

in the presence of hydrogen under pressure provided the chemical composition and the heat treatment have been adequate so that the ferrite contains a sufficiently high Cr-percentage.

Metallurgists are now interested in alloys containing 5 % Cr-Mo-Va.

- b) At temperatures equal to 650°C or exceeding this value, the steel grades with chrome contents equal to 12 % and more are physicochemically stable in the presence of hydrogen.

It may however happen that alloys with a 12 % Cr-content do not mechanically withstand the forces to which they are subjected. This is the reason why we give our preference to the austenitic alloys whether stabilized or not.

Besides, we will note:

- 1) that the carbides, poor in Cr and Mo, are chemically instable in the presence of hydrogen.  
This is reason why steel grades with Cr- and Mo-contents respectively equal to 2,25 % Cr and 1 % Mo are grades in which we take no interest, at least at temperatures in the region of 550°C.  
In this case the pressure is a parameter of a secondary importance.
- 2) A base metal, poor in Cr and in which a carbide phase chemically stable in the presence of H<sub>2</sub> is scattered, becomes brittle when H<sub>2</sub> is inserted in the lattice of the ferritic base metal. The metal becomes ductile again by being adequately heat-treated.  
The presence of internal stresses apparently catalyses the cation of hydrogen.
- 3) A base metal sufficiently rich in Cr and in which a carbide phase, stable in the presence of H<sub>2</sub> is perfectly corrosion-resisting.

- 4) The austenitic Ni-Cr alloys, although they absorb important volumes of molecular hydrogen do not lose their ductility.

By closing this technical report, we draw the reader's attention to the fact, that in said report we have only corroborated by bringing them out and elucidating certain points, the results published by several authors particularly Prof. B. Dodge.

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The corrosion of different steel grades by dry hydrogen sulphide with a water percentage equal to 5 % is the subject of a research which is now in progress. The methods used to this purpose are the same as those described above.

Before carrying out our tests, we had to develop a method for compressing the hydrogen sulphide up to a pressure, equal to 1 500 kg/cm<sup>2</sup>. The execution of said tests started in 1964 and different steel grades were tested. The experimental data collected are however insufficient, as regards their number, so that we are not in a position to publish conclusive results.

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### III. RESEARCH ON THERMODYNAMIC PROPERTIES OF GASES.

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During several years, we have endeavoured to study thermodynamic properties of gases used in the industry, and more specially the compressibility, the specific heat and the viscosity of several gases and mixtures.

This work is more a fundamental one, so that in this paper just some aspects relating to industry will be discussed.

The velocity of chemical reactions, their reaction rates and their velocity equilibrium constants can be calculated only by means of accurate thermodynamic data.

Such data are almost completely missing, when reactions occur in a gaseous phase, at pressures exceeding 1000 atmospheres.

Therefore, the "Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture" (I.R.S.I.A.) granted the "Institut Belge des Hautes Pressions", generous subsidies for erecting a laboratory for the study of experimental thermodynamics, under high pressures.

The equation of state of gases is one of the most important notions to be defined in the thermodynamics of high pressures. In fact, the influence of the pressure on the chemical equilibrium of the reaction studied, can be deduced by means of said thermodynamic data, resulting from the study of either pure constituents or mixtures of them, when the equilibrium is reached. Particularly, the equation of state must be known for correctly applying several methods of calculations, based on the knowledge of the specific heat of gases, under normal conditions and the variations of the entropies and enthalpies of the same gases, in dependence with their pressures.

The measurement of such quantities takes a long time and moreover, is difficult and expensive. Apparently, it cannot only be made for reactions already used in the industry and of which it is desirable to improve the efficiency, by better knowledge about their equilibrium constants under high pressures.

As examples of such cases, one can mention the ammonia synthesis and numerous reactions, based on methane. This justifies the selection of the gases, we have studied, namely, the stoichiometric mixture  $N_2 + 3H_2$ , and the methane which was the subject of my paper on the Third Symposium on Thermophysical Properties (Purdue University, 22-25th March 1965).

The determination of these quantities raises however technical problems, which are so difficult to solve, that very few laboratories indeed are in a position, to make such measurements. The Belgian Institute for High Pressures made a special study of this field and determines the gas equations of state using a method, derived from Amagat's one. A method for establishing the equations of state has been carefully studied and after receiving successive amendments, has been definitively adopted. Some details are given about the techniques applied to this purpose in the mentioned paper (6).

The experimental results, seem particularly interesting, because inflexion or inversion points are observed in the curves showing how the compressibility, the fugacity coefficient and the fugacity itself vary with the pressure, such observation being made, when the pressure reaches defined values in the region of 2000 atmospheres (Figure 9 gives the fugacity coefficient of methane up to 3000 atmospheres).