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The Complexity and the User: The Human Centered Design Approach as a Paradigm for This Integration

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If we consider that the growing technological development has a number of benefits to society, we can also observe that there is an increased complexity in the implementation of modern life activities. The increased complexity is unavoidable and is even desirable in certain aspects. What should be avoided is the complication in the execution of any of such activities. The article discusses the concept of project implementation focused on the human being who will operate or use the product of the project, and the control process automation of petrochemical plants as examples of the use of this technique. This concept called Human Centered Design (HCD) is important to the decision making that any worker is submitted in his workplace, especially the fact that the procedures cannot anticipate every situation that the worker is submitted (prescribed work) and what is expected from the worker (self-use). The examples chosen in this paper are specific to the automation market for industrial process control and were collected by a survey performed with the automation system manufacturers. In these examples, we can observe the importance of the projects put focus on the human and not just in the technology.

Keywords: automation, process control, human centered design (HCD), work management

The Automation Complexity

Despite the great economic crisis that erupted in 2008 and even with the potential resurgence of the same problems in 2011/2012, the oil and natural gas market has shown a strong growth mainly due to increased energy demand. Specifically in Brazilian case, the aggressive investment plan of Petrobras (2011), the main oil company with operations in the country, with a total of USD 224.7 billion during the period 2011-2015, has kept the market supplier of equipment and services warmed. The main reason for this is the amount of direct investments that are being provided in the domestic market (USD 213.5 billion) with a total of 688 projects, which 57% refers to projects already authorized for execution and implementation.

As mentioned in Barateiro (2011) study, the automation designed to the industrial process control has a significant importance in these projects and it obviously attracts a lot of potential companies that try to obtain significant portions of this market. The automation system investment for the oil and gas market has an expected growing of 6.7% only in the production area (upstream) (ARC Advisory Group, 2009a) and 5% on

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the refining part (downstream) (ARC Advisory Group, 2009b), which is quite significant. This growth is still small when compared with estimates of service purchase inherent in these systems—the expected growing in 2015 for services in Latin America is about 11.2% (ARC Advisory Group, 2007).

All these potential growths have some important complications that can put the company at risk. As mentioned by Barateiro (2011), industrial automation systems are becoming increasingly complex, with sophisticated functionality and the engineers and operators are unable to keep themselves updated with the technology advances. This discrepancy can be attributed to several factors:

- The manufacturers cannot train the operators of the client because the trainings are conducted in the final stages of projects when there is not enough time for it;
- These trainings are not tailored to the operators needs and modules are often assembled in a standardized manner regardless of the specific characteristics of the project;
- The technology applied to automation systems grows very quickly with many tools that need a good knowledge on information technology;
- The automation systems can generate an enormous amount of data with different formats and a variety of forms of communication between the various field devices and control room;
- There is a high turnover of manpower to operate these systems (engineers, technicians, and operators) because the market is much warmed and we have retirements and promotions.

There is another aggravating factor: The globalization of the world economy is resulting in the construction of chemical and petrochemical plants in areas with little or no history, and therefore with industrial workers with limited experience to use the systems.

Work and HCD Concepts

Undeniably the modern life is becoming more complex due to the technology that allows us to more features. But we need to define what is the complexity and complication. Norman (2010) distinguished these on two aspects—the complexity is linked to the state of things, performed tasks or the tools we use and complication is linked to our mental or psychological state that allows the understanding, use or interaction with these things that surround us. Modern technology can be complex, but complexity alone is neither good nor bad—the complication that is harmful.

Norman (2010) mentioned that some complexity was desirable. Very simple things are seen as dull or boring and what is very complex makes us confused. So we have the need to establish the correct trade-offs between complexities and simplifications in all projects.

A good measure of complexity is the amount of time necessary for learning the use of technology. And we hardly ever realize how great the time required for the complete understanding of simple things is, for example, driving a vehicle or understand a foreign language. Jones (2010) mentioned that the solution to control the complexity associated with today's technology in process plants was to build systems so that operators and users may quickly have a complete understanding of their use.

