ICAR-CM2T
Ingénierie Matière

e-Newsletter N°44 – June 2021

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On the testing side:
Liquid Aluminium Corrosion, Mechanical Strength of Coatings and Uncertainties

In this issue, two types of tests, one updated and the other brand new, are described. Marion and Nathan, two trainees in the Bachelor of Metallurgy programme, who have worked on these subjects, tell us about certain conditions... In addition, Fabiola, a trainee in the DUT Metrology programme, informs us about the uncertainty calculations that she carried out over several months and which are so important in order to be able to give valid results.

A. Study of corrosion by liquid metal:

In an increasingly competitive world, the primary processing and foundry industries are constantly striving to improve their productivity and the quality of the parts they produce. They need to understand the mechanisms involved and find solutions to increase the lifespan of their tools. Contrary to other fields, corrosion in liquid metal is very little documented scientifically. In this context, this test bench is justified since it allows both to be as close as possible to industrial conditions, but also to study the mechanisms involved scientifically. It offers industrialists solutions for tools and coatings improvement, since it enables them to study the thermal fatigue of foundry tools and the chemical damage resulting from contact between the molten metal and the mould wall during repeated filling. This wear bench can also provide answers to questions about the damage to glass tools and the behaviour of refractories in contact with other molten metals.

Principle :

A set of heating resistors are placed around the crucible to cause the bath to heat up. When the desired temperature is reached, the rotating crucible can be set in motion, producing a current in the liquid bath. When all the molten metal is in motion, the samples are immersed in the bath at a numerically predefined cycle rate (e.g. thermal fatigue study). Depending on the specification, the samples can be cooled either by compressed air via nozzles around the sample holder or by an internal water cooling system. Both the crucible and the sample holder are interchangeable.


View of the test bench (left), the samples in the hot furnace (right).

This allows the use of a wide variety of bath materials, as well as the study of refractory, ceramic and metallic samples and coatings (Thermal spray, CVD, PVD, …) or treatments (nitriding, carburing, die coating).

Characteristics

- Maximum temperature of the crucible in place: 1250°C
- Internal cooling rate: 20 L.min-1
- External cooling by compressed air: 6 Bars
- Minimum cycle time: 5 sec
- Dipping depth in liquid metal (20 to 30 litres): 10 to 190 mm

B. Mechanical strength of coatings

The use of functional coatings on all types of surfaces (metals and alloys, wood, ceramics, concrete, glass, polymers and CFRP composites) has accelerated in all industrial sectors (automotive, aerospace, medical, luxury, tooling, architecture) as well as application techniques (wet coatings, paints, PVD and CVD thin films, thermal spraying, polymer coatings, floor coatings, etc.) requiring the characterisation of coating adhesion.
The Elcometer 510 Automatic Tensile Adhesion Gauge accurately measures the cohesive strength between the coating and the substrate.
The device can be used to determine the load to failure of coatings of various types: Paints, thermal spray (metals and ceramics, carbides), wet and dry coatings of various types.

Test:
A counter-test is glued to the surface to be characterised using a structural adhesive (Figure 1). After complete curing, (24 hours or less depending on the adhesive) the tensile test can begin. The loading speed can be selected. The fracture surface must be analysed to determine whether it is cohesive, adhesive or mixed.

Features

- Efficient: Ideal for laboratory and field use,
- Measurement range up to 100MPa (14,400psi),
- Data transfer to PC via USB or Bluetooth® for further analysis,
- Possibility to choose the loading speed (0.04 to 5 MPa/s) and to adapt the diameter of the test tube (from 10 to 50mm).

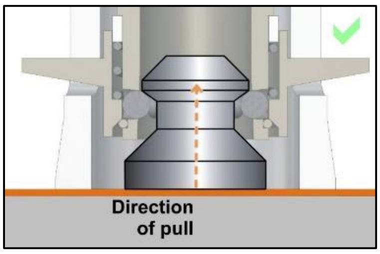

Fig. 1 : Schematic Diagram - Source Elcometer (left) - 510 Control Module and Traction Head - Source Elcometer (right)

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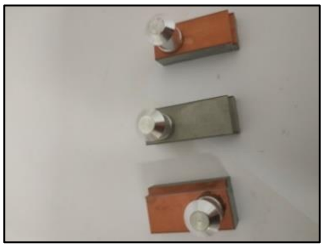


(a) Tests on coldspray metallic deposits (Cu, CuZn15) on aluminium 6082
(b) Flooring test (Source Elcometer)

Usable standards:
ASTM C1583, ASTM D4541, ASTM D7234-12, AS/NZS 1580.408.5, BS 1881-207, DIN 1048-2, EN 1015-12, EN 12636, EN 13144, EN 1542, EN 24624, ISO 16276-1, ISO 4624, JIS K 5600 5-7, NF T30-606, NF T30-062

C. Measurement uncertainties

In metrology, a measurement uncertainty related to a measurement "characterises the dispersion of the values attributed to a measurand, based on the information used" (according to the Bureau International des Poids et Mesures).

