

Role of toughness in abrasion, and impact-abrasion wear

A. R. Chinha^{a,b}, K. Valtonen^c, M. J. Peet^a, S. Kundu^b, V-T. Kuokkala^c and
H. K. D. H. Bhadeshia^a

^a University of Cambridge, UK; ^bTata Steel Ltd., India; ^cUniversity of Tampere, Finland.

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Wear in lifting and excavating industry

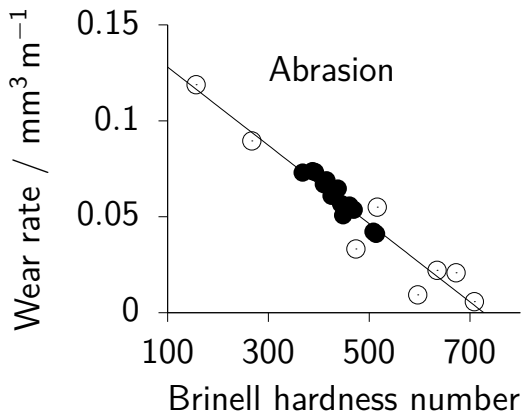


Loading



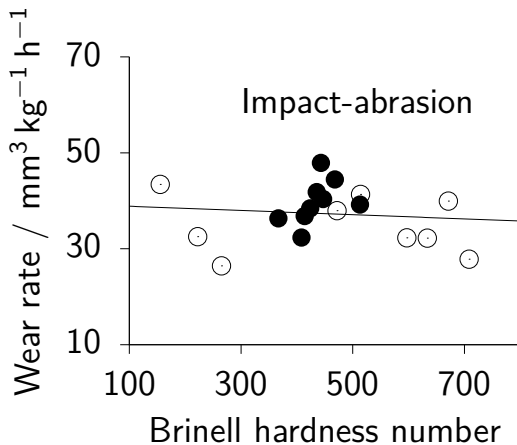
Unloading

Development of wear resistance steels



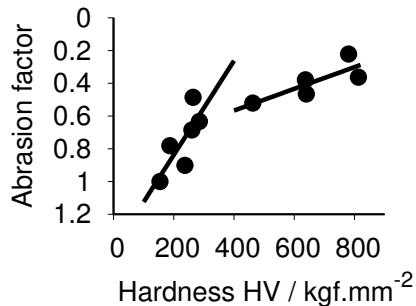
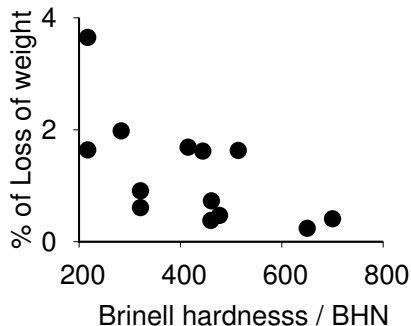
Joe H. Tylczak *et al.*, *Wear*, 1999

Steels under impact-abrasion wear



Joe H. Tylczak *et al.*, *Wear*, 1999

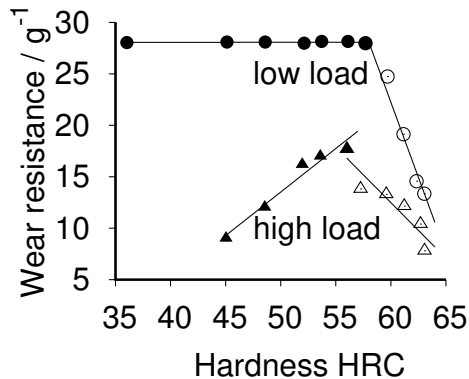
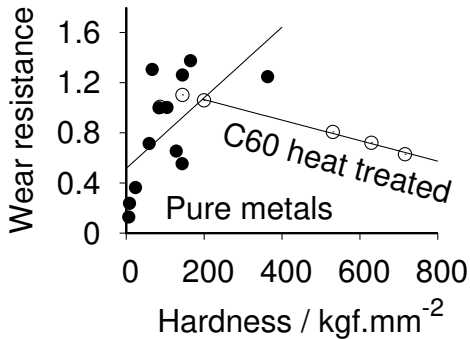
Field study



There are diminishing returns once the hardness exceeds about 500 HV. Why is this?

