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A study on lifetime of a railway axle subjected to grinding

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Abstract

For security requirements, no fatigue failure of axles is admitted in railway industry. Design process of axles must ensure that there is no crack initiation during its life. Maintenance inspections guarantee that no defect initiates critical propagation of fatigue cracks. In order to remove surface defects, wheel grinding is realized during maintenance task. The present paper addresses a lifetime comparative study of an axle with and without grinding operation. The goal is to investigate the influence of the grinding parameters on the lifetime of axle. In the first part of the paper, the context of maintenance of railway axle is briefly described and the grinding process is presented. The grinding process modifies the roughness, the microstructure of the surface and induces residual stresses: some experimental results are presented. In the second part, the case of a ground axle is considered without defect. A study of the effect of the grinding process on the lifetime of fatigue samples is presented. In the third part, the case of a ground axle is considered with defects. In this case, a study of the effect of the grinding process on the lifetime is presented for different types of defects. Fatigue tests results on specimens are presented. Numerical simulations results for lifetime evaluation are also presented.

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1. Maintenance of railway axle and grinding process

1.1. Maintenance of axles

The railway axles are subjected to high mechanical loads. The risk of the occurrence of fatigue cracks is perfectly controlled by the design. In spite of this, cracks could be initiated in different zones of the axles on defects like shocks, corrosion pitting or machining striation. On the axle journal, the origin of cracks could be an anomaly in the bearings. On the seats of wheels, gear wheels or brake discs, the problem comes from the fretting. In the body, every defect could cause the initiation of cracks: corrosion, shocks or machining striation.
To avoid such a failure, two philosophies are opposed.
The first is based on the high frequent and regular check of axles by NDT to try to detect cracks before the fracture. The second is to check the entire surface at regular inspection of the axles to detect all defects that can lead to cracks. If defects are found in maintenance visits, these defects have to be erased by machining or grinding.
SNCF chooses this second solution for the maintenance of the wheelsets. First axles are shot-blasted to strip painting, to perform magnetic particle testing. If some indications are found, surface around defect is grinded. The maintenance specifications impose criteria for this operation, geometry of the grinded area and direction of grinding. The documents also force to use specific equipment.
However some cracks were found in the middle of grinded zone. Crack initiation could be located in one point (figure 1.a) or on many points..

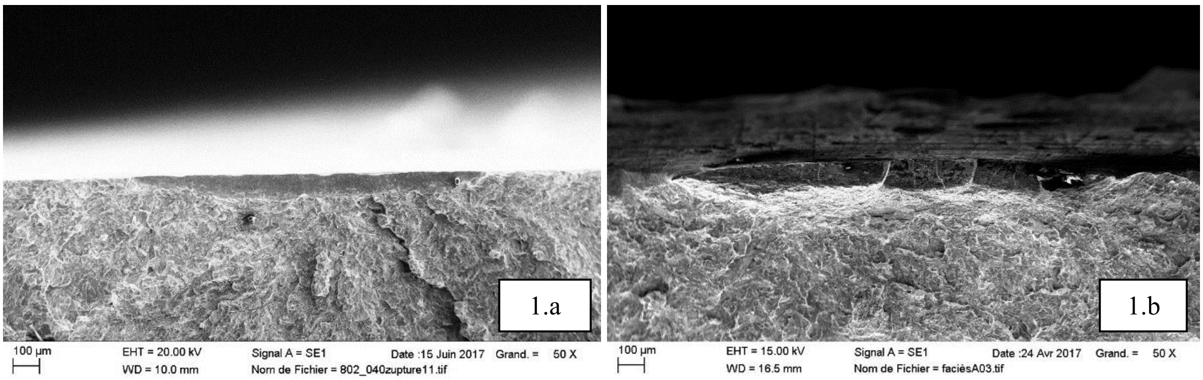

Figure 1 : Fracture surface - fatigue crack detected in the body of railway axle (SEM observation)

To explain these different cases, the residual stresses induced by grinding operation could be investigated.

1.2. The effects of grinding

A study started to try to determine the influencing of grinding on two steels used for axles manufacturing, C40 (EA1N) and 25CrMo (EA4T). Specimens were machined in different axles to study influence of grinding on microstructure, roughness and residual stresses. Different parameters like rotating speed, speed rate, strength and orientation were used to grind the specimens on an automatic grinding-bench.

The influence of grinding is obvious, with the cold hardening and grain deformation on the surface. The thickness of this modified layer reaches 20 µm for the ferrito-perlitic steel and 10 µm for the bainitic steel (figures 2.a, 2.b).