

Corrosion: technical problems, professional resources, working organization and RD&I characteristics for the Brazilian Productive Sector.

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ABSTRACT

In the introduction, they are explained the reasons for this text and it is made an analysis of the situation of the corrosion field inside the industrial processes, especially in relation to its structural differences with other areas. It is analyzed why the field of corrosion is not, in general, an important component of the industrial corporative knowledge. The consequences of this fact are deduced in relation to corrosion and corrosion with innovation. In section 3, after to give the general scientific and technical bases of corrosion, the multidisciplinary characteristics of corrosion are justified and some of the most important characteristic of corrosion in Brazil together with their necessities are described. In section 4 they are analyzed the Brazilian corrosion market characteristics, specially the two

existent markets and the possible strategies and possibilities to access to them. In section 5 they are analyzed some of the important corrosion Brazilian problems, thinking into the consequences and need, especially in human resources, group organization and, the most important, possible strategies. Finally, in section 6 are given the major conclusions.

1. GENERAL INTRODUCTION

The present text corresponds to a conference given in the First International Seminar on Innovation in Electrochemical Industry in the Institute SENAI for Innovation in Electrochemistry (ISI Electrochemistry) at the SENAI, in Curitiba in September, 2013. In that occasion the organizers asked me to make a reflection about innovations in electrochemistry, especially in the corrosion field, one of my areas of research and development [1-6], where at the same time, I solve problems under contract for any kind of industry in all Brazil. They are these two aspects of my corrosion activity (the research and the solution of problems), together with my research in the field of Management of Technology in Latin-American conditions [7-9], that leaned me to accept the invitation, considering that, perhaps, I have something to contribute, due a to my relation with the productive sector in all the areas of the electrochemistry. To do that it must be take into account that I will be always referring me to Brazil or, in general, only to Latin America, because I have worked also in the corrosion field and in Electrochemistry, in general, in Argentine, at the National Institute of Technology between 1972 and 1979 and I belong to the Latin America Technology Management Association (ALTEC).

Going to the concrete problem, as introduction, it must be pointed to the fact that the corrosion field is a special area which observed from the industrial field, in general in the entire world, is not a part of the normal production knowledge of the companies, but a very important peripheral system for them because implies direct and indirect costs. The reason is that in a great number of cases the industries have no knowledge capacities in them to defy the problems in the field of corrosion, because their area of activities is completely different. As a consequence, they depend, in general, on other specialized companies which produce and sell the solutions of the corrosion problems and even innovations, or in individuals or institutional specialists in different corrosion areas. This has tremendous effects in the markets of corrosion and in innovation in corrosion processes because their development occur, in general, not in the industrial companies with the corrosion problems they have, but in the companies that sell solutions for the corrosion problems or, a lot of times, in specialists, associated in different forms or belonging to research laboratories in the field. This does not means that big companies they do not have little groups to solve some of the problems or to become valid

interlocutors of the external specialist sources.

As a consequence, from my point of view, to think in innovation in corrosion in a given Latino American country means to think in innovation in the research groups or in particular companies or research groups selling corrosion services incorporated to their products. This fact produces important differences in the kind of human resources, equipments and organization which are needed, not only in the two analyzed cases but, fundamentally, when they are compared with resources and strategies for innovation in other industrial areas.

The paragraphs above need to be deeply considered, from my point of view, to have a reasonable strategy in the corrosion area in Brazil. The following text will try to show some other especial aspects that, even some times generals, contribute particularly in Latino America to this view and the consequent necessary strategies.

2. TOPICS

2.1 Multidisciplinary of the Corrosion's Science.

The corrosion of metals and semiconductors is based in the electrochemistry because involves changes in the oxidation state and/or conditions, of some of the constituents at the materials surface. The electrochemistry is the science which treats about the kinetic of reactions involving change of oxidation states within materials or surfaces, or distribution or transfer of charges in any interface. For its application to corrosion, the electrochemistry has their bases in the anodic and cathodic reactions that occur on the metals and semiconductor surfaces which are under corrosion. In non-noble metals these reactions are, by far, conditioned by the state of the surface, where the interface never is, in general, a metal/solution interface, but a metal/film /solution interface, giving rise to the well known phenomenon of passivation: the formation of a film on the surface under corrosion which inhibits the continuation of this corrosion.

In atmospheric corrosion, the corrosion is always a wet corrosion because it occurs due to the existence of a very thin film of a water solution on the metal surfaces. These can be of the order of several water monolayers, giving rise to true solutions at the surfaces with participation of atmospheric contaminants.

For underground corrosion the problem is totally equivalent to the normal corrosion, by immersion, differing into kinds and wettability of the soils, kinds of contaminants, soil porosity and rains regimes.

The corrosion processes are characterized by to correspond thermodynamically to open system which make that they can arrive to stationary states, but

never to equilibrium states. This means they always can display multiple steady states that depend on the history of the system. This is a great complication for solving many corrosive problems. They are the open conditions to the surroundings (the environment).