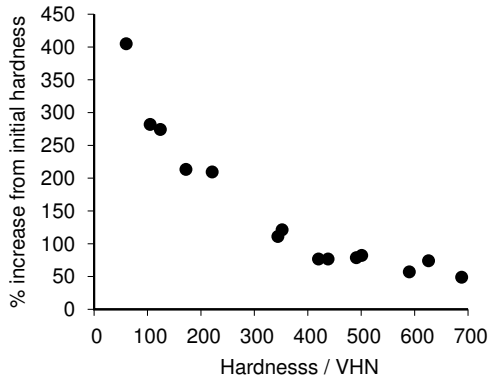
J. O. Everhart, *JACS*, 1938; J. Ito, *WSJ*, 1958

Impact wear



M. M. Khrushchov, *Wear*, 1974; H. Uetz, *Wear*, 1978

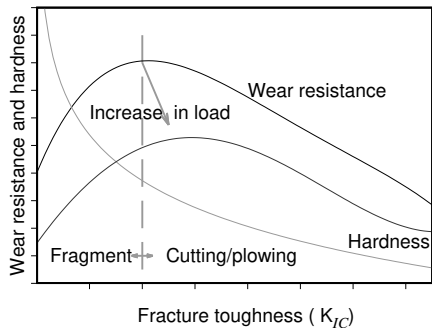
Beyond hardness: *Work hardening*



The surface hardness determines the interaction between the abrasive and the steel.

R. Richardson, *Wear*, 1984; A. R. Chintha, *MST*, 2019

Beyond hardness: *Fracture toughness*



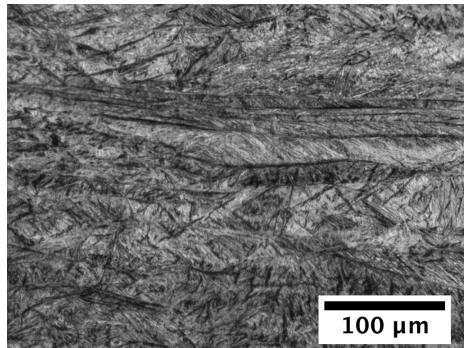
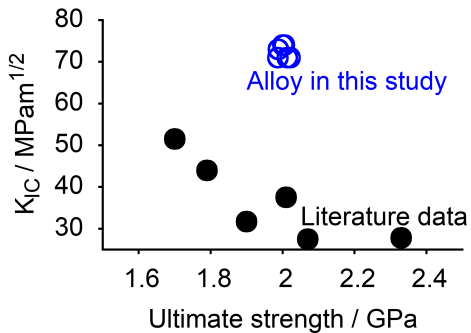
$$\text{Wear volume} \propto \frac{1}{K_{IC}^2}$$

E. Hornbogen, *Wear*, 1975

In circumstances where a steel is not too brittle, nor too tough, the wear rate varies inversely with the square of the fracture toughness.

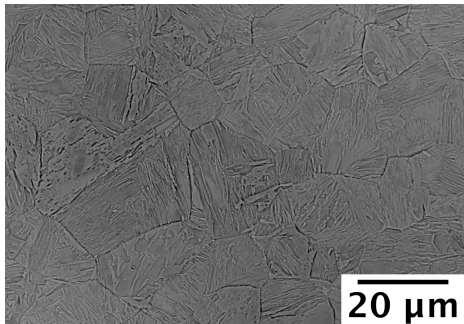
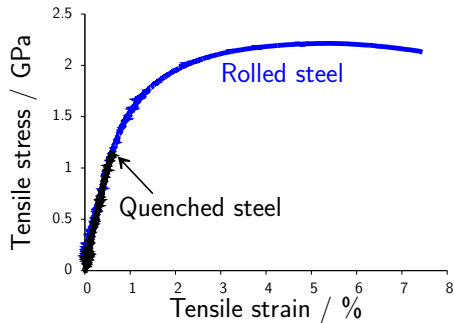
K. H. Z. Gahr, *Microstructure and wear of materials*, 1987

New steel: Hard AND tough



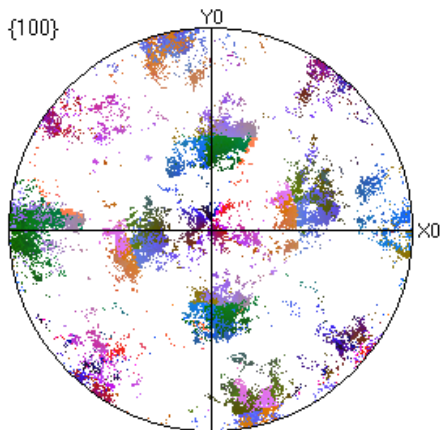
$C < 0.35$ and $Cr + Ni + Si \leq 7.0$ wt%

