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HYDROGEN-DATA: A NUMERICAL AND FACTUAL DATA BANK ON HYDROGEN-MATERIAL INTERACTIONS

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Abstract—Hydrogen-data is a factual and numerical file, in French and English. It provides information related to hydrogen-material interactions and includes the comparison of properties of materials with and without hydrogen (mechanical, electrical, magnetic, influence of surface treatments, structure, diffusion and solubility of hydrogen).

The data bank is available on-line on the Information Retrieval Services of the European Space Agency (ESA/IRS) through the ESAQUEST language. Numerical data may be retrieved with QUESTNUMERIC searching facility.

INTRODUCTION

The motivation for the data bank Hydrogen-Data is as follows: hydrogen diffuses into materials and embrittles them. This has been the cause of many accidents, such as the failure of bridges, pipelines, aircraft undercarriages, reactors for ammonia synthesis and so on. Hydrogen can arise from hydrogenous reagents or simply from water vapour; it can enter into materials, steels for example, throughout their lifetime, from manufacture to final use, including etching, welding, electrochemical coatings and so on. Recently, hydrogen effects were also studied in new materials such as amorphous alloys, superalloys, intermetallic compounds, oxides, superconducting materials, etc.

The present understanding of the phenomena does not allow the forecasting of behaviour under service conditions. So, it is usual to refer to previous practical experience in service. The computer is the ideal means of storage and retrieval of such useful information as test conditions, material composition, sample preparation, thermal history, structure, method of introducing hydrogen, hydrogen in solid solution or as hydride, nature of the test, etc.

THE DATA BANK

Coverage

The data bank consists of records written using information published in journals, books, theses, conference proceedings and so on. Systematically, about 50 journals are analysed (Table 1).

Each record gathers all the information concerning a test involving hydrogen. Records are in English if the original paper is in English, and in French in other cases. The records are reviewed by the authors of the source papers and therefore have a quality assurance.

Subject areas

Hydrogen-material interactions occur in the following fields: metallurgy, steel making, chemical industry, oil industry, nuclear industry, aerospace, compressed gas and so on. Various people are interested in these problems, in universities, research centres and laboratories, technological institutes, industries, brokering services. Hydrogen-data is an aid for information research and may help to choose a material.

Recent results may be obtained on-line easily and quickly, in standard units on hydrogen-material interactions, including

- Behaviour of metals and alloys in a hydrogen environment.
- Hydrogen content of materials as result of hydrogen charging.
- Diffusion.
- Embrittlement behaviour of materials in hydrogen.
- Isotope effect.
- Storage.

HOST AND SEARCH

Availability

The data bank is available on line on the ESA/IRS host with connection to the national Public Packet

Table 1. Hydrogen-Data journals

Acta Metallurgica et Materialia
Annales de Chimie
Applied Physics Letters
Applied Surface Science
British Corrosion Journal
Cahiers d'Informations Techniques de la Revue de Métallurgie
Corrosion (Houstone)
Corrosion Science
Comptes Rendus de l'Académie des Sciences
Diffusion and Defect Data
Electrochimica Acta
Europhysics Letters
International Journal of Fracture
International Journal of Hydrogen Energy
Journal de Physique
Journal of Alloys and Compounds
Journal of Applied Electrochemistry
Journal of Applied Physics
Journal of the Electrochemical Society
Journal of Material Research
Journal of Materials Science
Journal of Materials Science Letters
Journal of Non-Crystalline Solids
Journal of Nuclear Materials
Journal of Physics and Chemistry of Solids
Journal of Physics, Condensed Matter
Materials Performance
Materials Research Bulletin
Materials Science and Engineering
Materials Transactions of the Japan Institute of Metals
Mémoires et Etudes Scientifiques de la Revue de Métallurgie
Metallurgical Transactions A and B
Métaux Corrosion Industrie
Philisophical Magazine A, B and Letters
Physica Status Solidi A and B
Physical Review B
Physical Review Letters
Physics and Chemistry of Solids
Physics of Metals and Metallography
Radiation Effects and Defects in Solids
Revue du Vide
Scripta Metallurgica et Materialia
Surface Science
Surface Technology
Werkstoffe und Korrosion
Zeitschrift für Metallkunde

Switched (PPS) network for the transmission of data:

- Time span: 1986 to present, with a few records from 1980.
- File size: 1000 records.
- File update: reloaded every second month.
- Search language: ESA-QUEST with QUESTNUMERIC.