All these previous facts contribute to the multidisciplinary of the area. There are also contributions to the multidisciplinary which comes from the existence in the corrosion field of metallurgical and semiconductor aspects (due to the participation of metals, alloys and semiconductors); physicochemical aspects (due to the complexities of the corroded metals and variety of corrosion media); specific electrochemical aspects (due to the presence of oxidation/reduction processes and film formation and stability problems); weather aspects, due to the environment as a condition of corrosive processes (temperature, humidity, cycles of wet/dry surfaces, contaminants, presence of microbiological species, winds and airborne particles); air and soil composition; wet/dry cycles (of air or soils); polymer science, due to the use of anticorrosive paints to resolve many of the corrosion problems; etc.. Still further, all these aspects need to be considered in their evolution over time which is not been taking into account in the practical determinations of corrosion rates, in general.

Taking the example of Brazil, from my 35 years of experience solving corrosion problems from Belem, in the north, up to Porto Alegre, in the south, for example the temperature intervals during one year include many times not only tropical temperatures and characteristics, but tropical of altitude and, in general, they imply, at the same time, problems of microbiological corrosion.

All these facts by themselves imply, to solve the problems always from a multidisciplinary approach. On the other hand, the higher temperatures (around 10 ° C higher than in the case of temperate regions) imply not only much higher corrosion rates than in temperate countries, but for the material life expectancies, shorter times. This fact implies to look for special solutions which increase the life time and this means, once again, the necessity of multidisciplinary.

The characteristics of several regions of Brazilian land can be described as “mountainous lands” which generate valleys with their corresponding microclimates. These microclimates can give rise to especial corrosion conditions which need especial knowledge and experience to solve them, and then, multidisciplinary.

Finally, the immense Brazilian coastline, where there are points such as the “Beach of the Future” in Fortaleza, Ceará, one of the highest atmospheric corrosion rates in the world (a steel tube of 5 mm thick it can present holes in the direction to the wind in 4 months!), is another big problem for the Brazilian corrosion community. This problem requires not only knowledge of winds and their cycles but also to know how far the sea water drops come inside the continent carried by the wind, studies of how the water drops are transported and, especially, how

deeply. The importance of this knowledge is related with the fact that these water drops have between other ions, chloride ions, one of the most dangerous agents to increase corrosion. This shows also the necessity to know quite well the sea water compositions and their consequences in the corrosion field, a multidisciplinary problem another time.

If we wish we can follow with other equivalent problems from the point of view of the multidisciplinary, nevertheless, we think, that the analysis before is enough to show that several areas of science and engineering need to contribute if any one likes to solve corrosion problems really. This kind of conception needs to be considered when somebody decides to built up a company or a research group, active in the market, and which can contribute effectively to RD&I in the applied corrosion field of Brazil or Latin America.

As a conclusion of this section, the corrosion's community which will build the company or the research group, need to be trained in research to enable them to face all these challenges. How to do it? These are problems which need to be resolved through belonging to networks but, at the same time, the components of the team need to know the different languages to participate in multidisciplinary networks, giving them origin and convenient focus. To do that they need to do research in some selected areas related with their real practical circumstances. This is because, from our point of view, in Latino America, the concrete cooperative work is not always easily to develop and, perhaps, this is one of the higher differences with Europe or EUA. On the other hand, the necessary burocratic structures arrive to be oversized.

These show that a team dedicated to apply RD&I in Corrosion requires an interdisciplinary spectrum of activities in RD&I, as great as possible, in all these necessary senses and, at the same time, to have conformed knowledge networks related to their interests for not be obliged to become very large and uneconomical.

2.2 Some Brazilian Corrosion market characteristics

The market to which I will refer me, very important to ensure interaction between researchers/groups of RD & I/institutions and/or companies, is the way in which occurs the provision of corrosion services, together with the selling of products for corrosion (since anticorrosive paints until anodic or cathodic protection) in Brazil and Latin America. Even though some of these issues are general, as I see in the International Corrosion Congresses and other equivalents events, Brazil has its particular characteristics that must be known "to be in the market".

The first highlight is the fact that in this "corrosion market" exist two sub-markets: that of incorporated technologies into products to solve corrosion problems, and another, to which belong the solving of concrete problems of corrosion that has industrial companies.

The submarket for embedded technologies (from anti-corrosive paint until anodic and cathodic protections, including the process of electrodeposition) is a traditional market in the sense that can be described schematically, in general, as constituted by the companies which produce products and embedded technologies and those who only buy and use these technologies. In this submarket, in Latin America in general, are present fundamentally the international companies or those ones connected to them, the first ones providing the technologies by multiple pathways. In this submarket the Centres for RD & I, in our opinion, have had trouble to come inside, and the individual experts have no conditions to be present. For Centres, the reasons are historical and cultural, without the existence of valid interlocutors inside the enterprises and with the development of oversized bureaucratic structures on both sides of the market (Centres of RD&I and enterprises). They are, perhaps, one of the typical characteristics of the lack of development. Winning this challenge is, without a doubt, one of the fights that will face. Underdevelopment perhaps means fundamentally burocratization. The objectives disappear and the media turn objectives.

