

SCIENTIFIC EVIDENCE OF ATOMIC DECOMPOSITION OF GASEOUS MOLECULES IN METALLIC EUTECTIC BATH

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ABSTRACT

To ensure a mass production of hydrogen, the area of the metal – gas interface must be very large and may be ensured by stirring metallic bath with methane gas very fine bubbles. Gas stirring of liquid steel is a habitual practice in industry. The logic conclusion of all four scientific basis's is feasibility of the new hydrogen production route by atomic decomposition of methane molecules inside the quaternary eutectic metallic bath, stirred with methane gas fine bubbles, which permits the black carbon sequestration, without any CO₂ emission. Most of the elements of technology and equipment are known and usual in metallurgical industry.

Key words: atomic decomposition of gaseous molecules, Sivert's law, chemisorption, desorbition, quaternary eutectics, stirring of metallic bath.

Theoretical aspects

In the metal industry, we are using now small quantities of hydrogen, but in the future we need to produce and use very large amounts of hydrogen. How?

The last Brussels Annual Meeting of the European Hydrogen and Fuel Cells Platforms expressed the necessity of a focused, ten year research, development and demonstration program to bring into operation new hydrogen production routes for ensuring a reduction of its costs by a factor 3 or more. In the same time, this new H₂ production routes should be sure, with small carbon dioxide emission or, even, without such emission and on at very large (mass) industrial scale.

How can the scientists find the wanted new H₂ production routes in very short (ten years) period of time and with minimal expenses? In his chairman's message for the 14th European Conference and Exhibition on Biomass for Energy, Industry and Climate Protection (Paris, 17 – 21 October 2004), Prof. Lars Sjunnesson wrote an interesting answer: “Biomass is a wonderful energy carrier, where the sun energy is storage by the photosynthesis process. Part of this process can be imitated and used to produce hydrogen...” (our underlining).

In the “Basic Research Needs for the Hydrogen Economy” (www.sc.doe.gov/bes/hydrogen.pdf), American department gives a more concrete indication: for more than 4 billions of years in the solid crust and in the Earth's hydrosphere, there are producing large quantities of hydrogen (estimated between 250 – 1200 millions tons a year) by microorganism with or without chlorophyll by “biological decomposition of water and/or hydrocarbons” (our underlining). These natural hydrogen quantities are many times larger than present industrial H₂ production worldwide. It is however impossible to collect and used this natural hydrogen. Therefore, we have only two other possibilities to act: a) the bioengineers must find the

proper technology to use such microorganisms to mass produce hydrogen; b) the materials engineers must find new artificial/industrial technology to imitate the natural process of H₂ production [1-9]. How?

Now, we have only one possibility: to study the scientific known phenomena of splitting water and / or hydrocarbons molecules, to learn how splitting process occurs and try to create new technological means to enhance this process into new industrial proceeding. The present H₂ production technologies, including methane catalytic reforming, are also based on such scientific known phenomena.

All solid state researchers and especially the metallurgists know very well the phenomenon of gaseous molecules splitting in the moment of their chemisorption on the metallic surfaces (uncovered by rust or other matters, so called “with metallic glister”). This atomic decomposition of gaseous molecules (H₂, N₂, CO, H₂O, SO₂, H₂S, CH₄ and so on) respect “Sievert’s law”.

For instance, the Turkdogan’s, E.T., handbook, “Fundamentals of Steelmaking” (The Institute of Materials, London, 1996, page 96 – 126), presents Sievert’s law for the atomic decomposition of diatomic molecules of H₂, N₂, O₂, S₂, CO, a.s.o. in the moment of their chemisorptions on solid and liquid steel surfaces, according to this reaction:



Whose equilibrium constancy, K_X is expressed:

$$K_X = \frac{[\%X]}{(p_{X_2})^{1/2}} \quad (2)$$

From this formula, the content [%X] will be:

$$[\%X] = K_X \sqrt{p_{X_2}} \quad (3)$$

In Turkdogan’s Handbook there are the following equilibrium constancies formulas for temperatures near 1600°C, the steel making temperature:

$$\frac{1}{2}\{H_2\} = [H] \Rightarrow \log K_H = -\frac{1900}{T} + 2,423 \quad (4)$$

$$\frac{1}{2}\{N_2\} = [N] \Rightarrow \log K_N = -\frac{188}{T} + 2,73 \quad (5)$$

$$\{CO\} = [C] + [O] \Rightarrow K_{CO} = \frac{[\%C][ppmO]}{p_{CO}(atm)} = 20 \quad (6)$$

$$\{CO_2\} = [CO] + [O] \Rightarrow K_{CO_2} = \frac{p_{CO}}{p_{CO_2}} [ppmO] = 1,1 \cdot 10^4 \quad (7)$$

So:

$$\{CO_2\} = [C] + 2[O] \Rightarrow K'_{CO_2} = \frac{[\%C][ppmO]^2}{p_{CO_2}(atm)} = 22 \cdot 10^4 \quad (8)$$

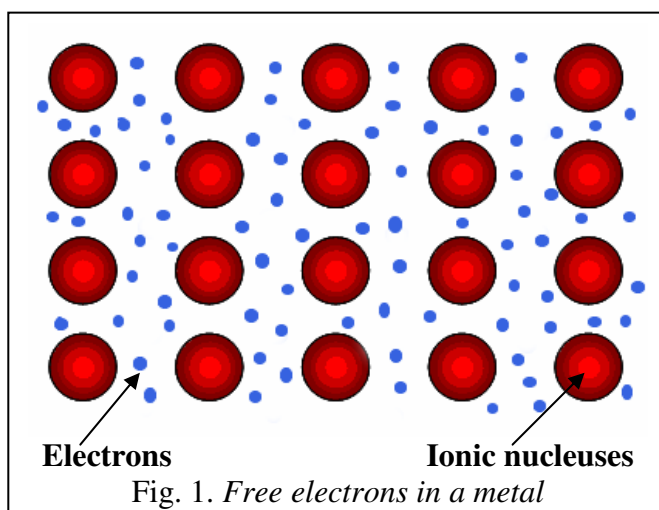
$$\{H_2O\} = 2[H] + [O] \Rightarrow K_{H_2O} = \frac{[ppmH]^2 [ppmO]}{p_{H_2O} (atm)} = 1,77 \cdot 10^6 \quad (9)$$

$$\{SO_2\} = [S] + 2[O] \Rightarrow K_{SO_2} = \frac{[\%S][\%O]^2}{p_{SO_2} (atm)} = 1558 \quad (10)$$

$$\{H_2S\} = [S] + 2[H] \Rightarrow K_{H_2S} = \frac{p_{H_2}}{p_{H_2S}} [ppmS] = 4,3 \cdot 10^6 \quad (11)$$

EXPERIMENT

All these formulas have a very laborious experimental basis, as is known by the specialists. In chemisorption, the hydrocarbons molecules are broken in atoms, according to the general formula:



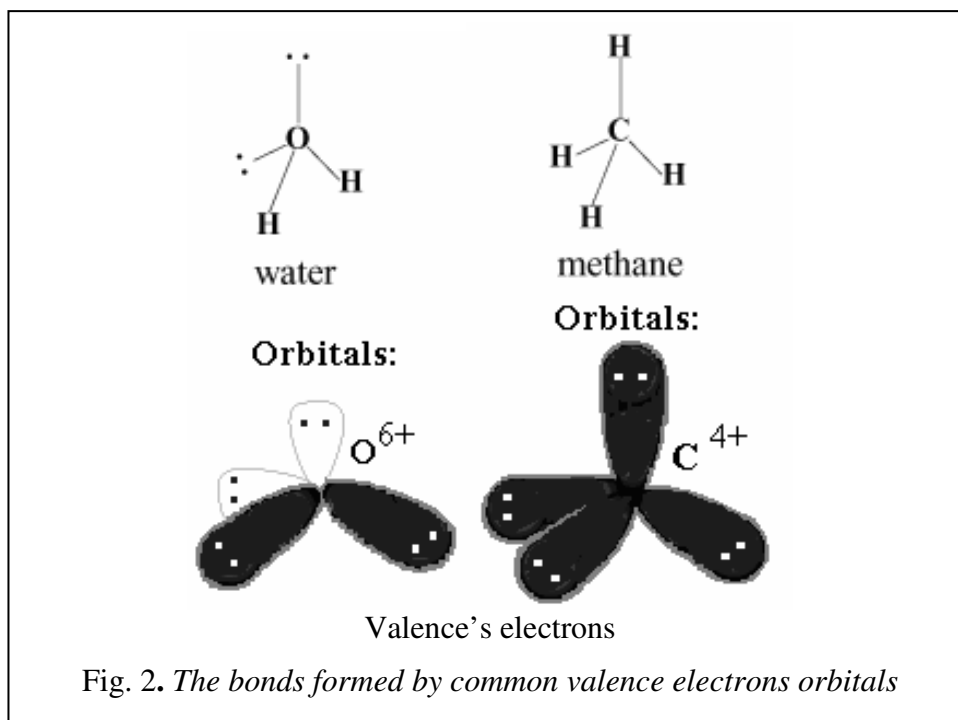
$$\{C_m H_n\} = m[C] + n[H] \Rightarrow K_{C_m H_n} = \frac{[\%C]^m [H]^n}{p_{C_m H_n} (atm)} \quad (12)$$

For methane gas chemisorption, this formula will be:

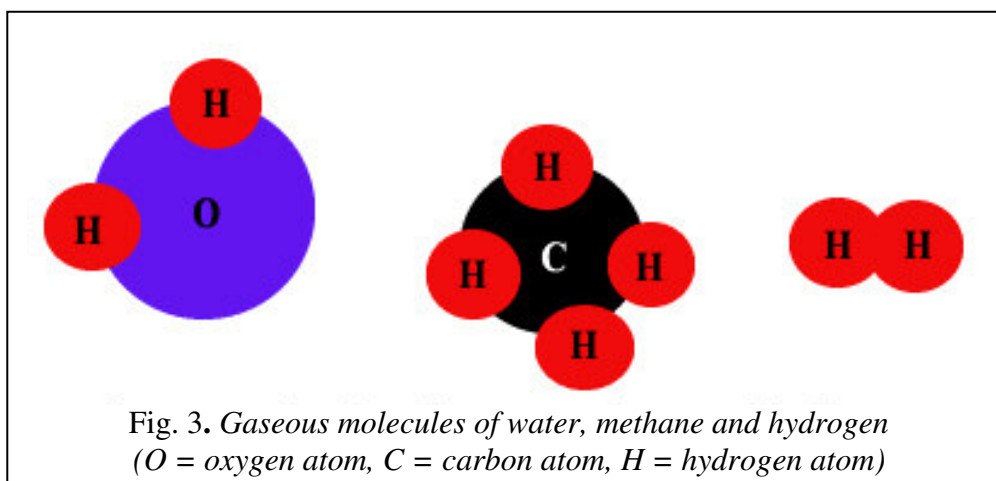
$$\{CH_4\} = [C] + 4[H] \Rightarrow K_{CH_4} = \frac{[\%C][H]^4}{p_{CH_4} (atm)} \quad (13)$$

How can we explain the atomic decompositions of gaseous molecules in the moment of their chemisorption?

