Interoffice Memorandum

15 years HYDRIS® – a revolutionary method to control hydrogen has become mature

by Dr. Wolfgang Glitscher, Director Product Applications Iron&Steel
Heraeus Electro-Nite International N.V., Belgium

Introduction: In the late 80's of our previous millennium a new method to measure hydrogen in liquid steel was born, a modification of hydrogen control in aluminium. Until then it was unthinkable that a sensing method could replace and even improve lab analysis of taken hydrogen samples. Today HYDRIS® is the world's industry standard for hydrogen control in steel with more than 350 systems operating.

1. The HYDRIS® principle

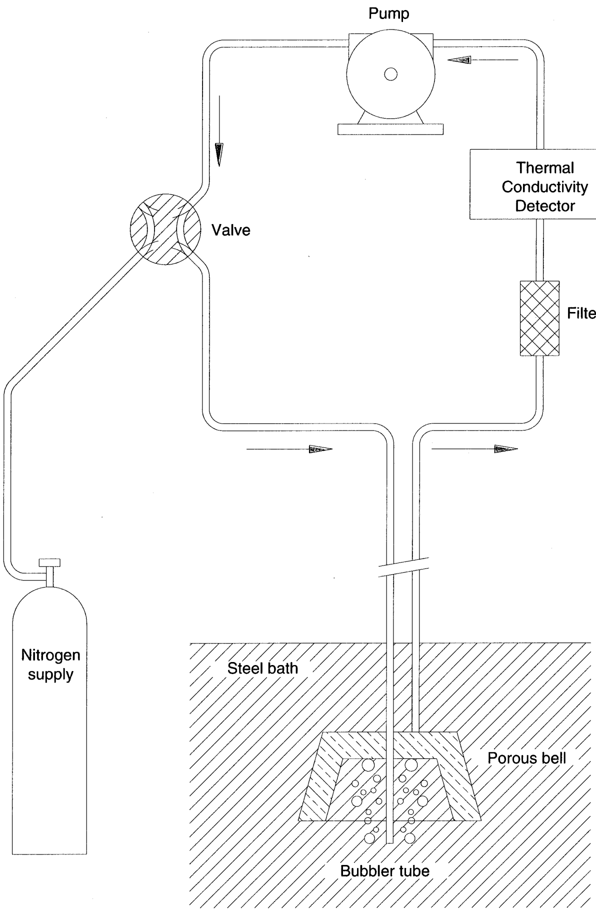


Fig. 1: HYDRIS® schematics

The physical principle of the HYDRIS® sensing method is shown in Fig. 1. Nitrogen carrier gas is injected via lance and immersed probe into the steel. Dissolved hydrogen (H) diffuses into the injected nitrogen, which gets recollected and circulated until equilibrium between liquid steel and gas phases is given. The equilibrium gas is then analyzed by the thermal conductivity detector of the HYDRIS® system comprising computer and pneumatic unit as main components. Sieverts' law gives the relation to dissolved hydrogen in ppm, the figure that steelmakers and quality people want to know:

Sieverts' law

$$[\%X]_{(steel)} = \frac{K}{f}\sqrt{pX_2}$$

2. HYDRIS® characteristics

HYDRIS® measures the full hydrogen range, under 0.5ppm to over 12ppm that may prevail in stainless steel. HYDRIS® accuracy is somewhat dependent on actual hydrogen level, in general better than 5% relative but deviating max +/- 0.2ppm in the low hydrogen range. In typically 30 to 60 seconds (dependent on hydrogen level) the result is displayed, **Fig. 2:**

