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Automated Measurement System for Catalyst Hoppers at the Cracking Plant of a Petroleum Refinery in Cartagena – Colombia

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Abstract: The measurement and control of levels of liquid and solid compounds have been present since the beginning of the petrochemical industry worldwide, with the advancement of time and technology these processes have become more exigent, demanding more accurate results with lower margin for the same. Taking into account the above, different types of industries have progressively incorporated in their control systems, leading technological inventories for recording measures, which over the years have evolved to reach their maximum potential seeking to deliver results more reliable. In the case of the Ecopetrol Refinery in Cartagena, there is a process called "Catalytic Cracking", which has the purpose of producing gasolines with a high commercial value due to their high demand in the market. Thus for the "Catalytic Cracking" process to be completed, it is essential to use as input a catalyst that is stored in two hoppers, one of which stores the "fresh or new catalyst" and another one stores the "spent catalyst" . In this context, if at any time you want to know the exact contents of the hopper remnants in order to replenish them, control the inventory of your purchase or finally dispose of what have become waste, is mandatory to make a measure not automated in the drums containing them, which is executed by operators manually using a tape measure which favors the exposure of the operators to the particulate material that makes up the catalytic substances. In view of the previous situation and the need to implement an automated online measurement to know exactly the inventories of the material, a project was carried out whose summary is explained below and shows the work of design and implementation of an automated measurement system in the hoppers Of catalyst in the Refinery Cracking plant in which radar sensors were used in line, which allowed to observe in the Distributed Control System (DCS) the tonnage they contained.

Specifically, the work looked out for technological improvement in the measurement systems in the Refinery and in the systems of control of inputs in the Department of Catalytic Cracking, allowing to reduce the environmental impact, occupational impact and measurement error in order to obtain benefits for the health of the persons responsible for carrying out the measurements and the reliability of the measurement levels. The instrumentation system was designed and implemented by two radar sensors which are installed in the fresh and spent catalyst hoppers at the Cracking plant, which are responsible for recording the catalyst levels and then being sent to the Control System Distributed (DCS) for viewing. The level signals from the radars are managed by a controller which is responsible for storing them to have a record of trends and historical data of the levels, showing good results and the solution to the problem posed.

Keywords: Catalyst, Catalytic Cracking, Hopper, Radar, Sensor

I. INTRODUCTION

As already mentioned, Ecopetrol - Empresa Colombiana de Petróleos S.A, is Colombian first oil company. A company that according to Forbes magazine, is ranked 114 among the largest in the world and is the second largest oil company in America behind Petrobras. In 2012, S & P Global Platts ranked Ecopetrol as one of the 14 best oil companies in the world, fourth in the Americas and first in America.

Among the processes carried out in the plant, "Catalytic Cracking or Catalytic Cracking" is one of them and consists of the thermal decomposition of petroleum components in the presence of a catalyst, for the purpose of cracking heavy hydrocarbons whose boiling point Is equal to or greater than 315° C to convert them into short chain light hydrocarbons whose boiling point is below 221° C. Such catalysts are presented in granular or micro spherical form. The catalysts are usually composed of silicon oxide (SiO_2) and alumina (Al_2O_3). The mineral most commonly used for this purpose is the faujasita. [1]

The purpose of the process was to obtain the largest amount of light hydrocarbons of great appreciation for the industry; the majority of the loads to catalytic rupture units are gas oils, heavy oils such as DMOH and DMO (Hydrogenated Demetallized Oil and Demetallized Oil, respectively). "Catalytic Cracking" produces high octane aromatic hydrocarbons and naphthas, such as benzene through the conversion of cyclo alkanes and paraffins. [2] Thus, cracking and catalytic reforming make it possible for the refinery to respond to changes in demand. The people in charge of the production scheduling are responsible for defining the routing of the different streams obtained in the distillation through the various conversion processes, to adjust the quantity and quality of the final products, according to the demand. It must be said that the first commercial use of "Catalytic Cracking" occurred in 1915, when Almer M. McAfee of Gulf Refining Company developed a batch process using aluminum chloride (a Friedel Crafts catalyst known since 1877) to catalytically break oils Heavy oil. However, the prohibitive cost of the catalyst prevented the widespread use of McAfee processes at that time. [3], [4]

II. THEORETICAL FRAMEWORK

A. *Catalytic Cracking Process.*

It is a refining process that aims to increase the production of gasoline and LPG (Liquefied Petroleum Gas), which converts the heavier fractions of oil into lighter fractions and with greater commercial value. Originally the cracking processes were born due to the need to increase gasoline production, in quantity and quality, due to the great growth of the automobile industry in the United States. The fluidized bed catalytic cracking process is the most widespread in the world because it contributes to the refinery to adjust its production to the real needs of the local consumption and because it allows to increase the real profits of the refinery due to the processing of residual fractions of low value in fractions of high commercial value.