Work Aspects

There is another important aspect to be considered—on the one hand, we have an increasingly sophisticate technology that requires a specialized training; on the other hand, we have increased the difficulty of establishing the prescribed work to be performed by operators and other users of the systems.

As mentioned by Daniellou, Laville, and Teiger (1989), the concept of the prescribed work refers to what is expected within a specific work process, with its local singularities. The work has two sides: the task (the prescribed work) and activity (real job). This difference was already observed in the studies in the 1960s, when ergonomists found that the workers did not follow strictly the planned method of execution in the assembly lines of the electronic industries since they should take decisions permanently due to variability of component specifications.

Wisner (2004) also mentioned that it is possible to notice the different behavior between the operators and the same operator, according to their degree of learning, time of day, the state of health or their physical and mental state. Durrive and Schwartz (2003) introduced the concept of “use of self” that is the use of personal capital of the worker to take the necessary decisions in the work environment “since you can never want to list completely and exhaustively, all what constitutes a working environment because the procedures can not anticipate everything, then work is to take risks, make use of them”. Wisner (2004) mentioned that the nature of work is already quite complex and involves an understanding of their behavioral analysis—based on objective facts—and other subjective—made by self-confrontation and eventually by subjective interpretation.

Cerf, Vallery, Gerard, and Bouchelx (2007) mentioned that the complexity is growing mainly by profound change that is occurring in the assignment due to the introduction of information technology and communication. Leplat (2004) on the other hand, mentioned that it is very difficult to define the complexity that is the work but we can consider that this characterization has two essential elements: the number of elements or units that make up the system and the number and nature of the relationship between these elements, represented in a model of this system. Leplat (2004) mentioned that “this model that we have made of the system will be dependent, itself and in the largest part, in the use and the possibilities available to regulate the own use”. Therefore, any study of the complexity begins with three issues: the complexity of what, for whom, and for what.

As the complexity of any task depends on the agent that executes it, then the essential problem is to characterize the relationship between the agent and the task considering its association and dimensions. Leplat (2004) mentioned that “if the task is seen as a result to be achieved through an appropriate processing, the agent, in turn, will be considered according to its capabilities to perform such processing”. This is essentially that its competence and the relation between this complexity and competence are the main focus for the establishment of the management of complexity that must be based on human and technical context.

Considering the current level of technology embedded in an automation system of a large chemical processing plant, these concepts are fully applicable because it is hardly possible to predict in all procedures to be taken to control this plant. And the wisdom in making decisions on the part of users (operators, engineers, and technicians) is closely related to the complexity (or complication) of how data and information are presented and how these are handled by users.

Human Centered Design

The Human Centered Design (HCD) is a multidisciplinary and interactive approach to the concept of project execution, in order to understand and meet human needs against the focus only on the characteristics of technology. The HCD concept is not new—it roots in the study of ergonomics and human factors as applied during the Second World War in the design of control cabins of aircraft given the limitations of pilots due to the stress of combat.

Jones (2010) mentioned that there are three main steps to implement the HCD concept:

- Understand the user needs: The understanding of what the user needs involves interviews, observation of how workers perform their functions, tasks and research on standards, and existing solutions;
- Creation of design solutions: It is how to meet the users' needs by developing new products or systems—For example, in the case of automation systems, after the identification of the information necessary for the operation, the personnel has full control of the process, we then project how this information will be available on workstations (2010);
- Test of solution: It is the assessment phase of the proposed solutions by testing with users, that it is a process repeated several times until the optimum solution.

This model alias is very similar to what is provided in ISO 13407 (Human Centered Design Process for Interactive Systems) presented in Figure 1, that is applied in the interactive life cycle of computer-based systems.