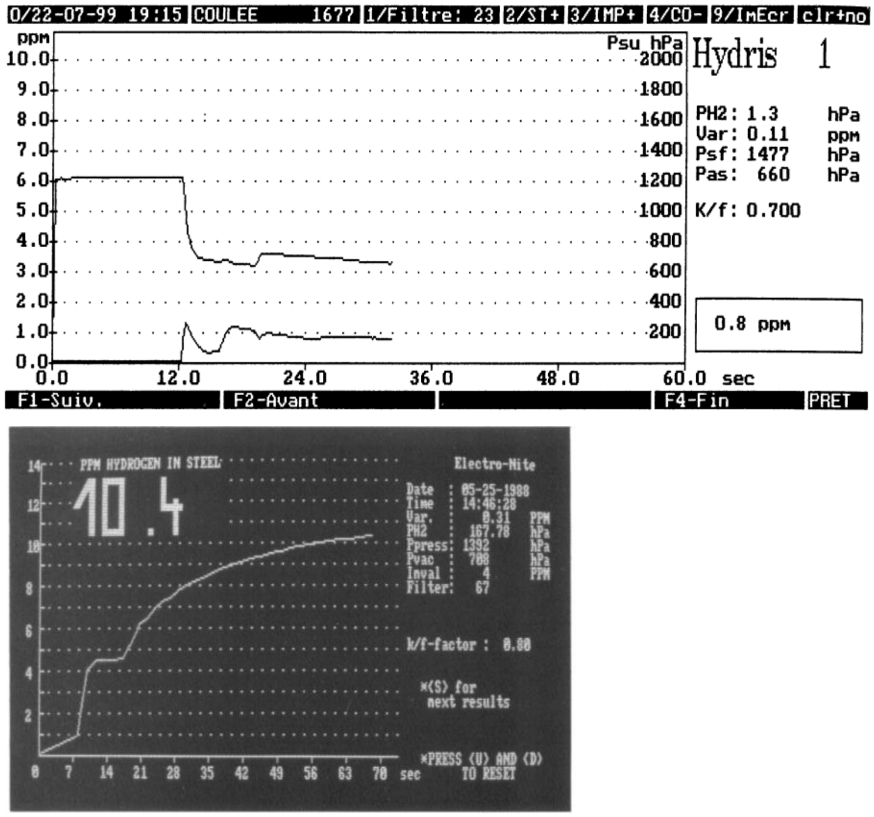


Fig. 2

3. HYDRIS® versus sampling methods

3 different sampling methods were used till HYDRIS® took over, and still some steel shops continue to use these. The one method is pin sampling from spoon and downstream water quenching and preservation of the sample in liquid nitrogen. This method is cheaper than HYDRIS® but suffers from reliability.

Fig. 3 shows the deviation to HYDRIS®. Comparison was made to 2 lab analysis. It is obvious that the pin sampling method suffers from hydrogen losses due to rapid diffusion. Even though good sample chill was used, just HYDRIS® catches hydrogen values above 6ppm. This pin-sampling disadvantage is critical, as blowhole formation due to excessive hydrogen may be underestimated this way.