In the case of specific problems of corrosion's submarket in Brazil, the problem has been traditionally quite well resolved due to the existence of the Brazilian Association of Corrosion (ABRACO). This association through its conferences, seminars and formation courses have promoted the corrosion in all its aspects. The seminaries and conferences have acted as a meeting ground between those who have the problems and those who can solve them, working at Universities, Research Centres or big Companies. In this sense, any new group of RD&I will need to be present with their specific works in those meeting which act as true exposition markets of who is who.

However, the aging of the Brazilian productive sector has been generating the need for a new higher level of trained scientific/technical professionals, not only with expertise coming from practice, but expertise coming from R&D in corrosion, through scientific approaches with practical objectives. The research and development approach is necessary because, for problems involving large costs (like the "pre - salt" petroleum problem, which contains a corrosion problem, for example), the cost of "not to use a scientific approach" can be very high. These kind of phenomena, which needs to include this scientific approaches, they open new areas in the Brazilian corrosion problems, together with a demand of new kind of human resources which, in general, have not been enough produced. This is another challenge in a country that all recognize, it has tremendous educative and formation problems.

2.3 Some Brazilian needs in Corrosion problems

The above discussion leads us to the central point of our presentation: Brazil is in a situation that needs to face new challenges in Corrosion due to the great economic growth and the aging of its existent productive sector. Both factors demand not only practical training, as traditionally it has occurred, but formation in applied research and basic research in Corrosion's Science, for to have bases to solve problems and to form in these researches another level of researchers with modern conceptions of how the science interacts with the technology. It is very important to understand and to state that these last demands require not only practical experience but a certain development in the field of basic scientific training pointing Brazilian specific topics together with basic general ones in the area, which always are needed to deal with problems complexes and with high costs. From our point of view this strategy has not been taken enough into account when is considered the challenges in this kind of corrosion problems that Brazil will have to defy.

For our point of view, as in many other areas, Brazil, like other developing countries, needs research and development, without turn them in the central key. Research and development which need to be able to provide inputs that ensure innovation and/or adaptations for the Brazilian case, without false nationalisms that are unreasonable in a universe that since the middle of the twentieth century is in the process of globalization, with a modern electronic media that accelerates infinitely this process, without to be able to change the local realities which inhibit the development.

What all this mean?

It means to recognize the necessity of high-level human resources. Innovation processes can be generated at any stage of the production processes or of technology generation and by any of the participants. Nevertheless, actually, to be suitable for the modern markets, the innovation should move up until it arrives to a final methodology or a product which should often have imbibed qualified highly advanced knowledge with participation of highly developed human resources (not necessarily many). These human resources, especially in the corrosion problems, are several times not necessary by their knowledge, but by methodologies and ways of thinking which they may exercise.

It means that the innovation participants need to have a clear understanding of their key role (fundamental, without being exclusive in relation to other workers) in the innovation process, understanding that innovation has an important aspect in the sense to be a "capacity to generate original ideas to solve specific

society problems”, but they need to know that the creativity comes from the effort, the hard work, under the conscience of a problem. In this context, innovation professionals they must see the University, fundamentally, as institution for forming highly specialized human resources, when it is possible, studying problems of our societies. In this context, innovation professionals they must see the University, fundamentally, as institution for forming highly specialized human resources, when it is possible, studying problems of our societies. In this context, innovation professionals they must see the University, fundamentally, as institution for forming highly specialized human resources, when it is possible, studying problems of our societies. In this context, innovation professionals they must see the University, fundamentally, as institution for forming highly specialized human resources, when it is possible, studying problems of our societies. In this context, innovation professionals they must see the University, fundamentally, as institution for forming highly specialized human resources, when it is possible, studying problems of our societies. In this context, innovation professionals they must see the University, fundamentally, as institution for forming highly specialized human resources, when it is possible, studying problems of our societies. In this context, innovation professionals they must see the University, fundamentally, as institution for forming highly specialized human resources, when it is possible, studying problems of our societies. In this context, innovation professionals they must see the University, fundamentally, as institution for forming highly specialized human resources, when it is possible, studying problems of our societies. They must see the Centres of RD&I as, between other tasks, implementers at the level of bench or first series of innovative ideas which have been generated in these centres or in the production activities in companies or other different places. Such innovation processes need to have first, technically existing markets and, secondly, in underdeveloped regions, they need to respond to real necessities of these societies. At the same time, of course, they need be viable economically.

It means that in the case of innovations in the field of corrosion, it is necessary not point the “market of embedded technologies”, for which are needed size’s scales in a worldwide market (without to exclude such a problems, in convenient cases). The target must be to centre the activities in the “market for concrete corrosion problems” (as they were previously analyzed). In this latter case, the innovation must be constituted by a set of new produced knowledge that enables us to solve and control certain kind of problems. This strategic approach to innovation is, perhaps, one of the contributions of the present paper to take into account for Brazilian conditions, and can be extended to Latin America. This strategic approach to the corrosion problem is not, in general, part of many current conceptions about the topic. We call it the “approach through the border lines” and, several times, they did us come to work in embedded technologies

through new contracts, generating new resources for our group, opening new technological markets.

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