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An experimental investigation on flash butt welded rails

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ABSTRACT

In this paper, experimental studies performed for flash butt welded rails used in Turkish railways network having 49E1 and 60E1 rail sections are presented. These studies comprise of full-scale laboratory tests such as four point bending fatigue and three-point slow bending tests, as well as related instrumentation of test specimens and data measurement. Fatigue and bending tests are prepared and carried out in accordance with EN 14587-2 standard. The fracture surfaces of the welded samples are examined to identify the associated failure modes. The fatigue test results are superimposed on a S–N diagram derived from earlier results reported as a part of the European Commission steel rails research project. A best fit curve following an exponential function is derived to describe the load deflection behavior of the weld under the slow bend testing conditions. It is shown that a single component of the equation defining the best fit curve is the factor controlling the scattering in the non-linear part of the load deflection curve, and hence control of this parameter can also be used to impart consistency to the welding process.

1. Introduction

Reliability of welds and signaling systems used for rails are two of the most important factors affecting safety and comfort of railways directly. Rails are joined by using various welding methods for construction of additional railway lines as well as for replacement of old or defective rails in the field. The two most common welding procedures used for joining rails are aluminothermic and flash butt welding techniques. Flash-butt welding is a resistance type welding procedure and can be applied by using mobile welding machines or in a fixed plant. Aluminothermic welding is essentially a casting process and used to join the rails in the field and eventually to form a continuous rail track.

Flash butt welding technique comprises the use of high current to produce a solid phase weld between the two rail ends. The two rails are held between water cooled copper dies acting as both clamps and electrodes. The first stage in the flash butt welding sequence is generally called as the Burn-off or the Pre-flashing stage. During this stage, the rail ends are slightly separated, and after initiating arcing between them a stable temperature distribution is achieved and the rail ends are squared up. In order to initiate flashing easily, a preheating is needed where the rail ends are heated to a sufficient temperature. To maintain rail end squareness, 1 s to 10 s duration is allowed between each preheating stage as well as a very short period of flashing from 0.5 s to 1.5 s, too. During the flashing stage, the interfaces of rails become molten so that the appropriate conditions for the final upset are completed. While the welding machine moves with a constant acceleration, number of flashing arcs across the weld interface and the resultant increase in the frequency, so that the oxygen content at the weld interface is sufficiently reduced to introduce a semi-protective atmosphere. In the final flashing stage, it is aimed that a plastic zone develops under enough heat generation where adequate upsetting is expected. In order to ensure the consistency of properties for the finished weld, it is needed to control a range of parameters caused by the welding process explained above [1]. The flash butt rail welding technique is more preferable with regard to the weld failure rates

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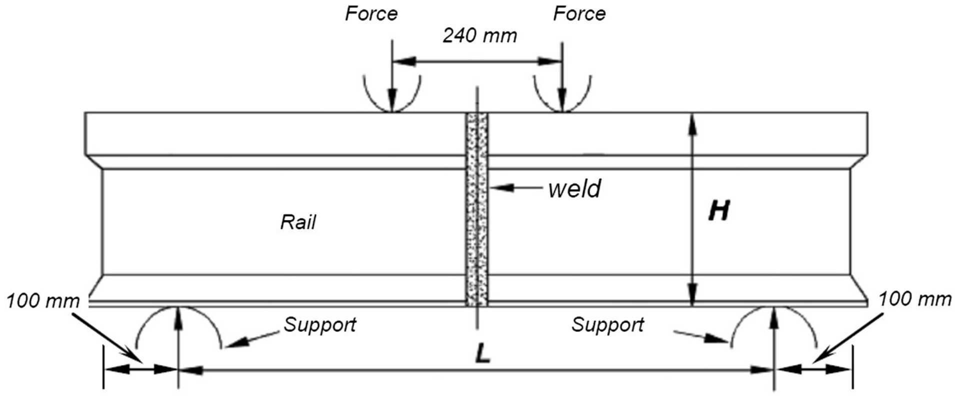

Fig. 1. Fatigue test scheme for the flash butt welded rails.

than aluminothermic welding, particularly under higher axle loads. The flash butt welding is a fast welding process which is performed at a fixed welding plant or by mobile welding machines operating on track. Many experimental and numerical studies related to the flash butt welding processes used for rails and defects observed in these welds have been performed by various researchers [2–8].

Cannon et al. [2] presented an overview on the rail defects. In studies performed by Beretta et al. [3] and Desimone and Beretta [4], the failure modes and fracture mechanics for flash butt welded joints of rails were addressed and studied. Skyttebol et al. [5] investigated the effect of welding residual stresses on fatigue crack growth in rail welds. Tawfik et al. [6] developed a short-term post-weld heat treatment procedure to reduce the risk of fatigue failure in flash-butt welds under high axle load conditions. Zerbst et al. [7] discussed effects of the loading conditions including contact forces from the wheel and thermal stresses due to restrained elongation of continuously welded rails together with residual stresses from manufacturing and welding in the field on the crack propagation and fracture of rails. The residual stresses that occurred on the surface of a rail joined by flash butt welding method were measured with hole drilling method and computed using FEM by Zhipeng et al. [8].

Fig. 2. General view of a fatigue test configuration.