Abstract

High performance pipeline steels are frequently used for storage, transportation and energy development applications. Pipeline steel works under severe service environments such as corrosive, low-temperature and high pressure conditions. In seismic and sea bottom areas long-distance pipes continuously suffer from internal as well as external water wave forces. Long distance pipes are connected by various smaller pipes by welding joints. These weld joints are more prone to failure due to external conditions such as corrosion, low-temperature and low or high pressure operations. Due to this demand for high corrosion resistance, high strength, low temperature toughness, high wall thickness and better strain capacity is required for pipeline performance. With continuously increasing demand of API grade pipeline steel the significant methods of joining these steels also increased. Due to various inherent qualities such as smooth finish, deep penetration, easy control and welding thicker sections submerged arc welding is the most suitable process for welding of thicker pipeline steels in different applications. In SAW welding both the base metal and weld electrode are melted underneath a blanket of flux. Due to excessive heat generation the protective bed of flux shields the molten metal from contamination and oxidation and concentrates the total heat into the joint. Flux (rises above the weld pool) in submerged arc welding plays an important role in cleaning the molten metal. Various physicochemical and electrochemical reactions are taking place in the weld pool during submerged arc welding. Physicochemical and thermophysical properties of fluxes widely affect the mechanical behaviour of weld metal because different oxides from fluxes disintegrate in the weld pool during slag-metal interactions. Suitable selection of flux compositions are not clear and patented, so fluxes for submerged arc welding of high strength low alloys steels are not readily available. In present work, an attempt has been made at the development and optimization of flux composition for submerged arc welding of pipeline steel (API X70). Extreme vertices design approach was used to formulate the twenty one agglomerated fluxes for three flux systems such as basic, rutile basic and rutile acidic. Regression models for density, grain fineness number, weight loss, change in enthalpy, thermal conductivity, thermal diffusivity and specific heat in terms of flux components were developed. At constant welding parameter multi-pass bead on plate weld deposits experiments were conducted using formulated fluxes for three flux systems. Regression analysis of multi-pass bead on plate weld deposits properties such as bead chemistry, average grain size and average microhardness was performed. ANOVA (F-Test) for the regression equations has been checked for developed models for 95% adequacy. Adequate fluxes from three flux systems were selected by qualitative analysis during multi-pass bead on plate weld deposit analysis. Two fluxes from three flux systems were selected for final submerged arc welding. Mechanical properties of weld joints such as tensile strength, impact strength and microhardness was evaluated and compared with the SAW commercial available flux. Microstructural behaviour of weld as well as HAZ specimens was also analysed. Hydrogen induced cracking measurements for weld and HAZ specimens were performed and compared with commercial available SAW flux.