Conventional steel: Hard but not tough

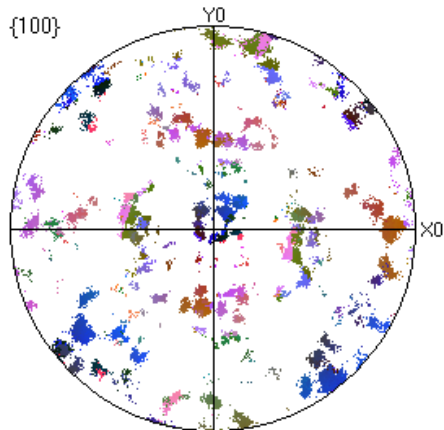


Quenched steel: 666 ± 8 VHN

High toughness *versus* Low toughness

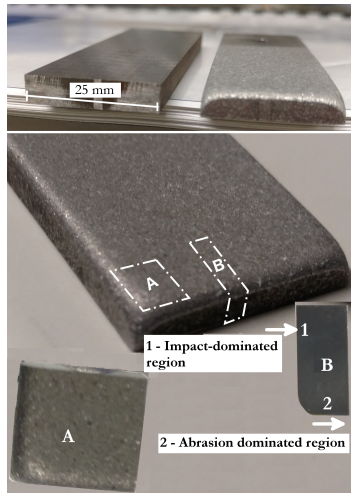
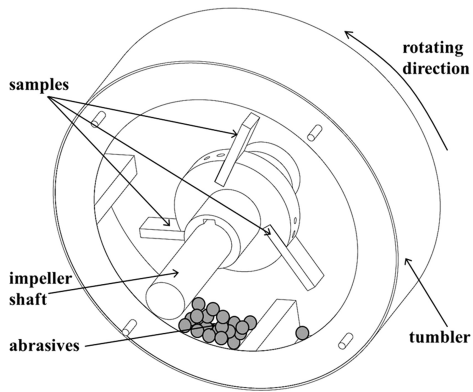