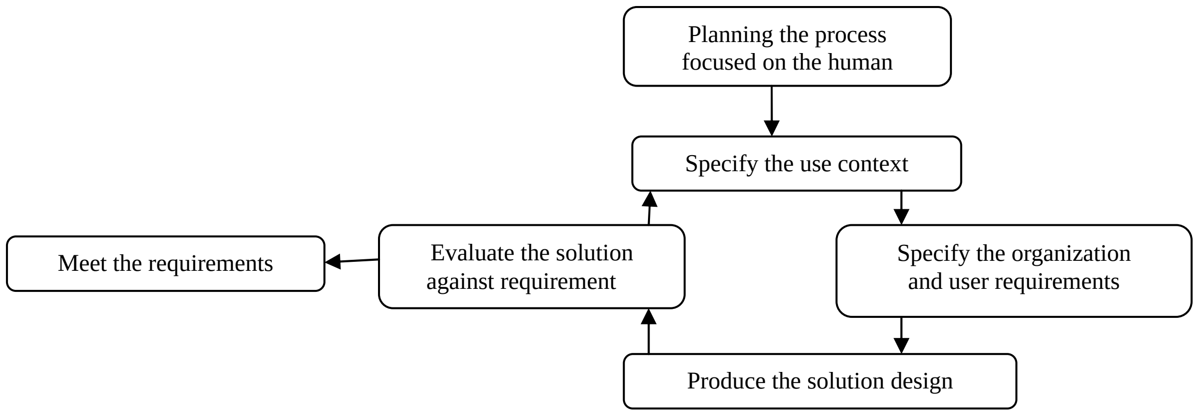

Figure 1. Model of interdependence of the activities according to ISO 13407.

Norman (2007) mentioned five basic rules to establish a proper communication between people and machines, which are guides for the establishment of a HCD project:

- Keep things simple because the people have difficulties with complicated things that they do not like to hear or read;
- Make people understand the conceptual model of what is underway;
- Give reasons for the facts for people to understand the consequences of actions;
- Make people think they are in charge even when they are not;
- Give continuous feedback which is a more emotional than informational need but it is important because people can feel that things are correct.

Methodology

The main objective of this study is to analyze the implementation strategy of automation systems using the HCD concept as a way to allow that the operators, engineers, and technicians to cope with the growing complexity of technology of the current days. For this goal, we used a deductive method constructed from the literature with manufacturers of these systems and those are important players in the supply chain of automation area for large petrochemical projects.

From the standpoint of addressing the problem, we consider the use of a qualitative method with the main players of this market that allowed us to analyze the degree of use of the concept of HCD. There was no reason to use a quantitative method since the diversity of suppliers of such systems that operate in Brazil is relatively small.

From the standpoint of the objectives and the technical procedures, we have used an exploratory method to obtain a greater familiarity with the problem, as discussed by Gil (1991). So we considered a literature search regarding the issues related of the work and the HCD concept.

Research and Results

The survey of the five largest manufacturers of automation systems that operate in Brazil found that most of them already have their systems in accordance with the HCD concept. In fact, we found that manufacturers use this concept with different nomenclatures—Human Centered Design and User Centered Design. However, an analysis of these two forms shows that they have addressed the issue of living with the complexity of the same way.

Numerous solutions have been found. Their focus is to make users of automation systems be able to have a better interface with the increasing complexity inherent in the current state of technology, with solutions applied in control rooms, in the field, and in its interfaces. We will present some collected examples of how projects and products may be appropriate to focus on the human.

Examples of HCD Concept in the Automation

The modern control rooms are the location where most decisions within an industrial petrochemical plant are concentrated. They mainly serve to allow operators and engineers to understand what happens to the processes and to make the necessary interventions. Over the years, the technology has allowed these control rooms to stay friendlier to their users. Figure 2 shows some examples of first-generation for these control rooms where a wide number of measuring instruments and control panels are spread for entire room. This type of solution was the possible at the time and we have had a great difficulty in concentration of the necessary information for decision-making.

Figure 2. First generation of control room (Nimmo & Moscatelli, 2004).