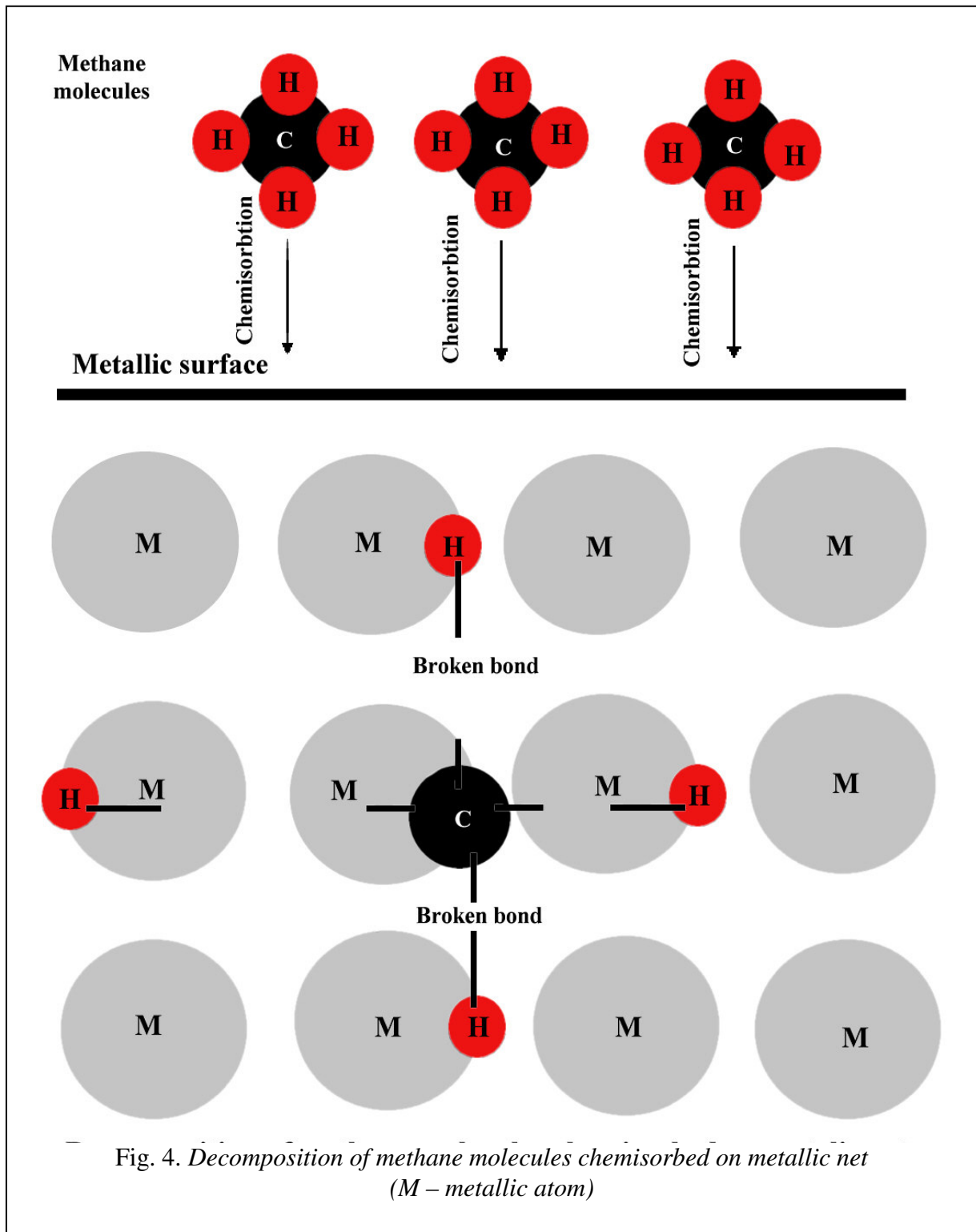
We know that in solid and liquid metals and alloys (which are first degree conductors of electricity) valence electrons form so called “common electronic gas”, because their bonds (with the ionic nucleuses) are broken by atomic forces existing in the crystalline net. This existing in metals and alloys “common electronic gas” can be proved by everybody by very simple experiment of the electric conduction.

