

## The influence of surface roughness on the determination of the yield strength of reclaimed low-carbon steel via the instrumented indentation test method

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### EXTENDED ABSTRACT

Many reclaimed steel elements in France require characterization of their mechanical properties. In this study, the instrumented indentation test (IIT) is proposed as an alternative to destructive methods such as tensile testing, providing comparable accuracy. In IIT, surface preparation methods such as grinding and polishing could significantly influence the results due to surface roughness (i.e., rugosity). Therefore, IPE200 specimen has been ground with a conventional laboratory grinder to prepare its surface. IIT was then performed and the load-displacement curves (i.e., F-h) have been extracted. Rugosity for the first three tests is measured 1.93  $\mu\text{m}$ . Next, the same element has been polished, and the indentation test has been used for the second time with rugosity of 0.68  $\mu\text{m}$ . Then, the yield strength as well as hardening exponent has been quantified with CaMMatl software [1]. The results illustrate when rugosity increases, incertitude for determination of yield stress increases simultaneously.

### 1. Experimental Tests

A rectangular specimen with the dimension of 4 cm  $\times$  3 cm  $\times$  0.5 cm is used in this study. The indenter had a radius of 0.5 mm, and based on the adopted assumption, the penetration depth was limited to no more than one-third of the indenter radius. In Figure 1, the surface before and after polishing is shown. Using these surfaces, the F-h curves via penetration of the indenter based on

Figure 2 is exploited, then, CaMMatl software [1] is utilized to quantify the yield stress as well as hardening exponents. The results are illustrated in Table 1 for six tests on surface with two different rugosity.

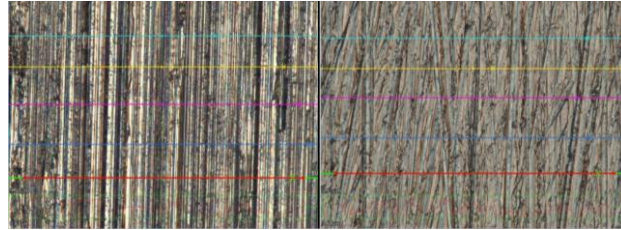


Figure 1. Left) Before polishing with rugosity = 1.93; Right) After polishing with rugosity = 0.68.

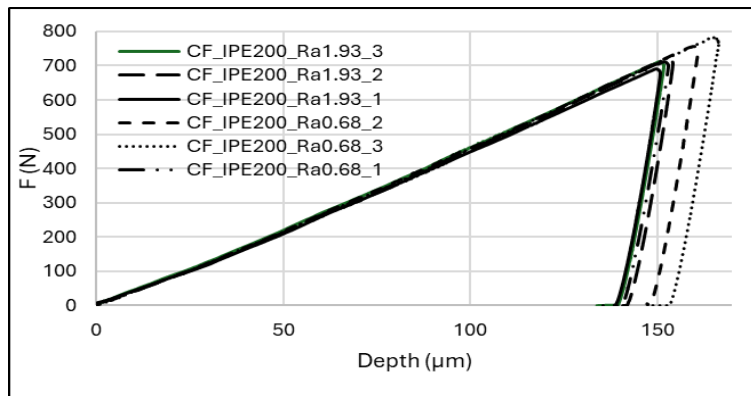


Figure 2. The F-h curve obtained via indentation test on the same specimen with two different rugosity.

Table 1. The quantified yield stress and hardening exponent.

No.	Specimen	Surface	Rugosity (μm)	Yield stress (Mpa)	Hardening exponent
1	IPE200	Ground	1.93	174.4	0.2437
2	IPE200	Ground	1.93	107.4	0.2524
3	IPE200	Ground	1.93	100.4	0.2142
4	IPE200	Polished	0.68	177.0	0.1990
5	IPE200	Polished	0.68	157.1	0.2351
6	IPE200	Polished	0.68	165.2	0.1851

## 2. Conclusion

The instrumented indentation test was performed twice on the same specimen. In the first case, specimen is ground, rugosity = 1.93 μm and three tests are conducted. Next, the surface is polished, rugosity = 0.68 μm, and three more indentation tests were conducted. The results show that ineffective noise in the force–displacement (F–h) curves decreases as surface rugosity decreases. Consequently, the deviation in the measured yield stress is significantly reduced with decreasing rugosity.

## 3. References

- [1] C. Moussa, O. Bartier, X. Hernot, G. Mauvoisin, J.-M. Collin, and G. Delattre, “Mechanical characterization of carbonitrided steel with spherical indentation using the average representative strain,” *Materials & Design*, vol. 89, pp. 1191–1198, Jan. 2016.