Experimental and Simulation Analysis on Surface Residual Stress of Abrasive Belt Rail Grinding

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1. Introduction

With the increase in the operation time of railway lines, rail surface and its inner structure are prone to suffer from various defects due to the complex and variable impact load associated with the harsh vehicle–track interaction [1]. Nowadays, rail grinding has been widely recognized and applied as the most effective means to repair the rail profile and extend the rail's service life [2].

Recently, a new rail grinding method called "abrasive belt rail grinding" has been proposed and experimentally investigated due to merits such as higher metal removal rate, elastic contact, lower noise, etc. compared to the traditional rail grinding using grinding wheel [3]. Its fundamental principle is schematically displayed in Fig. 1.

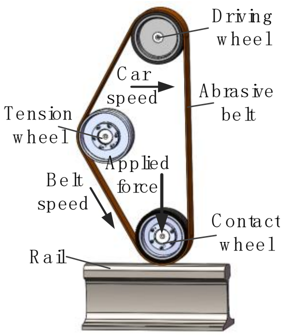
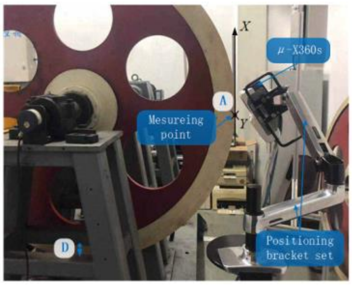


Fig.1 A rail grinding way based on belt grinding

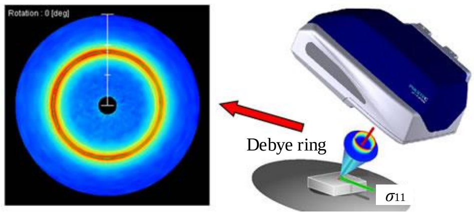
Although it is known that residual stress (RS) is significant for the fatigue life and the reliability of rail, there is no public paper concerning residual stress after rail grinding, not to mention the abrasive belt rail grinding. Therefore, this paper is to investigate experimentally the influences of grinding process parameters on residual stress of the rail surface, initially. Then, a 3D finite element simulation model of grain scratching based on thermo-mechanical coupling method was given to further investigate the formation mechanism of residual stress during belt grinding.

2. Experimental study

In this section, the influences of grinding parameters, including contact force, belt speed and car speed, on residual stress were experimentally investigated on the self-built test bench of abrasive belt rail grinding, as shown in Fig.2 (a). The residual stresses after grinding were captured by *μ*-X360s from PULSTEC presented in Fig.2 (b). The grinding process parameters for each group of the experiments are listed in Table 1.



(a) residual stress measurement scheme



(b) 360 ° measurement based on Debye ring

Fig.2 Residual stress measurement

Table 1 Grinding process parameters

Parameters	F_n (N)	v_b (m/s)	v_f (km/h)
Contact force	460~1310	10	15
Belt speed	500	5~25	15
Car speed	500	20	5~25

Fig.3~Fig.5 give the residual stresses (σ_{11}) of the rail surface, which were influenced by contact force, belt speed and car speed, separately.

