Thermit welding of chromium-vanadium rail steel

H. D. Fricke (U.S. Thermit Inc.)

Thermit welding techniques are discussed with particular reference to short preheat cycles and its suitability to the welding of high-strength chromium-vanadium rails. The composition of the Thermit steel used is adjusted to match the phase-transformation characteristics of chromium-vanadium steels. To avoid a martensitic or bainitic structure in the finished weld, the cooling cycle must be controlled.

1. INTRODUCTION

Thermit welding has been applied as a regular welding process since 1898, when the aluminothermic reaction between a metal-oxide and aluminum was discovered by Hans Goldschmidt. This type of reaction is characterized by its exothermic nature. Due to the difference of free energy between a metal-oxide and aluminum-oxide, sufficient heat is generated to produce liquid steel or any other metal and alloy without applying energy from outside. All components for the aluminothermic process are used as granules or powders. Once the reaction is initiated by an external heat source, the aluminum reduces the oxygen from the metal-oxide, which will result in a liquid superheated metal and aluminum-oxide (Al_2O_3). Since these two components are different in density, they separate automatically and the liquid metal can be utilized for different welding applications, or just for the production of special metals or alloys.

Thermit welding had its most important large-scale technical application during the early part of this century as a process for joining heavy cross-sections for machinery, millhousings, rudderstocks, stern frames and pinions, but the welding of rail sections has become more and more important with the widespread installation of continuous welded rail. While the majority of rail steel is still rolled according to the AREA or UIC specifications, the continuing development towards faster speeds, higher axle loads and increased train frequencies has led to increased requirements for rail steels with improved mechanical properties. The common carbon-manganese rail steels do not satisfactorily withstand these parameters and show gross plastic deformation and abrasive wear after relatively short periods of time. This has led to the development of special alloyed rail steels with higher yield and tensile strength.

During the course of development of these alloyed rail steels, one major demand has always been taken into consideration, that is weldability by both the in-plant welding as well as field welding processes such as Thermit welding.

2. RAIL STEEL TYPES

Since the time the first alloyed rail sections were rolled by various steel mills, extensive research has been done in our metallurgical laboratories to develop Thermit portions for this new type of rail. The welding parameters had to be changed in order to avoid critical cooling rates in the weld, as well as the adjacent heat-affected rail sections, since, generally speaking, alloyed rail steel has different transformation temperature characteristics which will result in embrittled bainitic or martensitic microstructures where the

Table I. Chemistry of various alloyed rail steels

	Chemical Composition							
Manufacturer	C, %	Si, %	Mn, %	Cr, %	Mo, %	V, %	P, %	S, %
A	0.55 to 0.75	Max. 0.70	0.80 to 1.30	0.80 to 1.30	–	Max. 0.30	Max. 0.03	Max. 0.03
B	0.65	0.50	1.00	1.00	Max. 0.15	Max. 0.20	Max. 0.03	Max. 0.03
C	0.65 to 0.80	0.30 to 0.90	0.80 to 1.30	0.70 to 1.20	–	–	Max. 0.03	Max. 0.03
D	0.68 to 0.78	Max. 0.35	1.10 to 1.40	1.00 to 1.30	–	–	Max. 0.04	Max. 0.03
E	0.76	0.84	0.37	1.49	–	–	0.02	0.02