The technology has enabled a breakthrough in the design of these control rooms and the biggest improvement is in the ease of information access. There are not more instruments installed in panels, but a large number of terminals and monitors that are designed to concentrate the information. Figure 3 presents a proposal for a control room to a modern refinery.

Figure 3. Control room in compliance of HCD concept (Nimmo & Moscatelli, 2004).

In fact the solutions are not restricted to the layout of these control rooms—the main changing was the way that the information is presented to operators. Figure 4 shows the design of a display constructed in accordance with the HCD concepts: the information really needed, such as alarms, is presented in contrasting colors than used to show the process lines and other equipment.

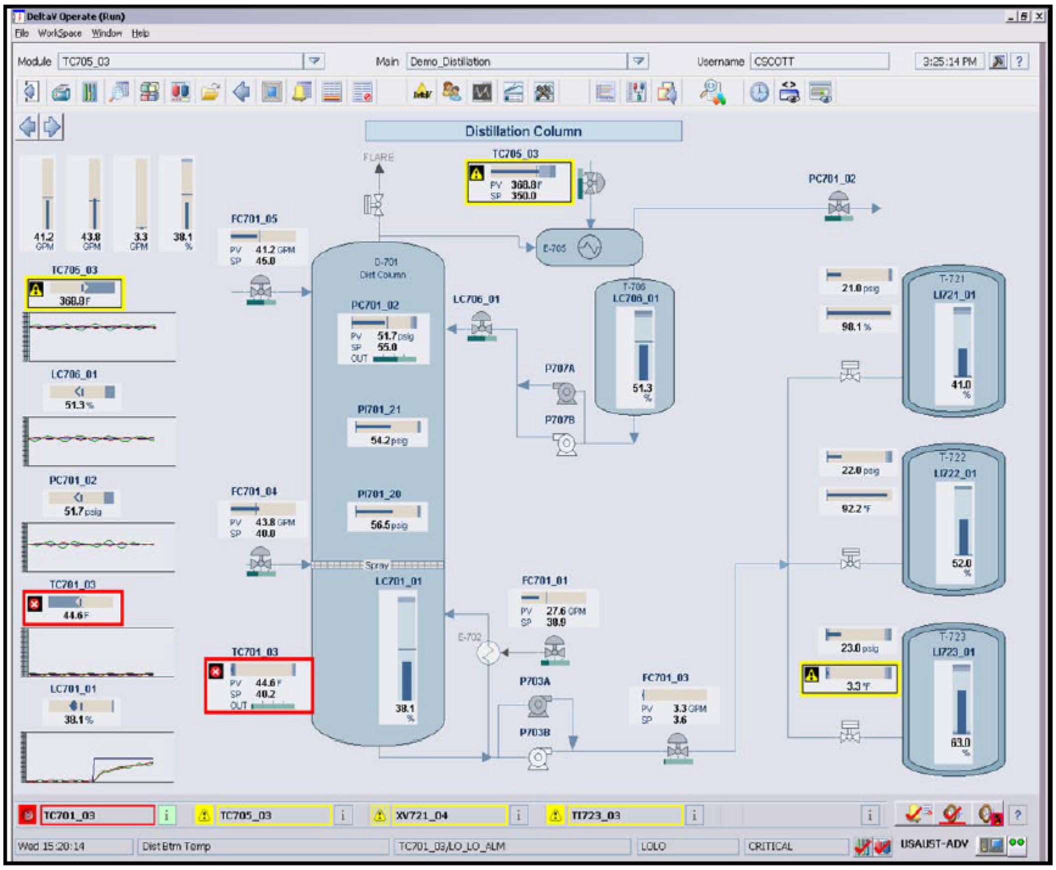

Figure 4. Operator screen (Emerson Process Management, 2011).

Within this screen other required information is presented to facilitate decision-making. In Figure 5 we can see the value of a particular process variable (PV—process value)—in the specific case, it is the flow of a particular product, and the value of the control set point (SP—set point). It is much easier for the operator to view this information through a movable bar, which allows him to evaluate how the process close to the point of control and alarm points, rather than simply see the numerical values of these variables.

