Alloy 699 XA® Tubes for Application in Petrochemical and Power Generation Industries under Metal Dusting Conditions

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Metal dusting is the disintegration of metals and alloys into a dust of metal particles, oxides and graphite in the form of pitting or general attack. The following factors are well-known to be involved in corrosion by metal dusting:

- Environment: gas phase, potentially carburizing and reducing with or without oxygen, i.e., mixtures of CO, H\textsubscript{2}, H\textsubscript{2}O and CO\textsubscript{2}.
- Temperature: usually 450°- 800°C.
- Form: pitting and/or general overall surface consumption via carburization.
- Product: dust or powder composed of graphite mixed with metal, metal carbides and metal oxides.

Metal dusting is a common problem in the petrochemical and power generation industries. The US Department of Energy calculated annual savings of $220-290 million only in hydrogen production if the limitations caused by metal dusting would be eliminated.

Fe base, Ni base and Co base alloys when in contact with hot reactive gases with high carburization potential are susceptible of corrosion by metal dusting. In the specific case of stainless steels, metal dusting is typically triggered by formation of carbides, cementite and/or graphite in the microstructure. A way to gain protection against metal dusting in this type of steels is to improve the nature of the protective oxide layer, as it acts as a barrier preventing the entry of carbon into the steel microstructure.

TUBACEX, as a leading Multinational Group devoted to manufacture seamless tubes in stainless steel and high-nickel alloys and superalloys, in collaboration with VDM Metals, as a leading producer of high performance materials in metal, are working in the development of an alloy to prevent metal dusting, Alloy 699 XA®. This alloy is intended to show superior metal dusting resistance compared to already existing alloys, such as Alloy 602 CA®.

The present study focuses on the development of Alloy 699 XA® tubes for application in petrochemical and power generation industries under metal dusting conditions. Alloy 699 XA® bars, manufactured by VDM Metals, were used as raw material to produce hot and cold-finished tubes in TUBACEX. Every step of the tube manufacturing route, i.e., hot and cold forming processes, solution annealing treatment, finishing operations and inspection procedure, was carefully designed and controlled to obtain final tubes with an optimized microstructure and surface quality, which guarantee the optimal mechanical, oxidation and corrosion properties.

The hot and cold-finished Alloy 699 XA® tubes produced were extensively tested. Different microscopy techniques were used to characterize the tube microstructure. Mechanical properties at room and high temperatures were evaluated. Resistance against metal dusting was tested at laboratory scale with promising results. Additionally, tube samples have been introduced in real equipment to check the performance under real conditions. Alloy 699 XA® tubes are presented by TUBACEX as the perfect alternative against metal dusting.