1) *Flow of the Cracking Process*: The charge of a catalytic cracking unit is a pure gas oil, this charge is preheated in exchangers and then injected into the riser or vertical pipe which is in the Reactor where it is mixed with the regenerated catalyst to be vaporized. The catalyst currently used is the zeolitic catalyst which is based on silica-alumina. Cracking reactions occur along the *"riser"* producing a mixture of gases composed of LPG, gasoline, heavy oils, and coke that adhere to the surface of the catalyst which decreases its activity. Thus, the spent catalyst whose activity is diminished is separated at the exit of the riser, falling into the stripper in which by means of an injection of steam the excess hydrocarbon is removed that adheres to the surface of the Catalyst, catalyst particles that are entrained with the cracking gases are recovered by means of the cyclones, the catalyst after stripping is sent to the regenerator where the coke is blown with air, the burning of the coke recovers the activity of the catalyst and generates All the energy required for the process, the combustion gases generated in the burning of the coke are sent to the atmosphere through the regenerator chimney, the catalyst particles that leave together with the combustion gases are recovered in the cyclones of the regenerator. Finally, the cracking gases are fractionated in a tower distillation which is called the main fractionator. The products in this are laterally extracted, these side currents depend on the boiling and dew point of each product.
2) *Cracking Catalyst:* Is a simple or compound chemical, which modifies the speed of a chemical reaction, intervening in it without being part of the resulting compounds. The catalysts have two variables that define them, the active phase and the selective phase. The cracking catalyst used in the Cracking plant has three important functions in the process: to promote cracking reactions, to serve as a coke transport agent and to serve as a thermal transfer agent between the reactor and the regenerator.
3) *Types of Catalysts:* There are three big types of catalysts: natural, amorphous and zeolitic.
4) *Catalyst Importance within Catalytic Cracking:* The catalyst is the core of catalytic cracking. Without this one could not be done the process of cracking, for that reason the importance to keep the levels in control and to follow them strictly. Depending on the composition of the catalyst, the production can be directed towards certain products, either towards gasolines, bottom products or gases. Due to the importance of this in the process, it is very important to keep a load in control because with this come the different pollutants that poison the catalyst and generate its deactivation. Control of the levels is performed to know how much catalyst is counted, to be able to perform controlled fresh catalyst dosages and controlled withdrawals of spent catalyst, to cool the circulating catalyst bed in the process.

B. *Process of measurement of Catalyst and Control of Inventories*

1) *Hopper:* are the equipment destined or arranged for the storage of the catalyst both fresh and spent in the Catalytic Cracking Unit in which all the catalyst inventory is stored.
2) *Addition and Replacement System:* currently, the Catalytic Cracking Unit has two fresh catalyst addition systems which operate independently and separately, the first system called the conventional system consists of a small hopper which is Adds the daily amount of catalyst to meet the replacement rate, which is calculated by the loss data of the unit, it is pressurized with air and the catalyst is added by time bumps which are calculated by the console operator, The second system is the continuous

replenishment system which consists of a hopper even smaller than the previous system which has weight sensors and take the exact measurement to add this system is handled by a controller which performs all calculations and optimizes the addition of catalyst.

3) *Calculation of Losses and Control into the Process:* the calculation of the losses is done manually by the console operator and / or the process engineer assigned to the unit, this calculation takes into account the inventory levels of the fresh hoppers and spent, in addition to the levels of catalyst in the reactor, the regenerated and the daily addition of catalyst.
4) *Catalyst or Cyclone Trapping Systems:* they are responsible for trapping the particles that are suspended in the reactor and regenerator exhaust gases; cyclones work with the principle of centrifugal force, so that particles possessing greater weight that the air decanted towards the bottom of this and to be recovered, to maintain the losses of catalyst in the process in control. **Fig. 1** shows the operation of the cyclones and how they are constituted.

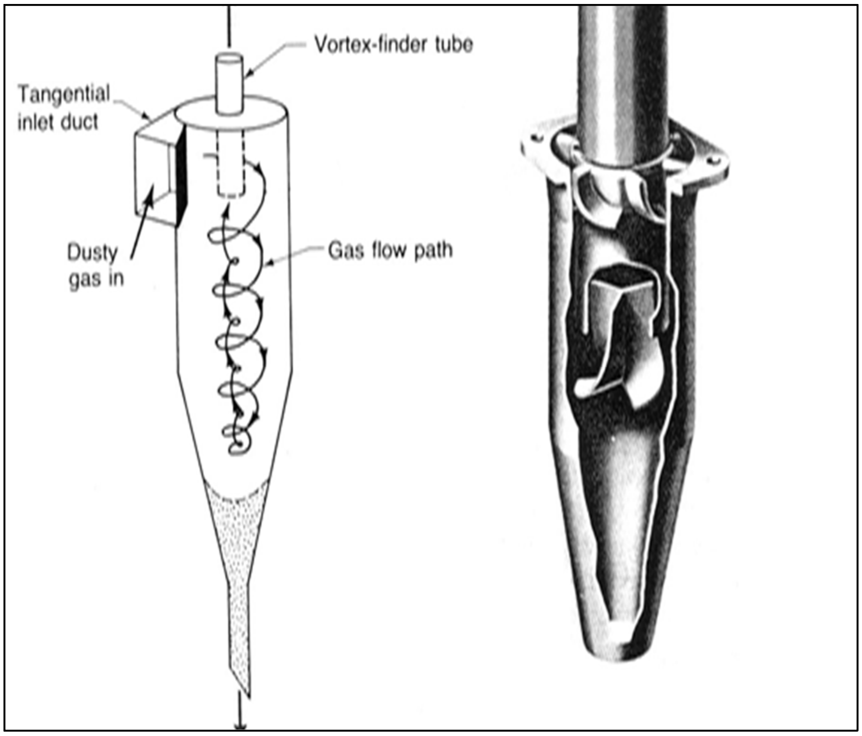

Fig.1 Operation and structure of a Cyclone.