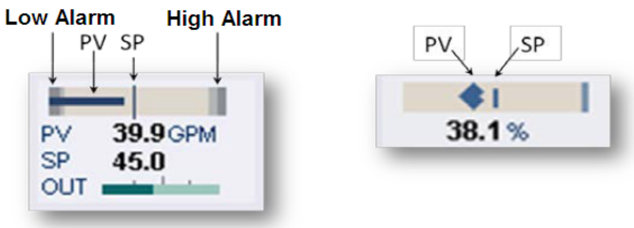

Figure 5. Process variable screen (Emerson Process Management, 2011).

We found numerous other examples of presentations on the screens of the control systems that can provide a better interface with operators. Figures 6 and 7 show the use of different color systems to present different operational situations.

Another interesting solution found using the HCD concept is in the layout of how the values of the process are shown. Besides, the status of the instrument and equipment operation, the activation of pre-specified routines and the performance information are other examples for it (see Figure 8 and 9). In all these examples, we see how screens are arranged to facilitate the work of the operators and often portraying the same visuals that were found in the old instruments. That is, we try to let the operator or engineer more comfortable to view the screens reducing the possibility of errors by misinterpretation.

Figure 10 also shows another important feature present in most existing automation systems: have an online help that can be accessed in case of abnormal conditions of the process—it is very important because the operator has access to the product and equipment manuals, instructions, and procedures in a very simple way in the operator's screen. Previous situations that had occurred in the plant can be documented in order to guide new users.

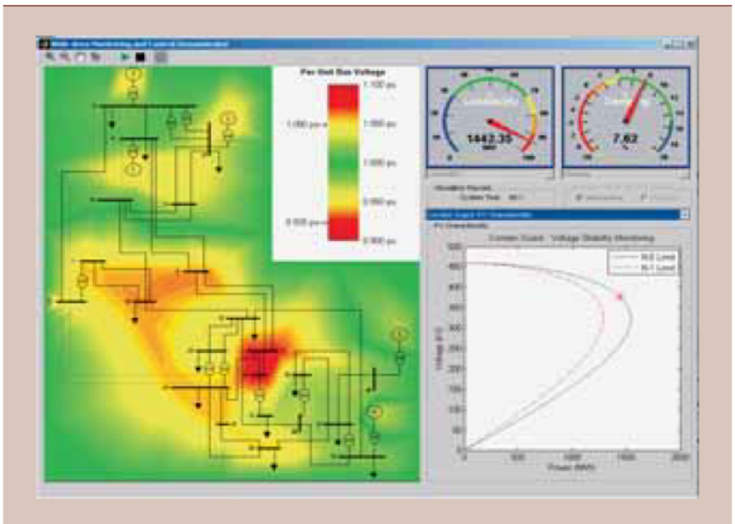

Figure 6. Screen with identification of abnormal situations in low voltage electric system (ABB, 2007).

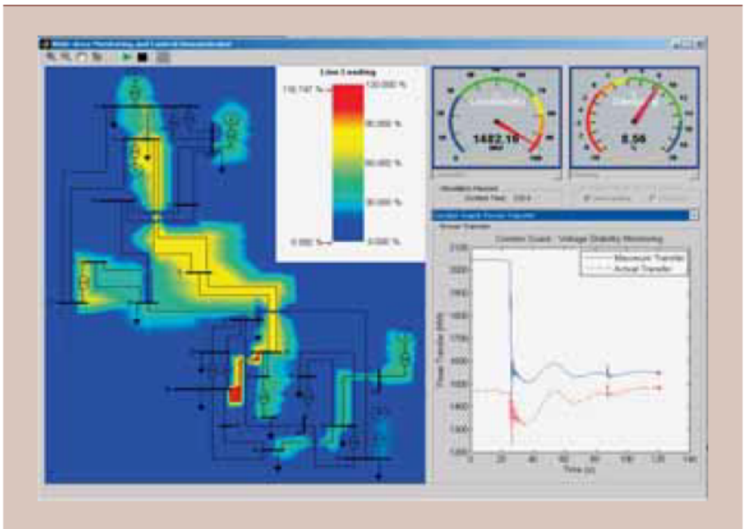

Figure 7. Identification of load screens with an electric system (ABB, 2007).

