your cost of production will reduce drastically and your estimates while quotations will be better, so it has multiple benefits. Welding will no longer be art but will be well understood science and will be highly predictable.