III. BACKGROUND

Currently, in the catalytic rupture plant of Ecopetrol S.A - Cartagena, it has a system of storage of spent catalyst and new catalyst [6], which is used in the catalytic cracking process [7]. In order to know and keep in control the inventories and the losses of the catalyst, manual measurements are made with a measuring tape that has a potala or plumb line at the tip, these measurements are made by the operators of the plant, after the conversion is done in the capacity tables of the hoppers by throwing the amount of catalyst they have at that moment.

The above mentioned procedure has the disadvantage that the measurements made are not accurate which generates that the inventory data are not accurate for the calculation of the catalyst losses in the catalytic process. The measurement is done at a specific time and there are no values in line, finally emissions are generated to the atmosphere of particulate matter which affects the environment and the health of the people who carry out this measurement manually. Catalyst losses occur when the cyclones are not performing their function and allow the particles to escape together with the gases into the atmosphere and / or the fractionation tower.

IV. METHODOLOGY

AS. a source of primary information we worked with the field data obtained by observing the operation of the Cracking Plant of the Ecopetrol S.A. Refinery. Located in the industrial sector of Mamonal in the city of Cartagena de Indias - Colombia

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Map 1: Location ECOPETROL S.A. – Cartagena

The engineering of the project was developed through the stages described in the analysis and design of the engineering project. For the development of the works the following requirements were taken into account:

Design and implementation of an instrumentation system using a radar sensor to perform measurements of catalyst levels in the hoppers of the Cracking plant.

Design and implementation of a data transmission system to communicate the radar sensor with the field concentrator (Juntion Box) and from it to Distributed Control System (DCS).

Configuration of the Distributed Control System (DCM) Man Machine Interface (HMI) for the visualization of the measurements made by the sensor installed in the hoppers showing catalyst levels, trends and historical data

Configuration in the Man Machine Interface (HMI) of the Distributed Control System (DCS) for the visualization of total catalyst losses of the catalytic process to determine the level of efficiency of the catalytic process.

Minimization of the occupational hazards to the unit operators due to exposure to the particulate material of the catalyst and reduction of emissions to the environment.

A. *Design and Selection of the Instrumentation System*

Fig. 2 shows the block diagram of the instrumentation system that was designed. As can be seen, the system consisted of the field instrumentation, the Satellite Instruments House (SIH) and the Distributed Control System (DCS). The first block was formed by the Hoppers, the Radars and the Junction Box; The second by the Barrier, the S100 Module and the Advant Controller 450 device. The third block was formed by the Man Machine Interface (HMI).

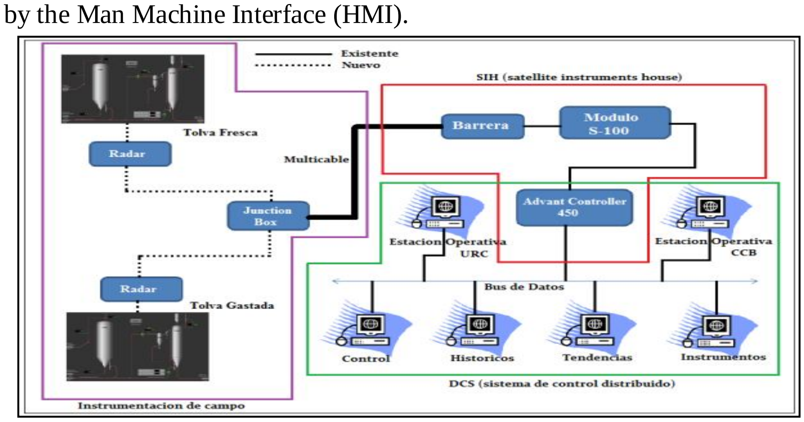

Fig. 2 Design Scheme Instrumentation System

1) The role of each block of the instrumentation system is described below:
2) *Radar Sensor:* is responsible for performing the level measurement of the catalyst in the two (2) hoppers and send the signal to the controller to be processed.
3) *Junction Box:* is a step concentrator box that organizes and channels cables from different transmitters located in the field to send them to the Satellite Instruments House (SIH) through a multi-wire.

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4) *Barriers:* they act as fuses inside the system, they are responsible for protecting the S-100 modules, the controller and the network in general from surges.
5) *S-100 Module*: these are inside the Satellite Instruments House (SIH) and are responsible for organizing all the signals coming from the field to send them to the controller to be processed by it.
6) *AC 450 Controller:* ABB's AC (Advant Controller) 450 is a high performance system for process control and monitoring. Its high processing capacity, powerful range and advanced communication system make it the ideal system for process control in demanding industrial applications.

The AC 450 performs logic, sequence, positioning and control, and manages data and text in general, and produces process reports. You can even perform self-tuning using the PID. The AC 450 controller supports a wide range of communication protocols, making it easy to design the control system architecture.

