Evaluation of Mechanical Properties of Composite Coatings using Small Punch Test Method

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Introduction

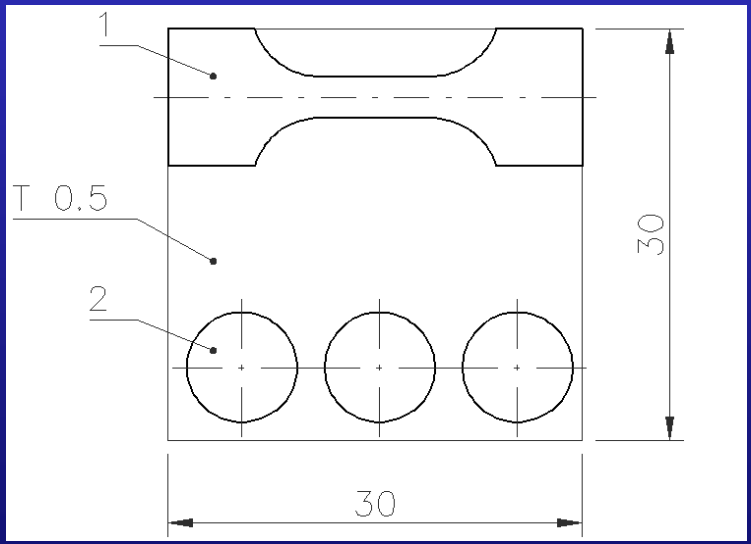
- Small punch test method – potent method capable of providing direct values of mechanical properties.
- Composite (electrodeposed) coatings – thin films (layers) → practically imposible to manufacture specimens and evaluate mechanical properties .
- Only one test technique – hardness measurement can give you idea about mechanical properties.
- Evaluation of wear resistance – time and money.

Motivation:

Try to use SPT to get any idea about mechanical properties such type of coatings (tensile strength)

Experiments

- There was no correlation between punch test and standard tensile tests for electrodeposed Ni
- For more results we have used various technological condition (current density between 1 – 7 A.dm^{-2}) of the deposition process for correlation for electrodeposed Ni

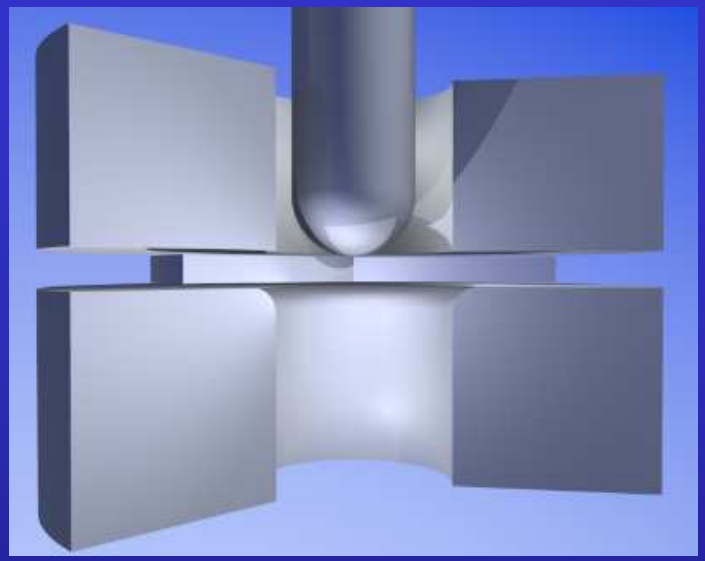


range of current density 1 - 7 A.dm^{-2}
thickness of coatings ~ 0.7 mm
square 30 x 30 mm

