Field Welding Rail

Effective rail welding, both plant and field, has been the subject of considerable past research. In fact, a special symposium dedicated exclusively to railroad rail welding was held in 1983. However, recent research has focused particularly on the subject of the field welding of rail.

Of two recent studies into this subject, one addressed field welding in a general vein, covering conventional thermite (aluminothermic) welding along with other field welding techniques.[2] The second study focused on the determination of strength and other structural properties of thermite welds applied in premium rails.[3]

Analyzing available processes

In reviewing the various types of welding processes, there appear to be several having potential application in the field welding of rail. These are presented with selected parameters in Figure 1.[2-4]

One way of classifying suitable processes for rail welding is by their heating power densities (see Fig. 1). The techniques which produce a relatively low heat input (less than 1000 W/cm²) also require the lowest cost equipment short weld preparation time, and little or no preheat. However, those processes which produce higher heat inputs (more than 100,000 W/cm²) also call for expensive equipment, significant weld preparation, and preheating. It appears that the techniques requiring lower heat input lend themselves most readily to rail welding in general and field welding of rails in particular.

The thermite welding process is the most widely used field welding procedure in North America. When properly performed, it will produce welds of "suitable

Welding Process	Heating Power Density (W/cm²)	Heating Time (sec)	800 to 500°C Cooling Time (Without Preheat)	Preheat Required to Prevent Cooling from 800 to 500°C in less than 20 sec.	Cost of Equipment Time	Weld Preparation Grinding	Amount of Post Weld
Thermite	400	200	200	none	very low	short to moderate	large
Oxyacetylene	400	200	200	none	low	short	large
Flash Butt	600	150	100	none	moderate to high	short	large
Electroslag	200	600 to 1,000	400	none	low	short to moderate	large
Arc	3,000	10	30	200 to 300	low to moderate	short to moderate	moderate
Homopolar	100,000	1	5*	?†	high	moderate to long	large to moderate
Electron Beam	1,000,000	0.2	1*	500	very high	long	small
Laser	1,000,000	0.2	1*	500	very high	long	small

*At these very short times, the simple analysis given here begins to become incomplete.

†Volumetric heating may provide adequate "Preheat."

Figure 1 — Estimated Parameter Values for Selected Rail-Welding Processes

strength and integrity" for railroad use.[2] However, the welds obtained are characterized by low ductility and low impact toughness.[2] In addition, if the thermite welds are "improperly made," casting imperfections can occur such as shrinkage cracks, slag entrapment, or porosity defects. Depending on the shape and size of these defects, the strength of the weld can be reduced. Correspondingly, the weld's susceptibility to fatigue can be increased.[2]

Two other welding techniques, both with similar heat density inputs to that of the thermite welding process, appear to have potential application in the field welding of rail. These two processes are *gas pressure welding* and *enclosed arc welding*. They also require relatively low initial investment in equipment, along with little or no weld preparation. In addition, the two offer a potential for producing field welds with better ductility and improved impact toughness of the weld metal.[2]

Gas pressure and enclosed arc welding of rail appear to attain improved bending fatigue properties, together with increased static bending strength. These two alternative welding techniques have been used overseas for the field welding of rail.

Thus, it appears that the alternative procedures noted, together with proper inspection and maintenance, can provide maintenance officers with added options in caring for that potential weak point in the rail, the weld.

References:

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3. Schroeder, L. C. and Poirer, D. R., "Structure and Properties of Thermite Welds in Premium Rails"; Federal Railroad Administration Report DOT/FRA/ORD-85-02, December 1985.
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