B. Radar Sensor Selection

According to company guidelines in which the work was carried out, it was decided to use radar sensors because it is proven that they have a good performance in the measurement of solids with high presence of particulate level and have long intervals for maintenance. In addition, they do not have contact with the product to measure and therefore are not subjected to the erosive action of the product. Thus, taking into account the requirements described above for the selection of the radar sensor to be used, a sweep of the options available on the market was carried out. As a result, three models were chosen: the Micropilot FMR250 from the company Endress + Hauser; The Vegaplus 68 from VEGA and the Rosemount ™ 5600 Level Transmitter from EMERSON. To select the type of radar to be used, the technical characteristics of the above mentioned ones were reviewed as shown below.

Table 1: Characteristics of Pre-selected Radar Type Sensors

Characteristics	Sensor Models		
	Micropilot FMR 250	Vegaplus 68	Rosemount 5600
Hart Communication	X	X	X
2-wire connection	X	X	
Ecopetrol Supplier	X		X
Measurement of solids	X	X	X
Insensitive to dust	X	X	X
Non-contact measurement	X	X	X
Long Mantle Ranges	X	X	X
Field visual panel	X		X
Vacuum Pressure Range - 80 Psig	X	X	X
Measuring range: 0 ft. - 60 ft.	X	X	X
Technical support	X		X

According to the technical analysis shown in Table 1, the Micropilot FMR 250 sensor from Endress + Hauser was selected because it fulfills all the technical characteristics required by the company for its installation and implementation, having as reference determinants the communication to two-wires, ease of maintenance and / or spare parts, as the manufacturer has coverage for the geographical area where the refinery is located and be on the list of materials and parts of the company ECOPETROL SA.

The Micropilot FMR 250 Radar is used to perform continuous and non-contact level measurements especially with aggregates that can be powdery or granular. It can also be used with liquids. It has an intelligent transmitter for continuous and non-contact solid level measurement and uses two-wires of 4-20 mA communication technology.

C. Assembling and Installation of Plant Instruments

We proceeded with the assembly of the radar sensors in the catalyst hoppers for which the radar location in the "Fresh Hopper FC-D-505" was chosen in the first instance, as shown in Fig. 3.

Fig. 3 Radar Location "Fresh Hopper FC-D-505".

Next, the location of the radar location in the "Hopper Hopper FC-D-509" was chosen as shown in **Fig. 4.**

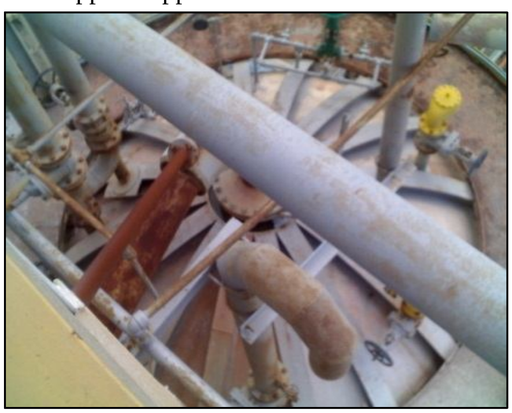

Fig. 4 Radar Location "Hopper Worn FC-D-509".

The radar was then mounted to the flange located at the top of the hopper. The transmission cables were then connected to the "Junction Box" junction box, as shown in Fig. 5**.**

Fig. 5. New radar installed.

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After the radar was installed in the "Hopper Hopper FC-D-504", the protection pipeline was installed containing the transmission wires that reach the "Junction Box" shown in Fig. 6 to where the signal of the FC-LT-509 arrives.

Fig. 6. Junction Box (FF-IJA-01)

Fig. 7 shows the "Junction Box" open, you can see the pair of wires coming from the FC-LT-509 before being connected to the terminal block.

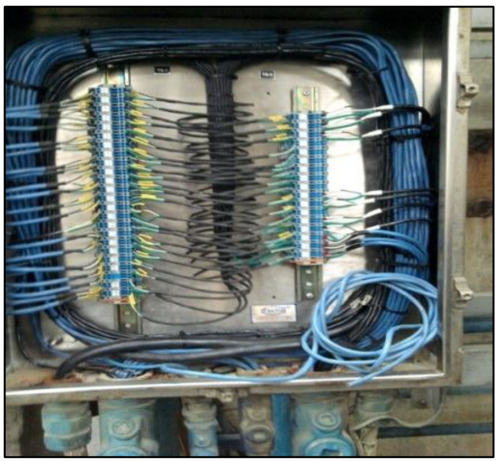

Fig. 7 Interior Junction Box Terminal.

When the wires arrive to the junction box they are connected to the terminals chosen for the transmitter signals as shown in **Fig. 8.**

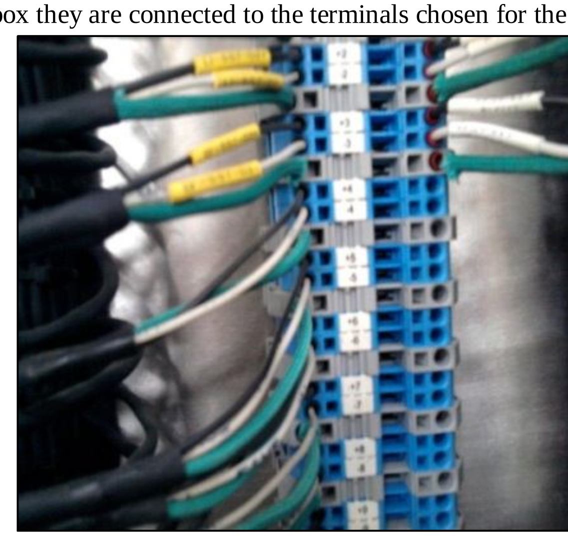

Fig 8. Junction Box Connection Terminals.