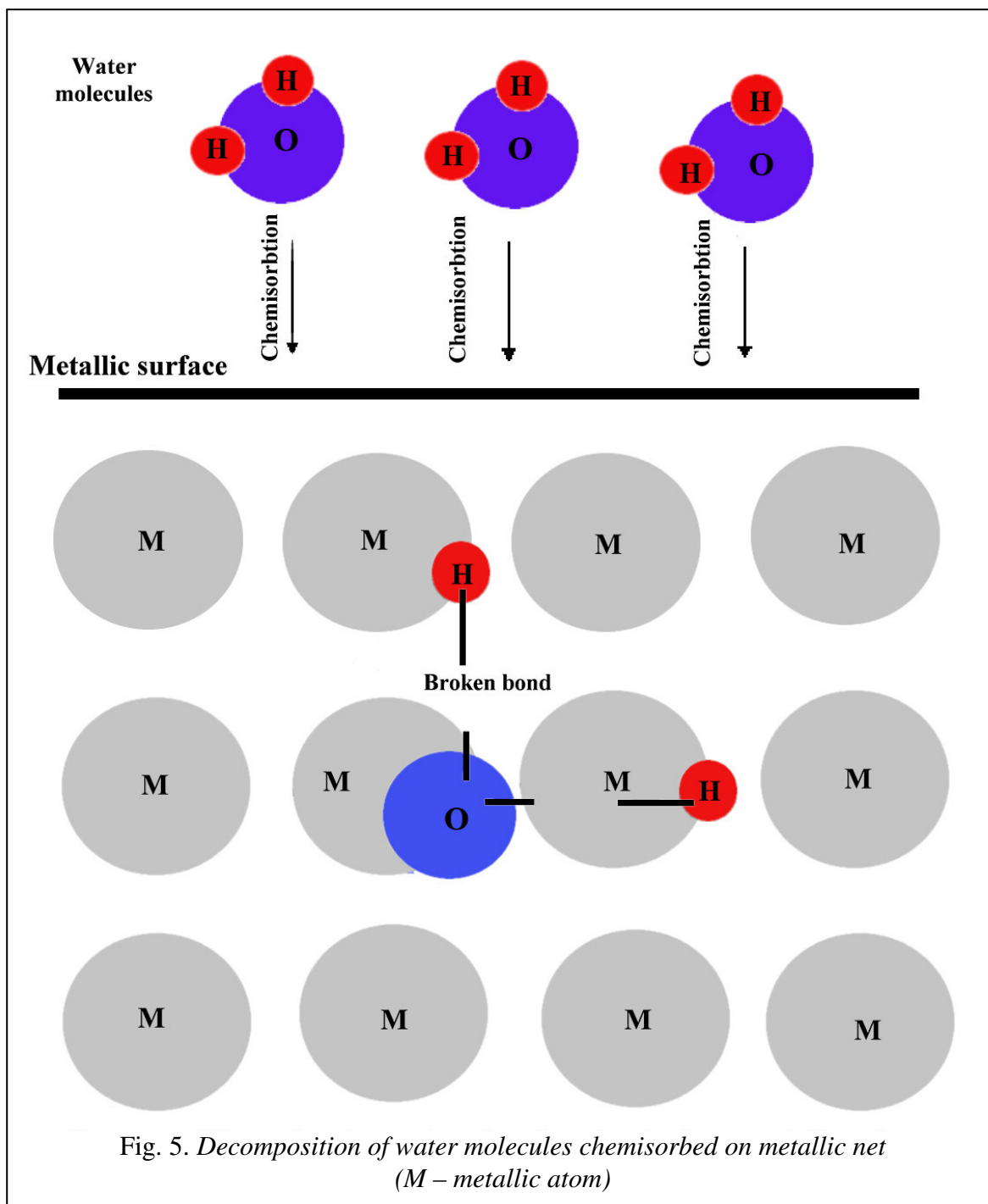


The same atomic forces break the bonds between valence electrons and ionic nucleuses in the moment of chemisorption of water or methane molecules (for instance). Thus valence electrons enter in the “common gas” and ionic nucleuses are dissolved in the crystalline net.



Thanks to this atomic decomposition phenomenon, inside of the crystalline net of the used metal or alloy, there are dissolved more atomic species (hydrogen, carbon, oxygen a.s.o.). To obtain hydrogen we have to make possible the other very known phenomenon: the desorbtion of hydrogen molecules. For this aim, the hydrogen atoms must catch their electrons, combine their selves by pairs, and leave the metallic surface into gaseous phase.