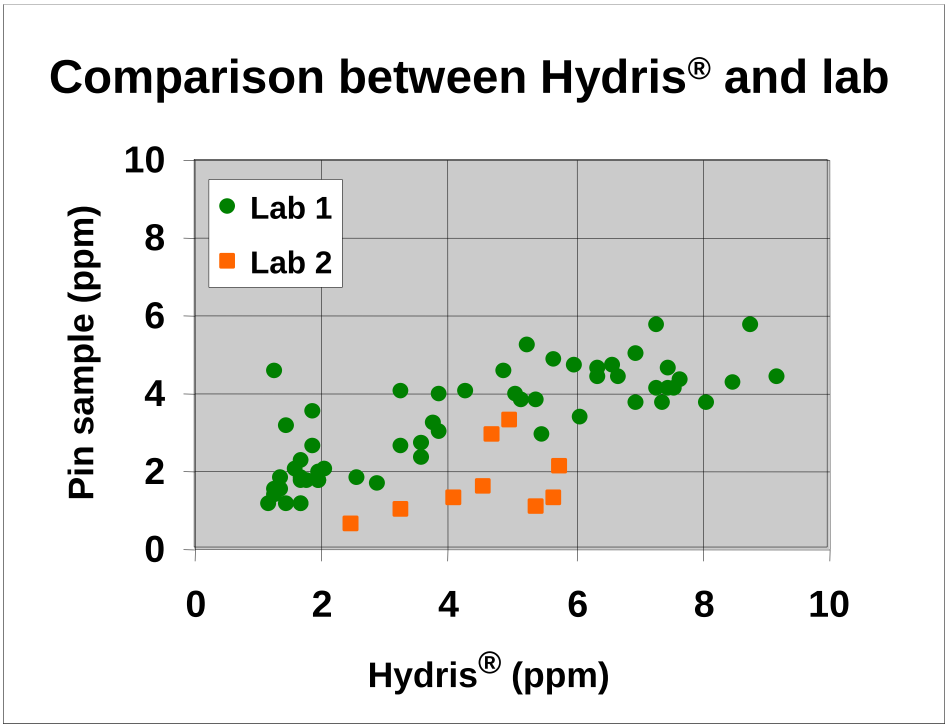
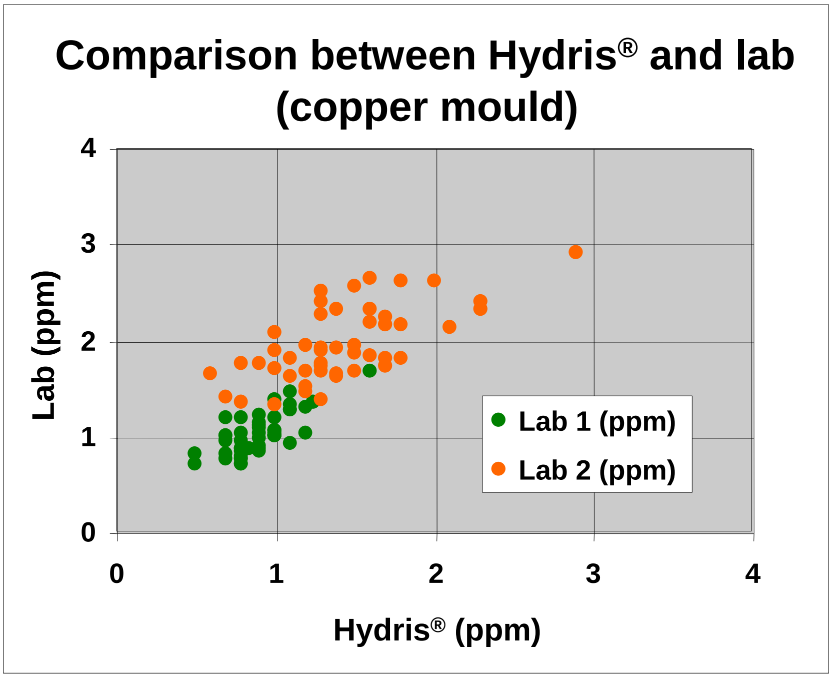


Fig. 3

A similar method is copper mould sampling for hydrogen, **Fig. 4**. Here the copper mould removes heat quickly and freezes hydrogen in the sample. The same drawbacks as with pin sampling are given.

Interoffice Memorandum

Fig. 4



A further invented method was the dual wall sampler. Although expensive there was mismatch with HYDRIS®, **Fig. 5**.