After installation of the transmitter in the "Cool Hopper FC-D-505", the piping was done with the transmission wires that came to the "Junction Box" shown in Fig. 9 where the signal would arrive Of FC-LT-510.

Fig. 9 Junction Box (FF-IJA-14)

After connecting the cables from the transmitter to the junction box terminal, they were sent by a multicast to the cabinets located in the instrumentation satellite house "Satellite Instrument House - SIH" shown in Fig. 10.

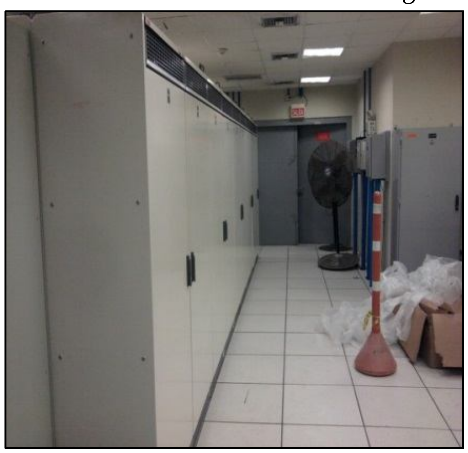

Fig. 10 Satellite Instrument House (SIH).

The cabinet was opened to be used for the arrival of the wires coming from the junction box, which are responsible for carrying the information of the radar and were connected in their respective terminal. In turn they were linked to the barrier as shown in Fig. 11.

Fig. 11 Terminal block. Arrival of Radar Threads

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Once the terminal block was used to connect the wires from the junction box to the "Satellite Instrument House - SIH" cabinet, the wires were connected to the terminals arranged as shown in the Fig 12.

Fig. 12 Cabinet Interior View – SIH

After connecting the transmission wires the complete connection was made from the transmitter to the barriers. In Fig. 13, the outlets of the barriers towards the boards are observed. It should be noted that one of the functions of the barrier is to avoid over-voltages in the system thus avoiding possible explosions because of a short circuit in the same.

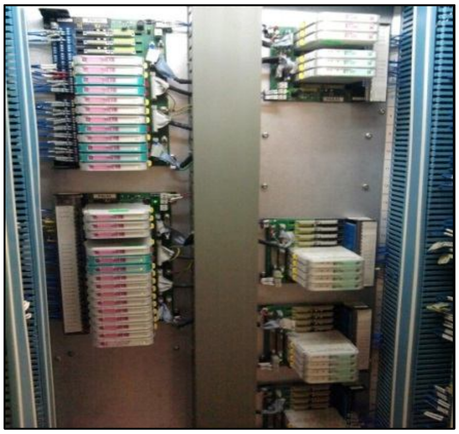

Fig. 13 Interior View Cabinet Radar Connections.

Fig. 14 shows the "Radar FC-LT-510" of the "Fresh Hopper FC-D-505" already installed and connected ready to transmit the current catalyst level.

Fig 14. Radar FC-LT-510 installed.

Fig. 15 shows the "Radar FC-LT-509" of the Spent Hopper in operation. The reading corresponds to the level of content.

Fig. 15 Radar FC-LT-509 Installed.

Fig. 16 shows the "Satellite Instrument House - SIH" where signal concentrator cabinets are located.

Fig.16 Exterior view home Satellite Instrument House – SIH

D. Programming the FMR 250 Sensor

The "Micropilot FMR - 250" Radar uses a measurement system based on the time - of - return method. It measures the distance between the reference point and the surface of the product. The antenna emits microwave pulses to the surface of the product, which in turn are reflected on the surface and the radar system detects the reflected pulses. The antenna receives the reflected microwave pulses and transmits them to the electronics and a microprocessor evaluates the received signal, identifying the level echoes produced by the reflection of the radar pulses on the surface of the product. The distance "D" to the surface of the product is proportional to the return time t of the pulse which obeys the following equation:

Equation (1) $$D = c * \frac{t}{2}$$

Where "C" is the speed of light. Then knowing the distance E of the empty tank, we proceed to calculate the level L from:

Equation (2) $$L = E - D$$

The location of the reference point "E" can be seen in Fig. 17. It is important to mention that the "Micropilot FMR - 250" Radar has functions that suppress the interference echoes, which can be activated by the user. The procedure prevents interference echoes from internal elements and internal frame assemblies to be interpreted as level echoes by the transmitter.