Figure 8. Instrument screen (Emerson process management, 2011).

Figure 9. Performance screen (Emerson Process Management, 2011).

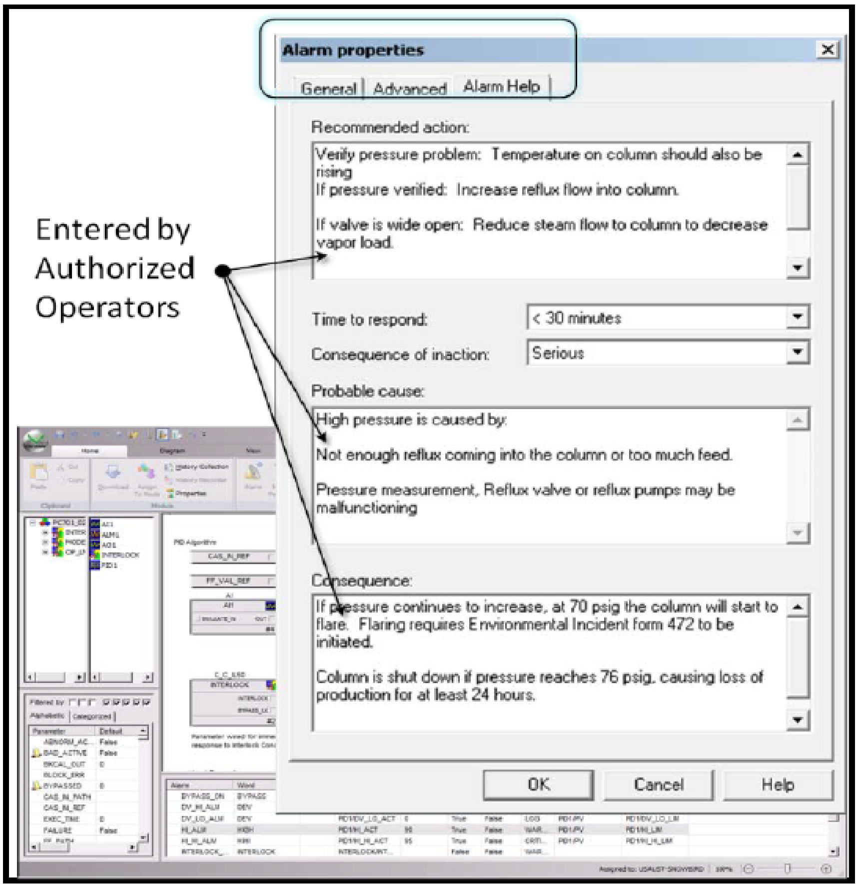

Figure 10. Abnormal conditions documentation (Emerson Process Management, 2011).

Another good example of the screens is the question of how the operator must navigate in the screens to obtain the necessary information for making decisions. Figure 11 shows an example of how the screens should be designed to facilitate access in fewer steps.

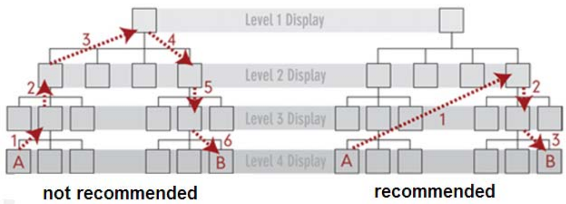

Figure 11. Navigating in the screens (Emerson Process Management, 2011).