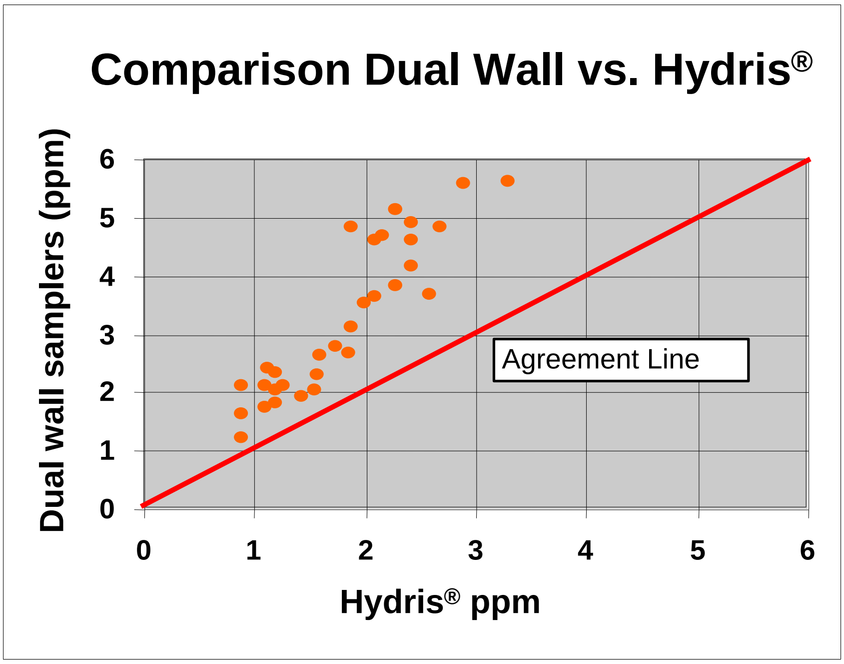


Fig 5

In conclusion it can be stated that all sampling methods suffer from the same drawback that could not be solved, i.e. hydrogen loss from hydrogen diffusion out of the sample. High hydrogen levels were not detectable, all hydrogen sample results showed a poor reproducibility and thus a high scatter between measurements. Compared to this HYDRIS® 5% accuracy was a revolution and this within seconds on-line time a rather than waiting 15 minutes and sometimes longer for the lab result.

4. HYDRIS® applications

A hydrogen certification of steel products is mostly requested for hydrogen sensitive products and steel grades, and certainly for many steel exports. All thick material is prone to hydrogen flake formation, especially when alloyed. Safety relevant steel products demand a hydrogen certificate. As an example Canadian railways request a HYDRIS® certificate for imported rail.

4.1 In ladle metallurgy

Hydrogen control in ladle metallurgy is applied to

- meet the hydrogen specification, if internal or by the customer (the later e.g. with rail products and forgings),
- avoid blowholes in the as-cast or as-rolled products,
- avoid hydrogen related break-outs in the CC-mould, and to
- decide if (additional) degassing is necessary.

Other interesting applications are shown in the subsequent slides, **Fig. 6** and **Fig. 7:**

- shorten degassing time, save energy and refractory
- see how lime and alloyers influence the heat’s hydrogen burden