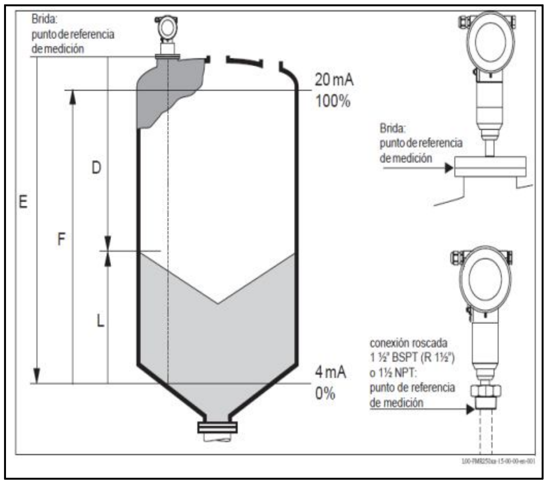

Fig. 17 Suggested Initial Configuration for Radars

1) To configure the radar, the following steps were performed

a) The software "Field Care Software" of the "Endress + Hauser" manufacturer of the selected radars was carried out. In the first instance, the computer name was established and associated with the system where it is installed. In this case, the name "FC-LT-509" was established and associated with the "FC-D-504" equipment as shown in **Fig. 18.** The procedure was the same for both radars.

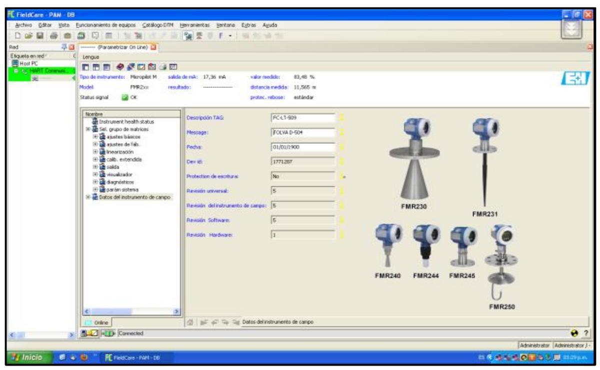

Fig. 18 Radars Configuration Procedure.

b) The characteristics to be measured in relation to the type of element (solid or liquid), shape of the container (hopper in this case) were established and the range of the dielectric constant was established. For the catalyst the range from 1.9 to 4 was used. See Fig. 19.

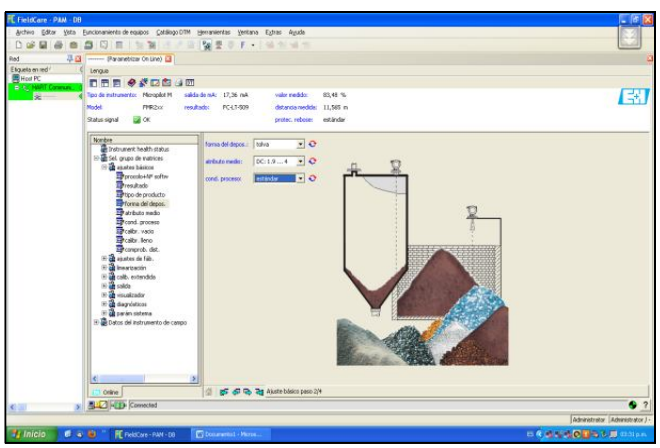

Fig. 19 Configuration System Content Characteristics.

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c) Measurement and calibration ranges were established when the hopper is empty and when it is full. In item 1 of **Fig. 20**, the empty calibration was established by taking the complete distance measurement of the Hopper. In item 2, the empty calibration was established by taking the distance measure of the Hopper when it was full leaving a safety range of at least one (1) meter between the full and the empty.

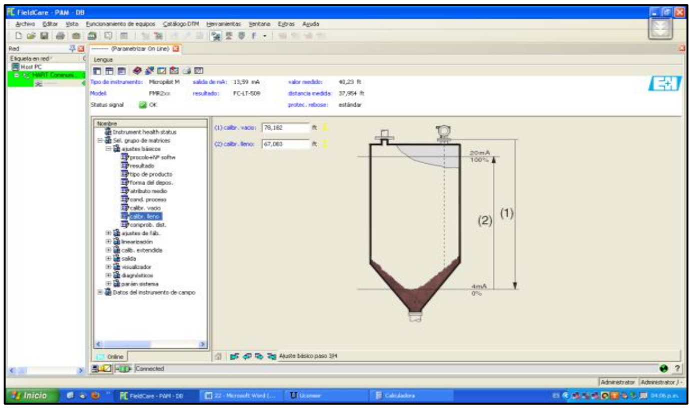

Fig.20 Empty-Full Ranges Setting

d) Next, we proceeded with the mapping of the hopper to eliminate any false signals that the radar could assume as a level signal. The mapping was performed up to 0.5 meters before the real level signal so that it would not remain as undesirable signal and did not present measurement errors. The ideal of the mapping is that it had been done with the hopper vacated but in this case it was not possible due to the current inventory of catalyst that contained the same. The procedure performed is illustrated in Fig. 21.

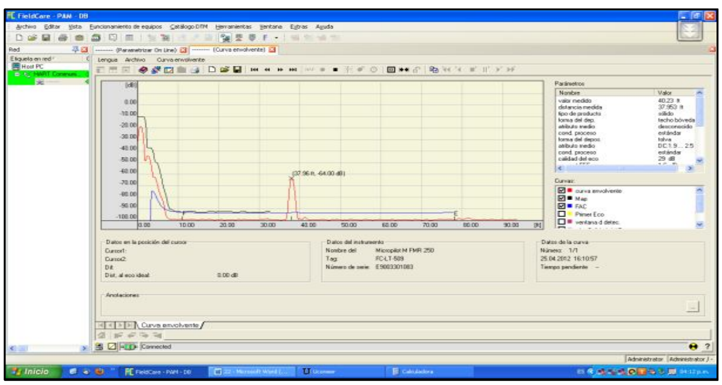

Fig. 21 Hopper Mapping Graph.

e) In Fig.22, it is observed how through the mapping possible connections of other instruments or outstanding structures were verified by the same internal configuration of the hoppers.