Searchable fields

Each record contains all the information concerning a test with hydrogen relative to:

- the material (name, standard, structure, mechanical and thermal treatments, grain size, superficial state, shape and size of the sample);
- the method of introducing hydrogen (chemical, electrochemical, gas etc.);
- the nature of the test which has been done;
- the precise conditions of the test (pressure, temperature, etc.); and
- the test data.

All these items are classified in several fields, searchable with suffix or prefix (Tables 2–4).

The language is English or French, depending on the language of the source paper, while the fields NM (material name) and SU (subject) are always in both English and in French.

If the results are diagrams, they are described either with data tables or with coordinates of singular points. If the same tests have been carried out on different materials, the registration numbers of the corresponding records are indicated.

Commands

Hydrogen-Data uses the QUEST language of ESA/IRS described in the ESA/QUEST User Manual; the commands are also explained in the Hydrogen-Data User Manual. The general method consists of selecting one term in a chosen field and entering this term with the label of the field (Tables 2–4). The system displays the number of items containing the term in the chosen field. Then, one can display the corresponding records, ask for

Table 2. Suffix fields

Searchable field	Suffix	Example (with EXPAND, SELECT, FIND)
Mechanical and thermal treatments	/TM	F (QUENCH? or TREMP?)/TM
Sample shape and size, cut-off direction	/SA	S CHARPY/SA
Superficial state, grain size	/SS	F (SINGLE or MONOCRISTAL?)/SS
Various other information: mechanical properties, inclusions, second phase particles, twins	/VI	S MnS/VI
Experimental test: nature, conditions, variables involved	/ET	S DILATOMETR?/ET
Results, other records to consult	/RT	S FRACTURE/RT

Table 3. Prefix fields

Searchable field	Prefix	Example (with EXPAND, SELECT, FIND)
Author names	AU =	S AU = SMITH R L
Coden	CO =	S CO = SCRMB
Hydrogen charging conditions (temperature Kdegrees—pressure MPA—deuterium—tritium)	HC =	S HC = NaCl?
Hydrogen charging environment	HE =	S HE = ELECTROCH?
Material name	NM =	S NM = STAINLESS
Numerical indexing	NI =	see Table 4
Publication year	PY =	S PY = 1986
Record number	NN =	S NN = 86050017
Reference: journal, page, volume	JN =	F (JN = METAL? and JN = TRANS?)
Standard name	SD =	S SD = 304L
Structure	SR =	S SR = AUSTENIT?
Subject index	SU =	S SU = fatigue
Toughness MPa square root *m*	TH =	S TH = KIC?

Table 4. Numerical fields

Searchable field	Prefix	Example (with EXPAND, SELECT, FIND)
Chemical composition (wt%)	NI =	S NI = Fe content (wt%)#70
Yield strength without hydrogen (MPa)	NI =	S NI = yield strength (MPa)#/580
Rupture strength without hydrogen (MPa)	NI =	S NI = rupture strength (MPa)#1560/
Ultimate tensile strength without hydrogen (MPa)	NI =	S NI = ult tens strength (MPa)#940
Rupture strain without hydrogen (%)	NI =	S NI = strain (%)#055
Reduction of area without hydrogen (%)	NI =	S NI = reduction of area (%)#75
Hydrogen determination (cm^3/100 g)	NI =	S NI = H determination (cm3/100g)#20
Deuterium determination (cm^3/100 g)	NI =	S NI = D determination (cm3/100g)#20
Surface hydrogen determination (at cm^{-2}) (at/cm2)#30	NI =	S NI = surf H determination (at/cm2)
Surface deuterium determination (at cm^{-2}) (at/cm2)#40	NI =	S NI = surf D determination (at/cm2)
Charging pressure (MPa)	NI =	S NI = charging pressure (MPa)#250
Charging temperature (K)	NI =	S NI = charging temperature (K)#1273
Diffusion coefficient ($cm^2\ s^{-1}$)	NI =	S NI = diffusion coeff (cm2/s)#6E-5
Embrittlement ratio (%)	NI =	S NI = embrittlement ratio (%)#75
Failure pressure ratio under helium and hydrogen	NI =	S NI = failure pressure ratio#0.5