Interoffice Memorandum

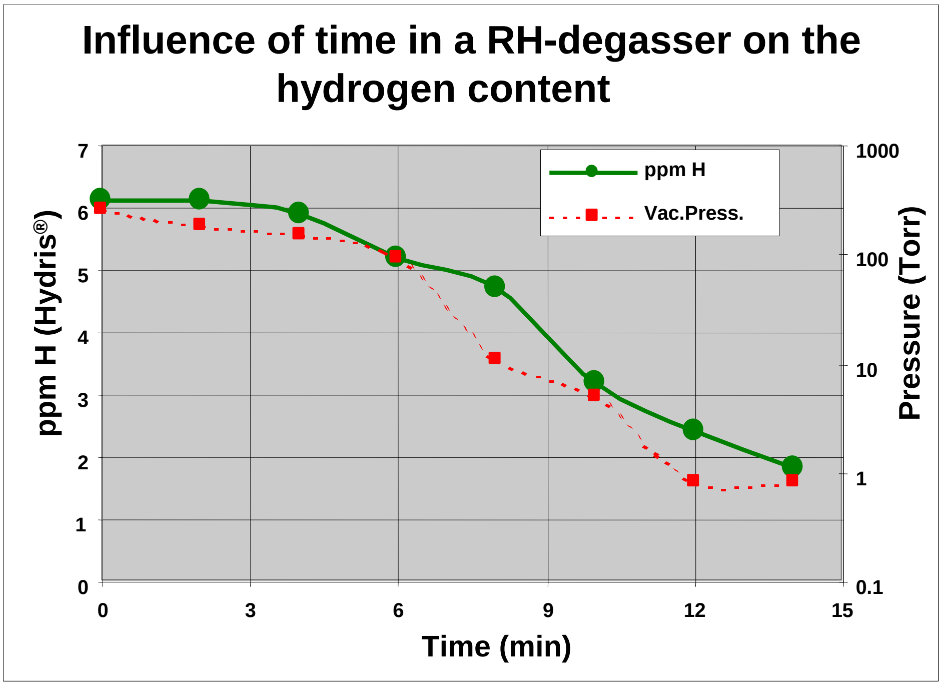


Fig. 6

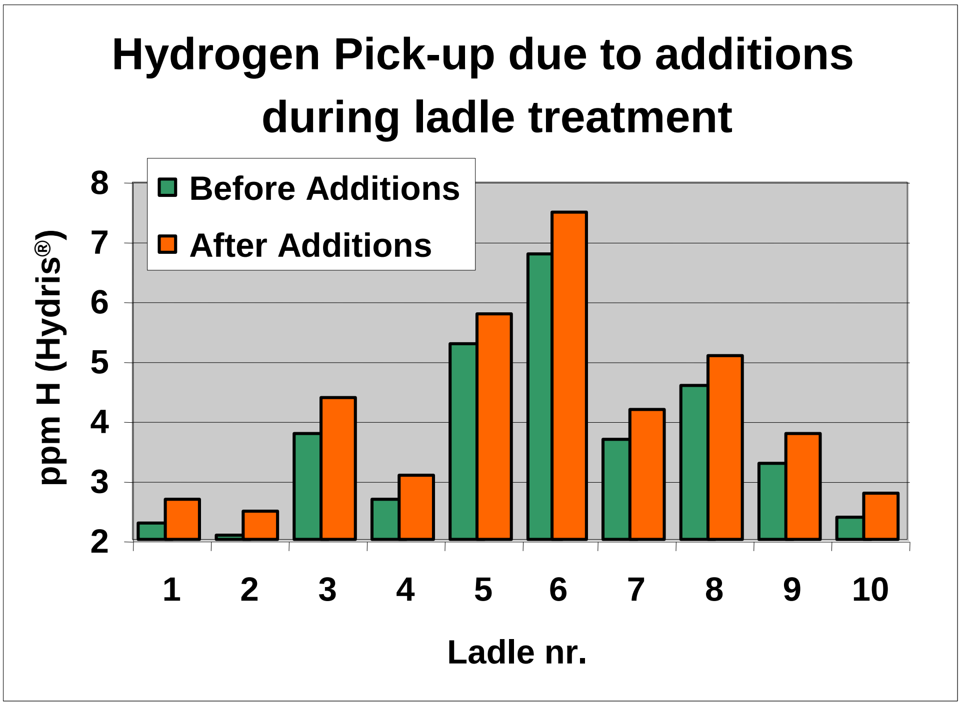


Fig. 7

4.2 In continuous casting

60% of all HYDRIS® are taken in the tundish of the casting machine. Most common reason for taking a measurement here is quality control and steel grading. Based on a HYDRIS® measurement the decision can be taken to post anneal as cast slabs, blooms, and billets. Especially the first cast tons of a sequence may show elevated hydrogen levels from tundish preparation (seating bricks are cemented), **Fig. 8**. Also steel castings projected for direct transit to rolling are especially hydrogen sensitive, as cooling and reheating prior to rolling are missing and more hydrogen is stored.