If the technology allowed a major advance in developing solutions that enable better control of complexity, perhaps at the interface between the field and these control rooms is where these developments are clearer. Figure 12 shows a typical rearrangement panel where the wiring needed to connect the instruments and field equipment is connected to the control units. There is a strong possibility of errors in establishing these connections in the event of maintenance or even in the plant, as can be easily viewed.

The same panel is shown in Figure 13 using the HCD concept applied in conjunction with the new technologies of digital process signals. The possibility of error is much smaller increasing the security of the process and the ease of installation itself.

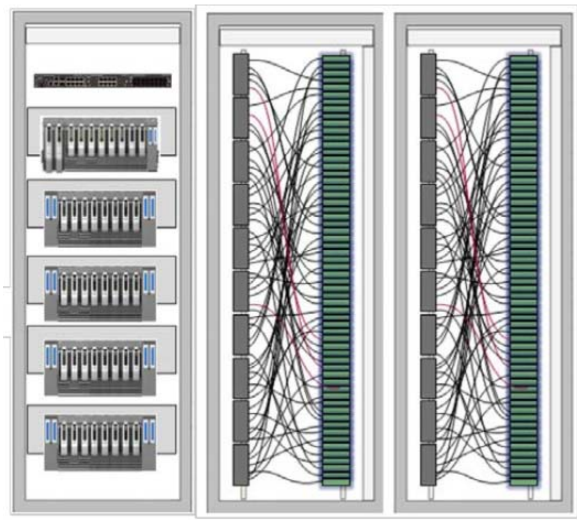

Figure 12. Typical rearrangement panel (Emerson Process Management, 2011).

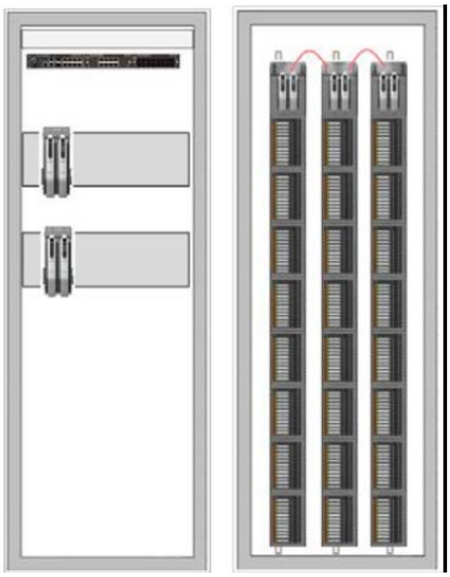

Figure 13. Rearrangement panels with digital technology (Emerson Process Management, 2011).

Conclusions

The survey allowed the collection of several examples of solutions that has used the HCD concept, enabling operators, engineers, and technicians to better work with the complexity of the technology, as discussed earlier in this paper, Norman (2010) mentioned that up to this complexity which is desirable and what should be avoided is the complication—the various examples presented are clear in showing how this complication can be avoided.

We can therefore understand that the concept of HCD as an important source could: (1) reduce unnecessary work; (2) facilitate the interaction with the complexity; and (3) reduce failures in decision making.

The advance of technology is increasingly requiring a higher level of knowledge on the part of operators, engineers, and technicians. As discussed in the description of the concepts of use of self and the prescribed work, it is impossible that all the procedures can consider all situations and the complexity of the systems will be a decisive factor for success in the decisions of these workers.

Based on the experiences reported by members of the Center for Operator Performance (COP), Montague (Montague, 2004) summarizes the key advantages of this concept:

- Improving the operator's performance up to 30%;
- Reducing the operators' response time up to 50%;
- Reducing the alarm overload up to 75%;
- Troubleshooting operating up to 40% faster;
- Reducing the time of screen navigation to obtain the necessary information;
- Reduction the number of screens.

This article covered the use of the HCD concept within the specific scope of automation systems for large petrochemical plants, and it is obvious that the solutions described may not be the same to all other industry segments. However, we can conclude that executing projects with a focus on human beings brings more significant results and better use of technology.

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