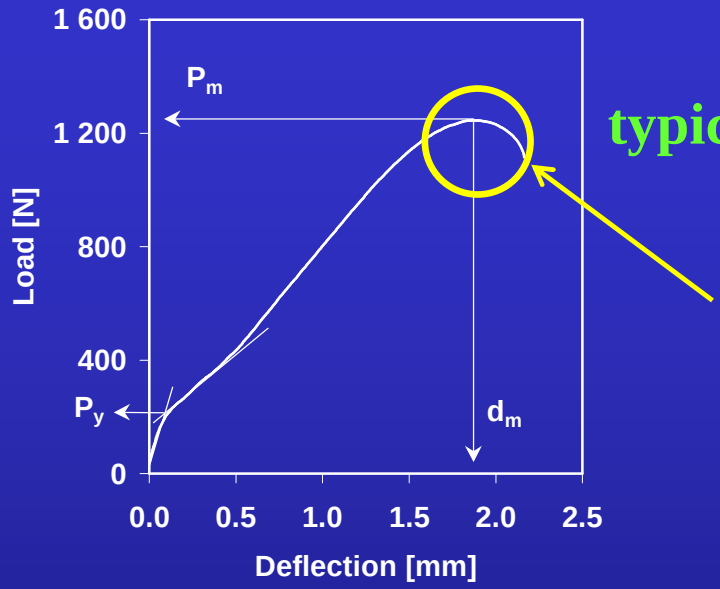
- Testing Ni coating → cheeper

→ nanoparticles – very expensive

Small punch test technique

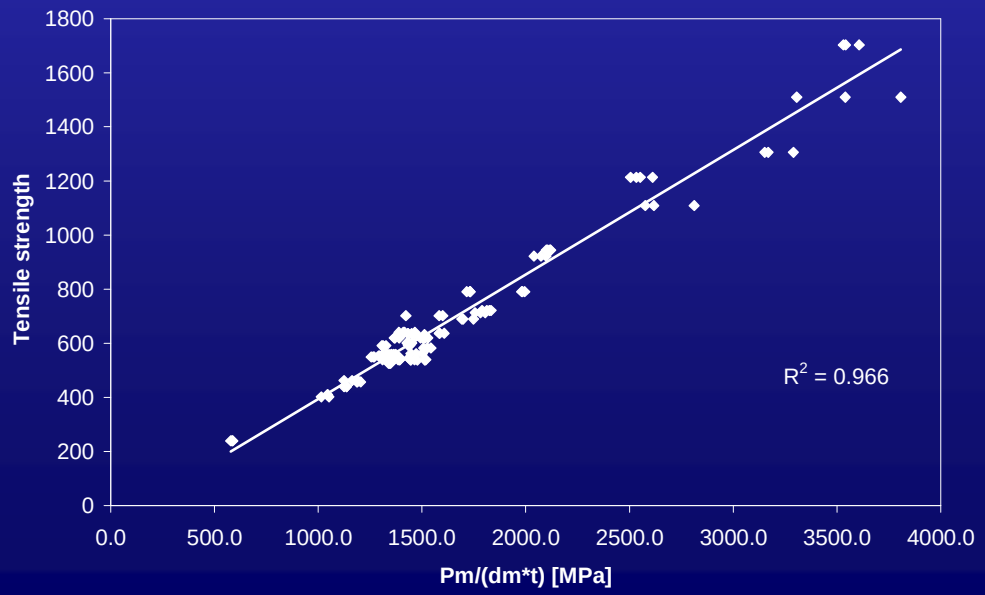


punch test



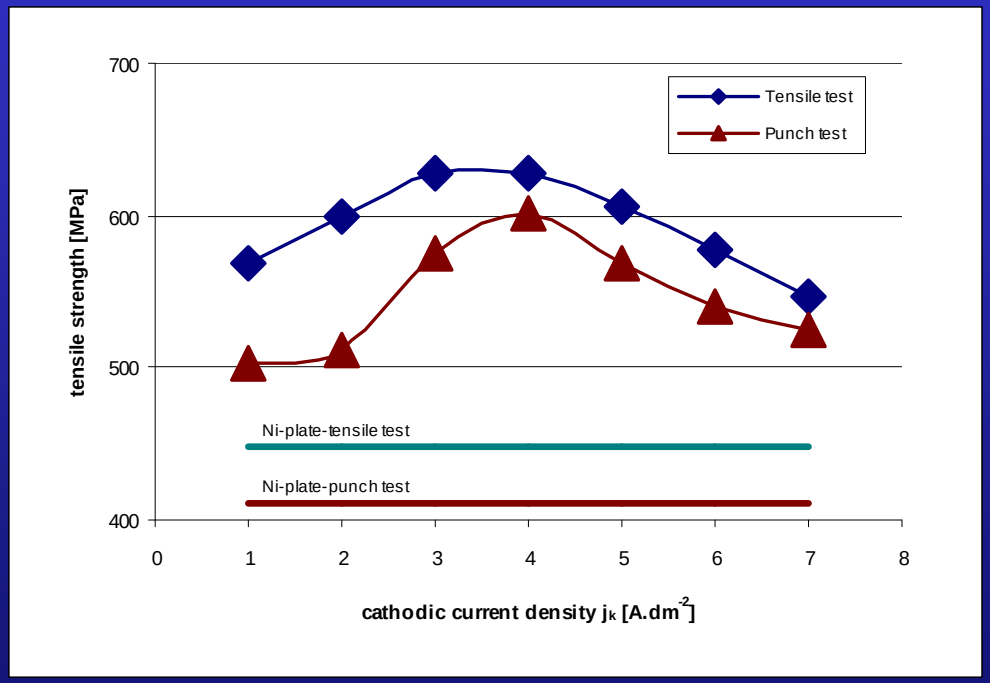
typical record

MMV correlation for structural steels



Correlation for Ni coatings

Typical SPT record of Ni coatings was recalculated for tensile strength using MMV correlation developed for STEELS!