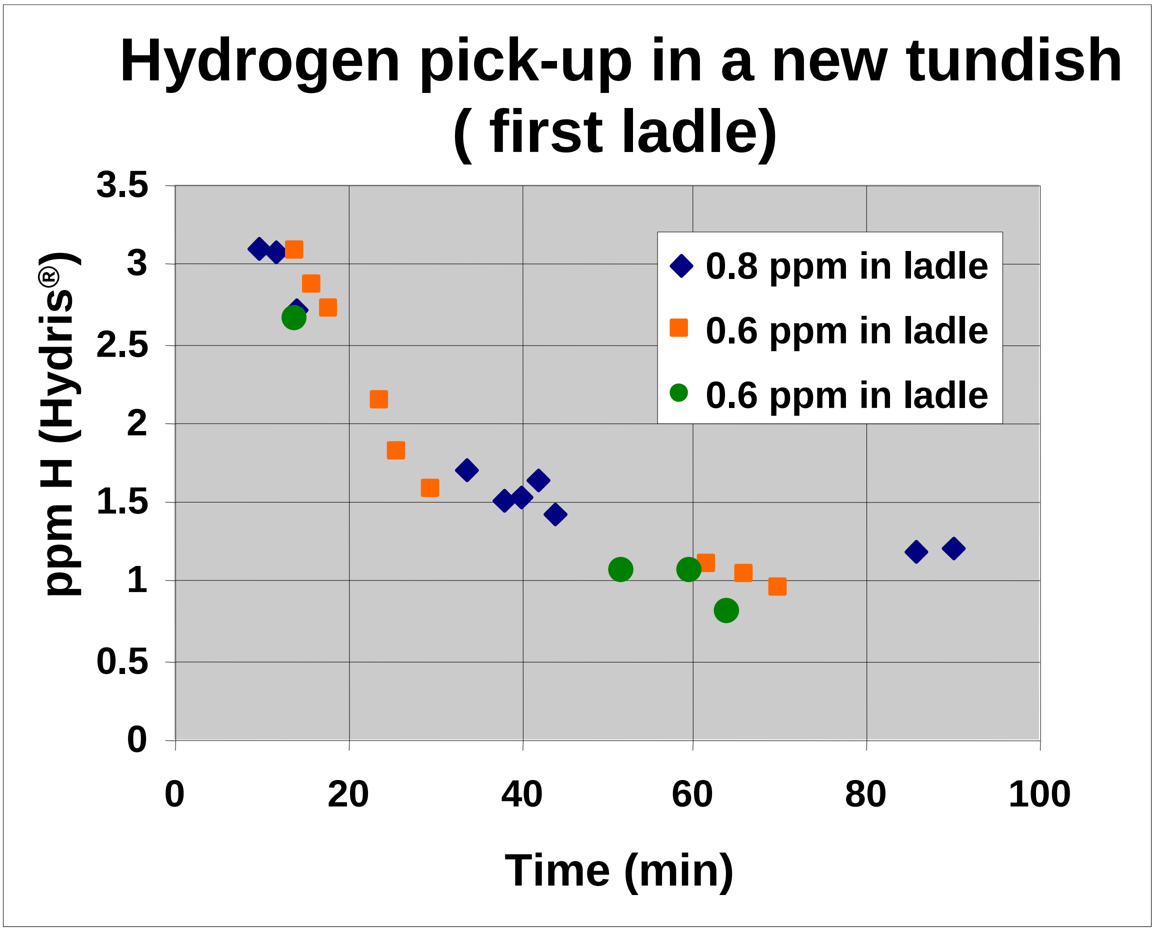


Fig. 8

4.3 In ingot casting

The HYDRIS® sensor is immersed into the ingot mould and the measurement is taken regularly. In Europe and the United States especially forging ingots are very carefully controlled on hydrogen. HYDRIS® does not have a problem to measure reliably down to 0.5ppm.

Concluding remarks

„The results obtained from various tests in this investigation lead to the unequivocal conclusion that the HYDRIS system gives reliable readings of hydrogen content in liquid metal".

Dr. E.T. Turkdogan

48th EAF Conference

December 1990