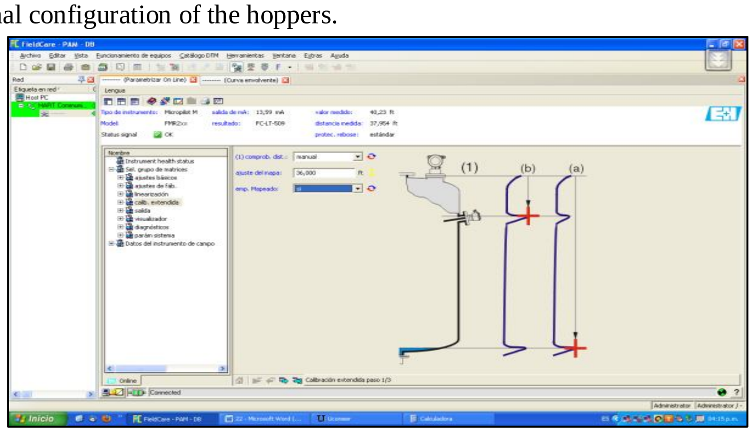

Fig. 22 Detection of Internal Structures in Hoppers

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f) In the radar the configuration of the table of capacity of the hopper was carried out, for which, up to 32 reference points were taken in order to linearize the system and so that it could vary the levels according to the value measured in distance. That is to say, each value of distance was configured a level value. See Fig. 23.

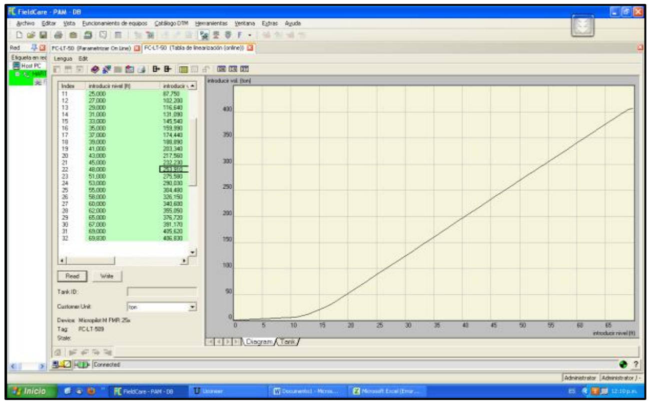

Fig. 23 Capacity Procedure of Hoppers

g) Fig. 24 shows the radar configured successfully with the units of measurement and ready to use.

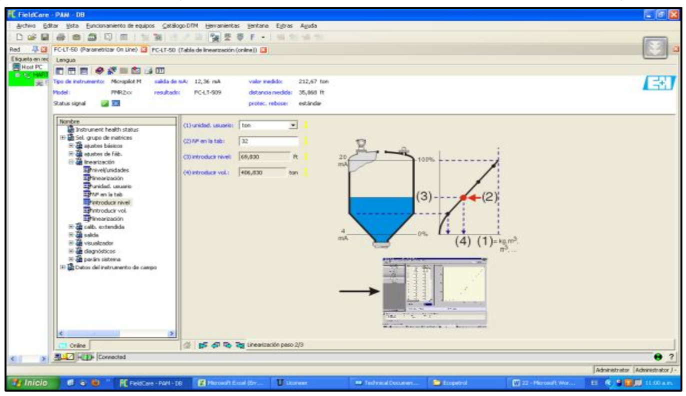

Fig. 24: Radar Configured Successfully

E. Configuration of the Distributed Control System (DCS) of the Instrumentation System.

Next, the initial configuration of the Distributed Control System (DCS) was carried out using the ABB configuration software of the FMR 250 Radar sensors. The sequence of activities used was as follows.

1) Using the ABB software in Total Access mode, the hoppers created to indicate the catalyst storage of the catalytic rupture unit are located on the monitor screen as shown in Fig. 25.

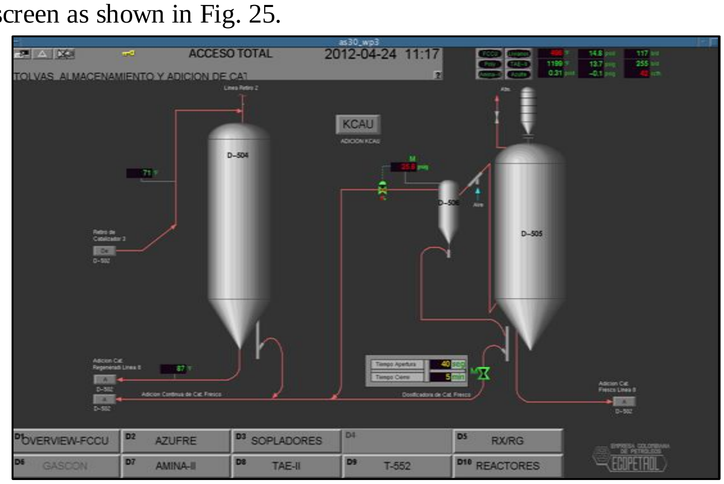

Fig. 25 Software Location of Hoppers without Level Indication

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Subsequently, in the software configuration menu, the "System Display Keys" option was selected and the list from which the "System Status" option was selected as shown in Fig. 26 was automatically displayed.