Quest Accession Number : 90000568

89020012 HYDROGEN

NN=: 89020012

AU=: Deimel P, Hanisch C

PY=: 1989

JN=: Int. J. Hydrogen Energy, 147, 14, 2

CO=: IJHED

NM=: acier steel pipeline

SD=: X56TM

TM=: thermomechanical treatment

SA=: smooth tensile specimen: 30mm length, 6mm diameter; notched tensile specimens: 30mm length, 10mm diameter, circular 45deg notch, 2mm depth, 0.25mm radius, as for Charpy iso V notch specimens; transverse to the rolling direction

VI=: Charpy-V impact value of 250 J for the upper shelf

HE=: gas

HC=: O content < 2ppm, H2O < 5ppm in H2 / temperature 0293K / pressure 09MPa

NI=:

C content (wt%)	0.08
Si content (wt%)	0.40
Mn content (wt%)	0.77
P content (wt%)	0.010
S content (wt%)	0.002
Cr content (wt%)	0.03
Ni content (wt%)	0.21
Mo content (wt%)	0.02
Al content (wt%)	0.05
Cu content (wt%)	0.26
W content (wt%)	0/0.01
Co content (wt%)	0/0.01
Nb content (wt%)	0.04
As content (wt%)	0/0.01
Fe content (wt%)	98.1 balance
Yield strength (MPa)	442
Ult tens strength (MPa)	556
strain (%)	32.5
Reduction of area (%)	78
Charging temperature (K)	0293
Charging pressure (MPa)	09

SU=: embrittlement / fragilisation

ET=: 3 different crosshead speeds: 0.5, 5 and 83.3mm/h; in the elastic range, this corresponds to constant strain rates of 4.6E-6, 4.6E-5 and 6.9E-4/s respectively, gauge length 60mm, fractographic examination of fracture surface was performed

RT=: the results are almost independent of the strain rate; the decrease in elongation caused by the gaseous hydrogen is not drastic (up to 34%) compared with the same value measured in air; the respective values of elongation (%) at strain rates (*E-5/s) of 0.46, 4.6 and 69 are: in air: no value given, 29 and 31; in hydrogen: 20, 22, 22; the respective values of the reduction of area, at the same strain rates, are 78% in air; in hydrogen: 32.5, 37.5 and 37.5; the detrimental effect of geometrical discontinuities is also illustrated by the determination of the reduction of area change in dependence on the mean peak to valley height surface roughness: a decrease of 1.2micrometer in the mean peak to valley height results in an increase of about 15 to 20% for the reduction of area ; cf record 89020011 for the 15MnNi63 steel

Fig. 1. Sample record.

them to be printed, or select another term and combine the result with the result of the previous selection(s) using the Boolean operators: "and", "or", "not".

QUESTNUMERIC commands enable the searcher to retrieve numerical data, both single values and range of values in any field with a Numerical Indexing prefix NI = (Table 4). The NI fields include the chemical composition, physical and mechanical properties.

EXAMPLES OF USE

- What is the magnitude of the solubility or of the diffusion coefficient of hydrogen in a material under given testing conditions?
- Which is the material fitting a peculiar value of a given property?
- Has the steel JBK75 been studied concerning hydrogen embrittlement?