It is considered a dispersion and involves statistical concepts. The causes of this dispersion, linked to various factors, influence the measurement result, and therefore the uncertainty and ultimately the quality of the measurement. It includes many components that are evaluated in two different ways: some by statistical analysis, others by other means.

During her 3.5-month internship, Fabiola took part in updating test quality plans in collaboration with the Test Manager and the Metrology Manager.

Uncertainty estimation procedures have been revised for the particle size tests and those associated with thermal control. For the slump test under load, both the modelling of the measurement process and the evaluation of the associated standard uncertainties were revised.

In terms of the traceability of test results, an improvement/revision of the Excel spreadsheets was undertaken.

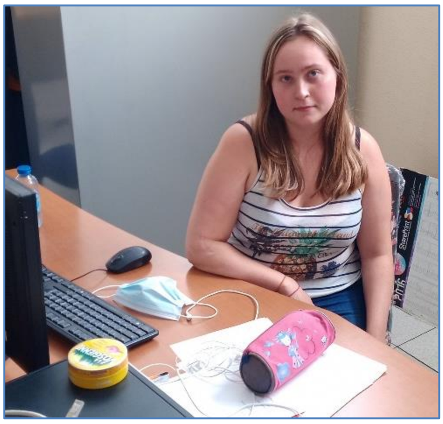
The interface of the support has been redesigned for greate friendliness and practicality, in particular by adding a colou to facilitate the implementation of data or by adding drop- lists standardising the response options according to the nee characteristics of the test.

In order to better understand the sequential processe disaggregation of the calculation steps is carried out for bo measurement estimation and the uncertainty estimation.

The updating of metrological data and/or uncertainty sou now facilitated by the insertion of dedicated input tables.

The cells and folders have been locked to prevent the manipu of the results obtained and to comply with the data se required by ISO 17025/2017.

Finally, the procedure for recording results was optimise reducing the number of forms to be completed by the technician.



The 3 trainees with, from left to right : Marion, Fabiola, Nathan. Thank to them for their involvement during these months at ICAR-CM2T to complete their internship. Good luck for your future professional life

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Recently, ICAR-CM2T has recruited 2 new people with **Stéphane Weinland** and **Robin Stocky**.

- Stéphane (on the right) is involved in the registration and machining of the test specimens that are to be tested.
- Robin (left) has just completed a thesis entitled "Study of the treatment of powders and the influence of the characteristics obtained on the transparency of spinel-type ceramics". He will focus on cold spray deposition and other spraying methods in order to functionalise surfaces generally used in extreme conditions.

Bibliography :

This selection of publications is the result of the Technological Watch carried out by the Documentation Department of the SFC (French Ceramics Society). For more information on these scientific, technical or competitive monitoring products: monthly monitoring bulletin, specific targeted monitoring, access to the "CeramBase" monitoring database, contact the SFC at: **soc.fr.ceram@ceramique.fr**

SFC

- HOSOGI R., KAMIO H., TSUJI Y.

Evaluation of the thermal shock resistance of fired monolithic refractory bodies

Journal of the Technical Association of Refractories, Japan, Vol. 41, n°01, 01/21, pp. 3-12, 14 fig., 2 tab., bibliographie (13 réf.), ANG.

The relationships between mechanical properties and thermal shock resistance of monolithic refractory shards are evaluated using experimental data from thermal shock tests at 600, 1050 and 1500°C. A digital image correlation method is employed and the thermal shock resistance parameters are determined.

Keywords: REFRACTORY. THERMAL SHOCK RESISTANCE. MONOLITHIC. DIGITAL IMAGE CORRELATION.

- MATSUDO H., TOMATSU I., KOIKE Y.

Effects of boron on determination of carbon and silicon carbide contents in carbon containing refractory

Journal of the Technical Association of Refractories, Japan, Vol. 41, n°01, 01/21, pp. 25-29, 8 fig., 3 tab., bibliographie (4 réf.), ANG.

The effect of a boron carbide anti-oxidant on carbon-containing refractories at relatively low temperatures is analysed and its anti-oxidation behaviour evaluated. In addition, this behaviour with other oxides and/or silicon carbide is also monitored to clarify the effect of co-existing materials on oxidation.

Keywords: BORON CARBIDE. BORON. REFRACTORY. OXIDATION RESISTANCE.

Next training sessions (in french)

- **22 to 24 septembre 2021 at Moncel-les-Lunéville : (STR1) Refractory Materials : Basics – (18h)**
- **28 to 30 septembre 2021 at Moncel-les-Lunéville : (STM3) Cast Iron Metallurgy and Applications – (21h)**
- **05 octobre 2021 at Moncel-les-Lunéville : (STR4) Thermal calculation – (7h)**
- **22 to 26 novembre 2021 at Moncel-les-Lunéville : (STR3) Material durability performance - Treatment of used refractories – 1st part 18h, 2nd part 14h**

As usual, the possibility to provide on site dedicated training program,

Please contact Us

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