Rolled steel

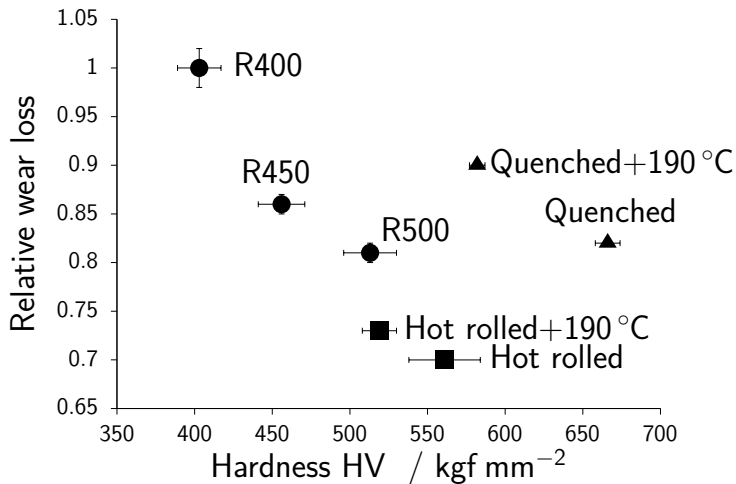


Quenched steel

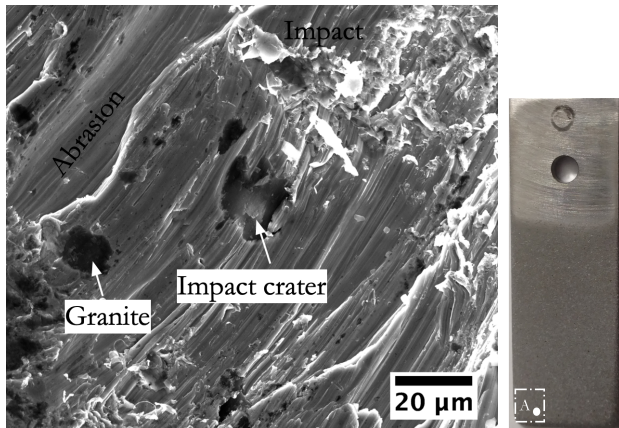
Impact-abrasion wear test



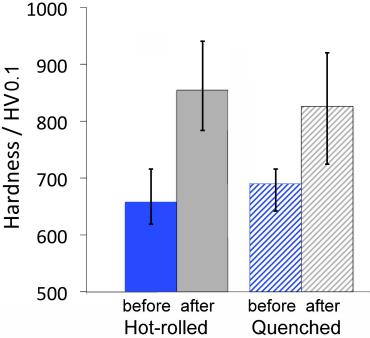
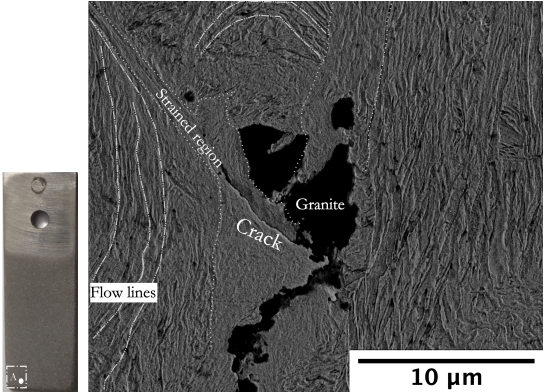
Results



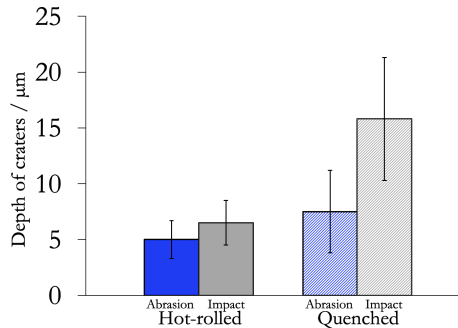
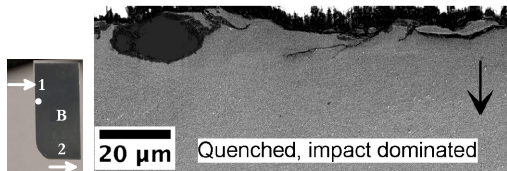
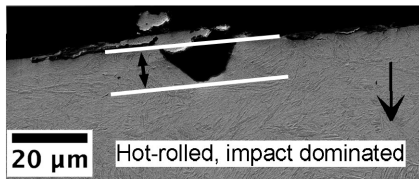
Surface topography: Rolled sample