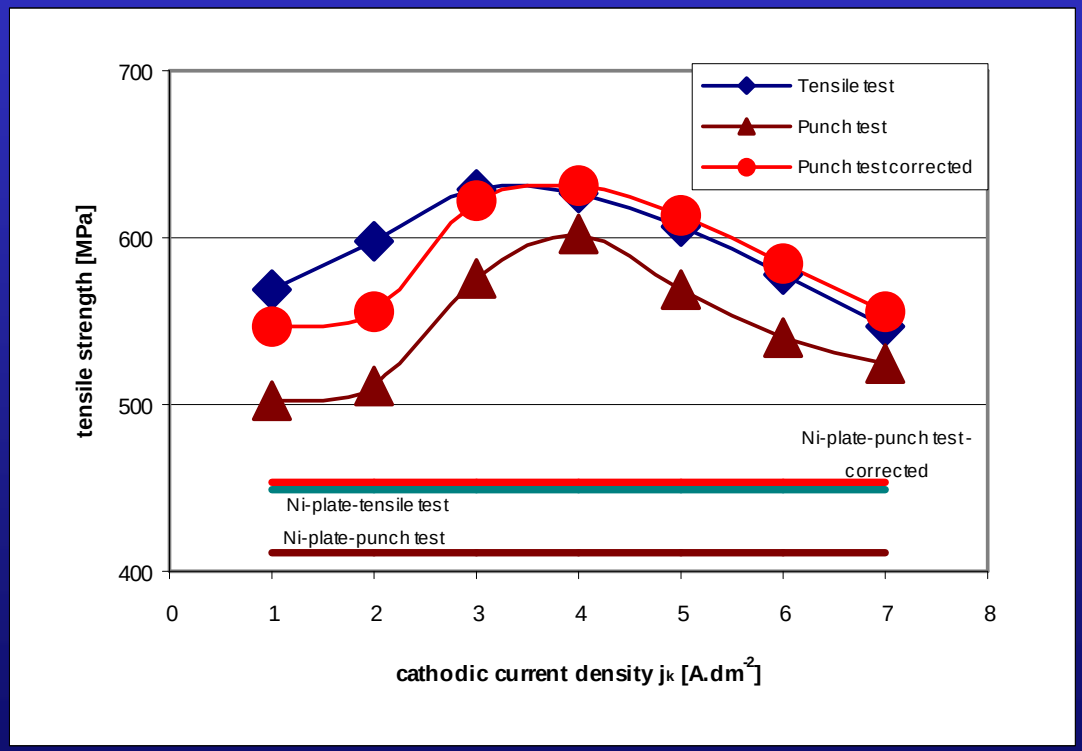


results of punch tests depending on current density

compare with Ni plate

Efect of friction (???)

Coeficient of friction should be taken into account. If you use Ni specimen and tool steel puncher, friction is not the same compared to steel specimen. Because STEEL correlation was used for evaluation of tensile strength Ni punch tests, results should be corrected to friction.



results corrected for friction coefficient

Equation $R_{m\ real} = R_{m\ SPT} + 35\ MPa$

Composite coatings with nanoparticles

Ni base coating

- **nanoparticles** — **SiC**, **SiO_2**, **Al_2O_3**, **TiCN**
- **effect of hydrodynamic conditions**

Results:

Tensile strength of Ni based coatings with nanoperticles

Coating	Stirring revolution per minute [min^{-1}]	Tensile strength evaluated using small punch tests and corrected [MPa]
Ni+SiC	200	565
Ni+SiC	400	760
Ni+SiO_2	200	650
Ni+SiO_2	400	695
Ni+Al_2O_3	200	980
Ni+Al_2O_3	400	1040
Ni+TiCN	200	1350
Ni+TiCN	400	1600

Conclusions

- Punch test can be used for evaluation of mechanical properties for special technical application (electrodeposed Ni coatings with nanoparticles).
- Effect of change of coefficient of friction should be taken into account.
- Punch test technique is very potent method and can be used not only for steels.

Acknowledgements

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Thank you for your attention