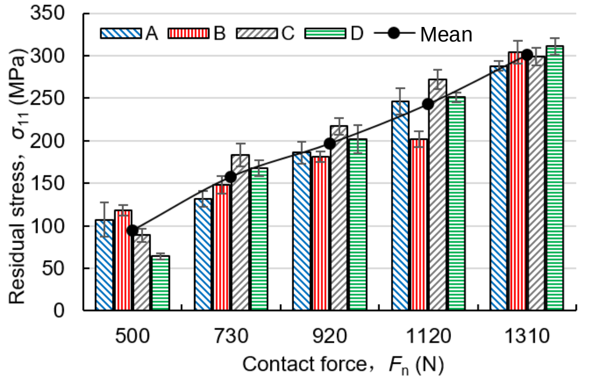


Fig.3 Residual stress v.s. contact force

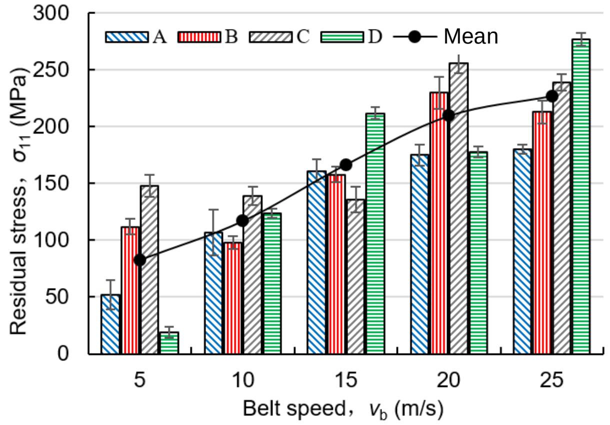


Fig.4 Residual stress v.s. belt speed

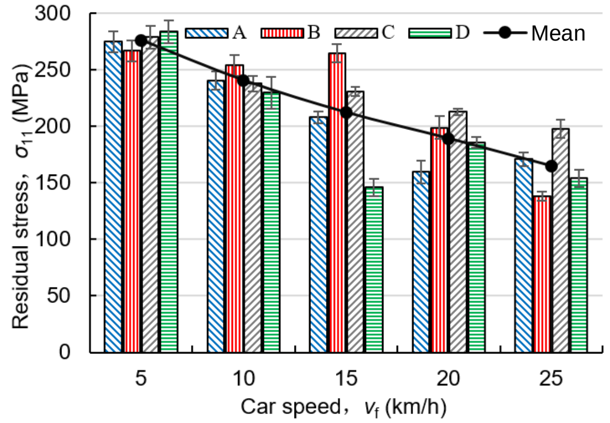


Fig.5 Residual stress v.s. car speed

3. Simulation study

Fig.6 shows the thermo-mechanical coupled FEM of single grain's scratching built in ABAQUS.

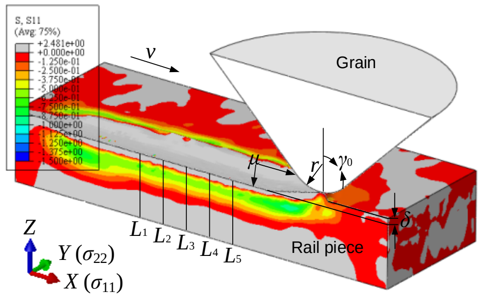


Fig.6 Scratching simulation and its R.S. extracted

Effects of contact surface friction, grain's tip radius, grain's protrusion depth, and grain's cutting speed on residual stress distribution in the sublayer are illustrated as follows.

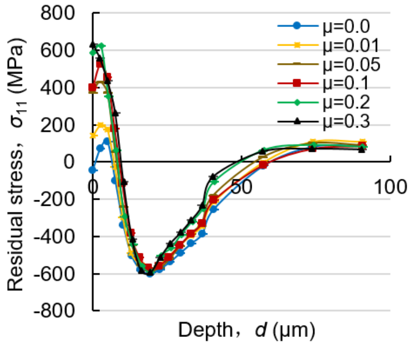


Fig.7 Distribution σ_{11} under different μ

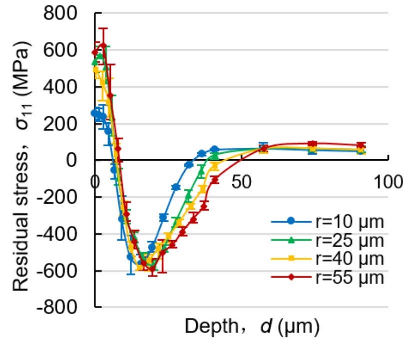


Fig.8 Distribution σ_{11} under different r

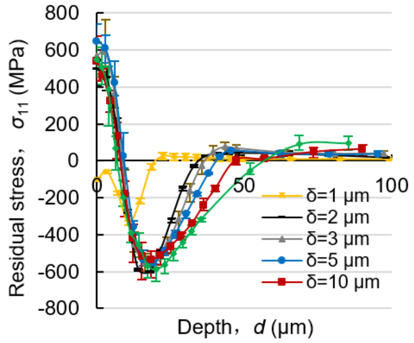


Fig.9 Distribution σ_{11} under different δ

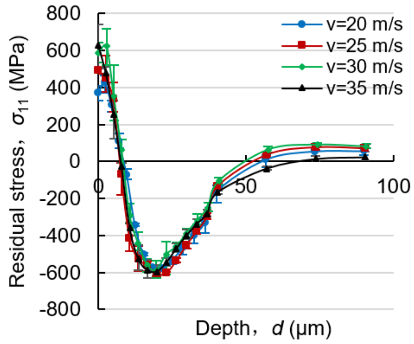


Fig.10 Distribution σ_{11} under different v

4. Conclusion

F_n and v_b have a positive correlation on rail surface RS, while v_f shows the opposite effect. Reduce friction is the key to obtain compressive RS. However, cutting speed of grain seems to influence the surface RS only, not for inner RS distribution.

References

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