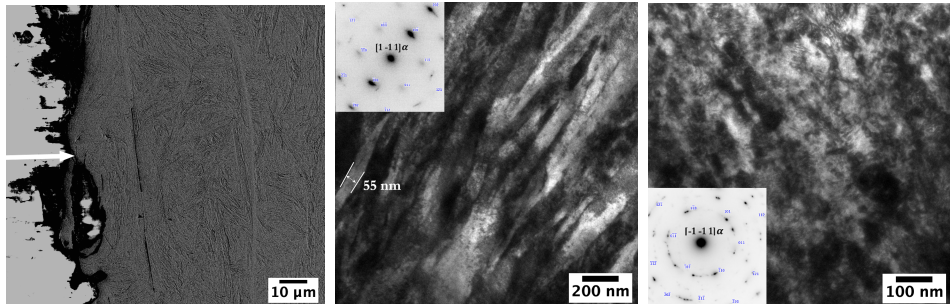
Subsurface topography: Rolled sample



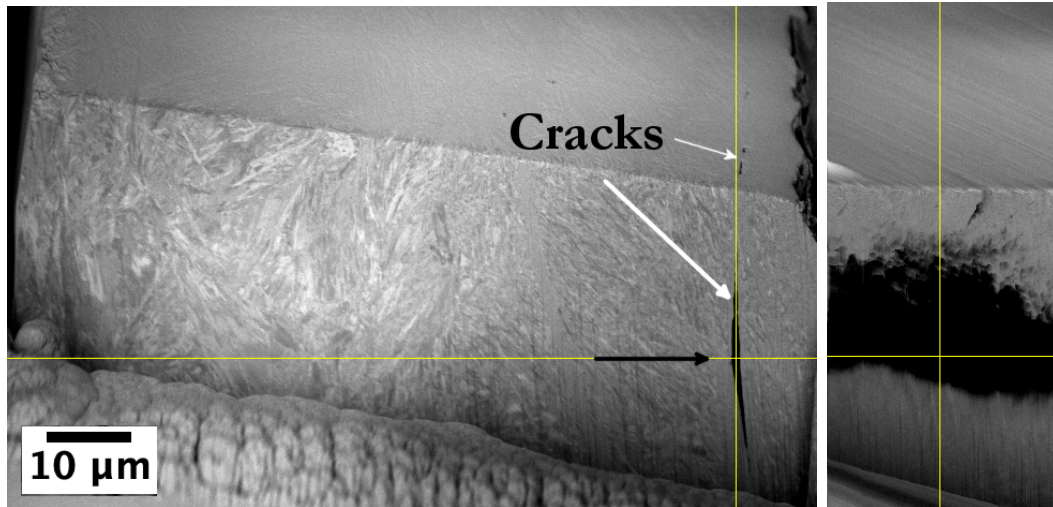
Cross-sectional microscopy



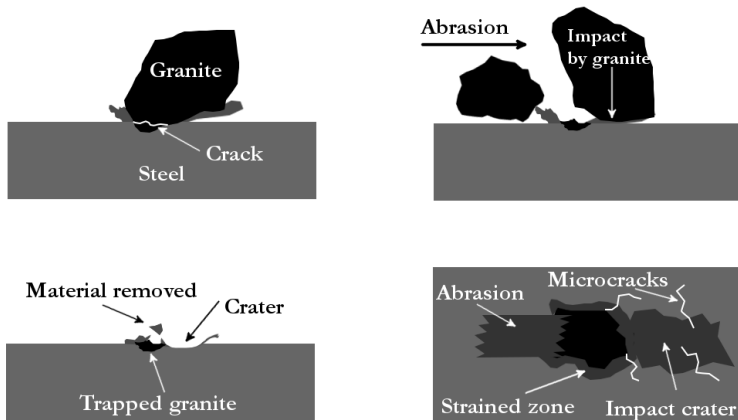
Subsurface: TEM



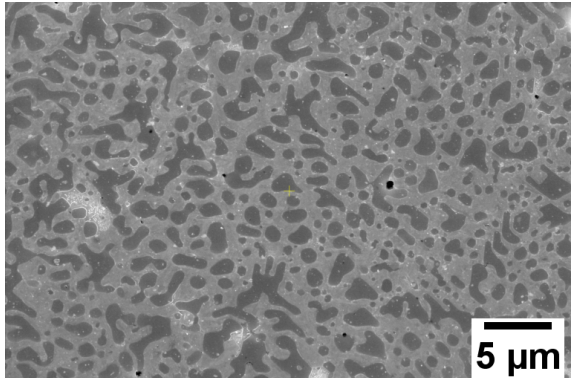
Subsurface: 3D SEM



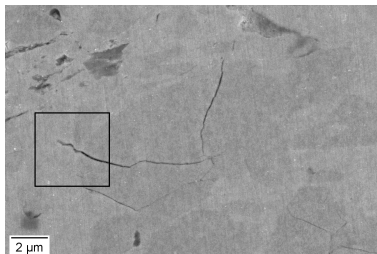
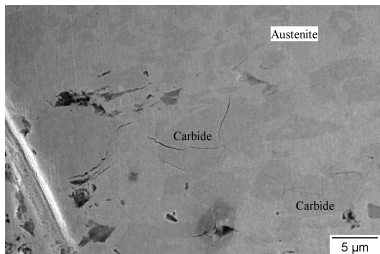
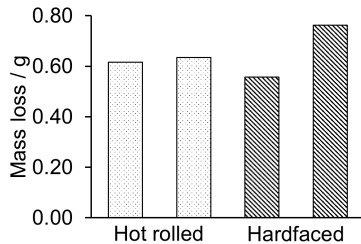
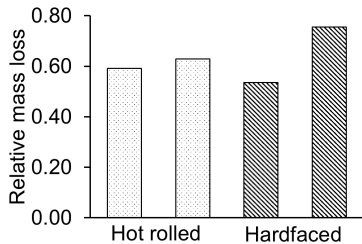
Impact-abrasion wear mechanism



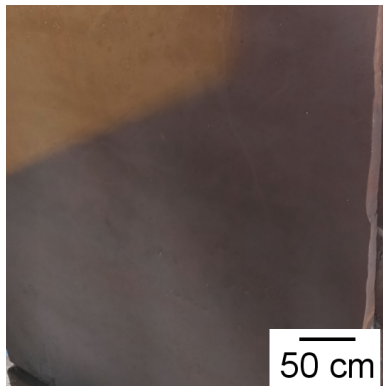
Field study - component level testing



Field study - component level testing



Field study - component level testing



Conclusions

- Role of toughness
- Impact-wear mechanism
- Further studies