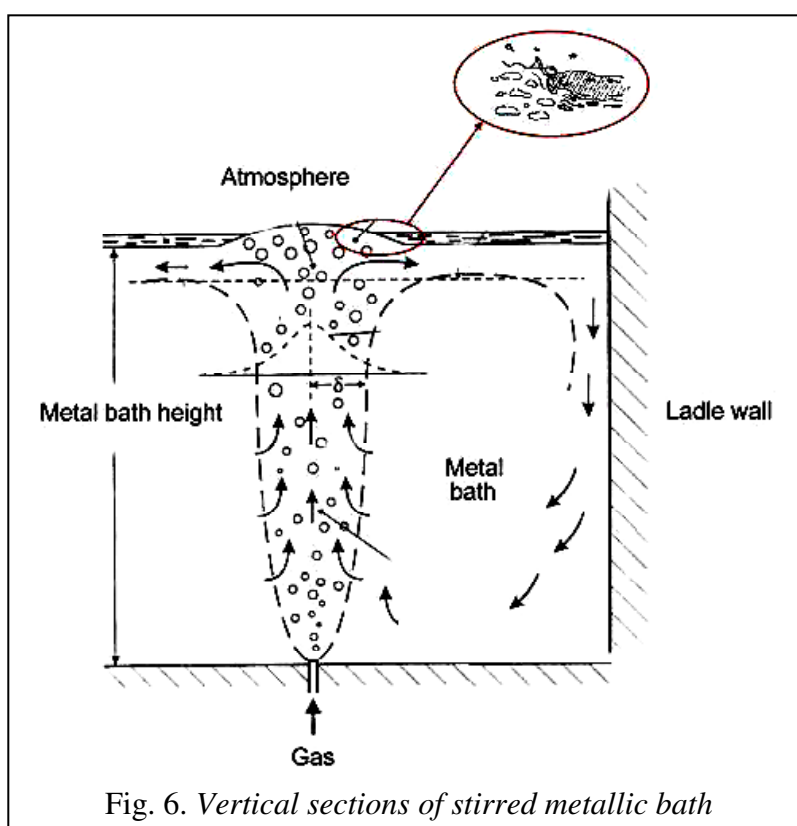




Secondly, we must separate all other species of atoms, existing inside of metallic net. Carbon atoms have the most convenient behaviour because they can form nodules (like in the nodular or modified cast irons) and leave the metal as black carbon particulates. Oxygen atoms must be tied by very strong deoxidisers (Ca, Si, Mg, etc.) into different solid and liquid oxides, to be easy separated from gaseous hydrogen.

Now, we – the metallurgists - are obtaining hydrogen from water and/or hydrocarbons, but we have not yet an industrial technology for hydrogen production, because the atomic decomposition of gaseous molecules is a very slow phenomenon, which can not have any

industrial significance. We must therefore enhance hydrogen productivity to industrial performance. How? By using very important metallurgist knowledge to change solid state of metallic support to liquid (molten) state, thus, we magnify by hundred times the mobility of atoms in the metallic support. Secondly, we can use a very known and versatile metallurgical technology: the stirring of metallic bath by very fine methane or steam bubbles, introduced through the bottom of containing metallic bath vessel. We – the metallurgist - know very exactly that the area of interphasic surface between metal and gas is in this case, hundred thousand times larger than the area of the quiet bath, thus the hydrogen productivity will be hundred thousand times bigger, because the chemisorption and desorption are surface phenomena.

