CONTRIBUTION OF ELECTRIC ARC TO THE MICROSCTRUTURE OF HARDENABLE STEEL IN HIGH-PENETRATION LASER-ARC WELDING PROCESSES

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RESUME

Welding is present in all industry sectors. In the construction, repair and maintenance activities of thick structures, welding is the main manufacturing process used, with the purpose of granting structural integrity of the joints. In addition, more productive welding processes directly influence costs, schedules, risk analysis and project feasibility. When using conventional arc welding processes in thick plate and pipe joining applications such as the GMAW process, pre-chamfering of the joint is required, allowing metallurgical joining in its full thickness. Thus, in addition to joint chamfering, consecutive welding processes are required to fill the produced chamfer, thus dramatically affecting the processing time and input consumption. One option for this problem is the use of laser beam welding processes (LBW). Unlike arc welding processes, LBW allows to achieve high penetration depths, thus removing the need for prior joint machining. However, the process has several limitations and disadvantages when compared to the GMAW process. Still in the late 1970s, Steen W. demonstrated the possibility of using both heat sources (laser and arc) in a single hybrid process, enabling the emergence of a new field of welding process research. Hybrid laser-arc welding processes (HLAW) are notoriously regarded as promising joining processes as they compensate for the limitations of laser and arc welding using both techniques in a single melting pool, achieving high accuracy and speed, good flexibility and low deformation or distortion. Still, rarely approached in the literature, the addition of the electric arc to the laser beam also has several metallurgical

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advantages. This work proposes the microstructural comparison of weld beads produced from high-penetration LBW and HLAW welding processes on ASTM A516 GR70 substrate. The tests were conducted from metallographic preparation and optical microscope analysis of the cross sections of the weld beads. The micrographs were analyzed and the observed microstructures were then related to their thermal causes, thus correlating with the causative agents in the processes. Clearly, the formation of harder microstructures in the weld bead produced by LBW was evidenced, with the presence of martensitic structures with superior bainite grains. While in the weld bead produced by HLAW, it was observed the formation of tempered martensite, superior bainite, refined perlite and acircular ferrite structures. As the lase power and the materials used remained fixed, the aid of the electric arc in the formation of microstructures with less fragility in welding is evident. This fact is justified by the different power densities generated by the processes. Thus, as the GMAW process melting pool has a lower thermal density, it will cool more slowly, assisting with thermal control after weld solidification.

Keywords: ASTM A516 GR70, HLAW, LBW, MIG/MAG, quenching.