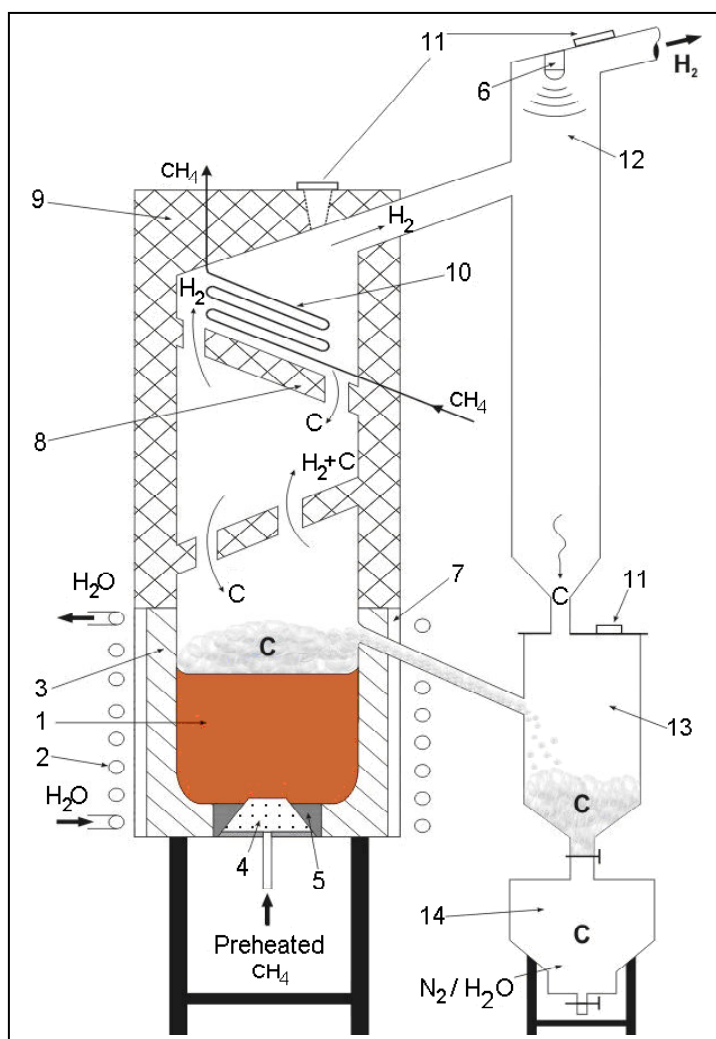


To diminish the working temperature we will use one of many quaternary eutectic alloys, because the specialists know that such alloys ensure the lowest melting point, low energy input, low cost of hydrogen production and high its security (no explosions and ignitions).

Most of the technological elements and the needed equipment are widespread used in metallurgical industry and thus this technology is very versatile.

The new hydrogen production route seems (for outsiders) enough complicated because they are not familiar with our in metallurgical schools received knowledge. In this case we have the privilege to refer to a similar, but widespread known phenomenon: the bactericide

properties of glisten metallic surfaces. Nowadays many of surgical operation rooms in the hospitals have all walls (even the ceiling) covered by stainless steel plates to destroy bacteria through the breaking of their cells, by a similar process with atomic decomposition of gaseous molecules in the moment of their chemisorption on the same metallic surfaces. The similitude of this both phenomena helps us to convince the people they know that in the officers' gourds was introduced, for years, a silver wire, which was killing all microorganisms contained in the marshy water in the war times. This is our last convincing argument to assert the necessity to research and implement our new hydrogen production technology, which is alike as the bactericide phenomenon.



- 1 – stirred metallic bath;
 - 2 – induction coil;
 - 3 – graphite crucible;
 - 4 – porous plug;
 - 5 – well block;
 - 6 – acoustic hooter;
 - 7 – thermal insulation;
 - 8 – refractory grate;
 - 9 – refractory lining;
 - 10 – pre-heater;
 - 11 – safety valve;
 - 12 – column for sonic coagulation of the carbon black dust;
 - 13 – carbon black collector;
 - 14 – carbon black lock chamber.
- Most of the elements are known and usual in metallurgical industry.

Fig. 7. New technology and equipment for sure mass production of low-cost hydrogen by atomic decomposition of methane gas molecules inside the quaternary eutectic metallic bath, stirred with methane gas. Proven black carbon sequestration = No CO₂ Emissions

CONCLUSIONS

There are large perspectives for further developments of new metallurgical H₂ production route:

- Our new route has **many possibilities to be developed** for other raw materials such as hydrocarbons, biomass, organic wastes a.s.o. with minor changes in technology and equipment. Preferable are those, whose molecules contain only hydrogen and carbon atoms (they permit black carbon sequestration, without CO₂ emissions).
- **The most attention must be given to water**, whose molecules do not contain carbon. Instead, the ties between atoms are very strong and technological energy input will be higher.

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