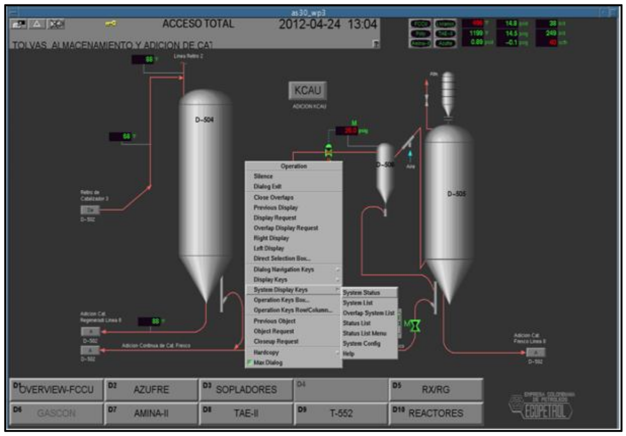

Fig. 26 System Display Keys Option

After the "System Status" option was deployed, the "Cracking" option was selected, where the level transmitters are to be located and where the connection boxes are located where the transmitter wires arrive. The "Network 11 / Node 53" option was selected. See Fig. 27.

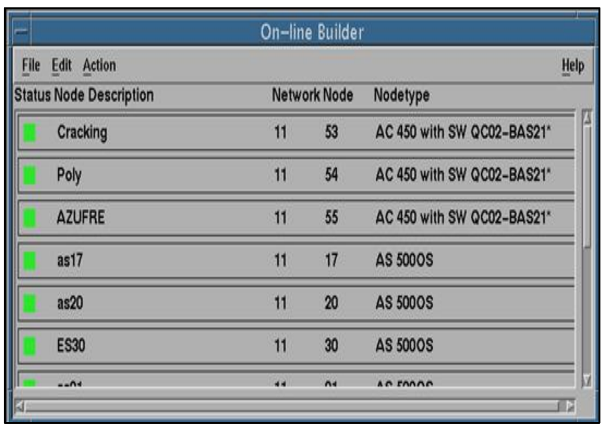

Fig. 27: On-line Builder Dialog Box

After executing the immediately preceding step, the message of the Software that was observed in **Fig. 28** was displayed and in the application the location and configuration of the instruments such as location and node from which the signal originated were initiated.

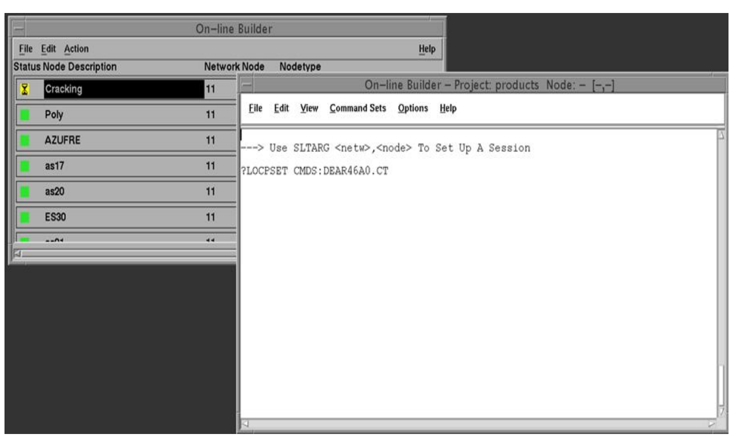

Fig. 28 Settings Start Dialog Box

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In Fig. 29, it can be seen that once the node was configured, the data were entered as TAG of the equipment, operating ranges and desired units of measure according to the requirements of the user. After entering the data of the transmitter was saved and the session ended.

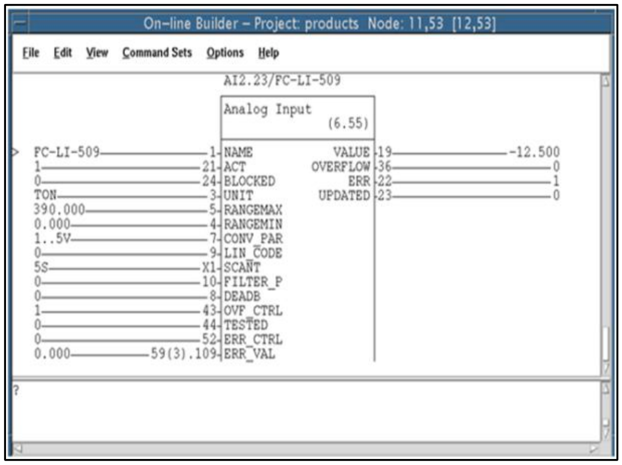

Fig. 29 Data Entry Dialog Box

After the configuration of the signal from the transmitters to the "Arrival Node", the "Display Builder" application was executed. This option displays a series of tools to draw and shape the indication that will appear on the screen where it is to be displayed. We proceeded in the tool with the assignment of format, size, color etc. The software also allowed to display the name of the hoppers of each transmitter with exact position. See Fig. 30.

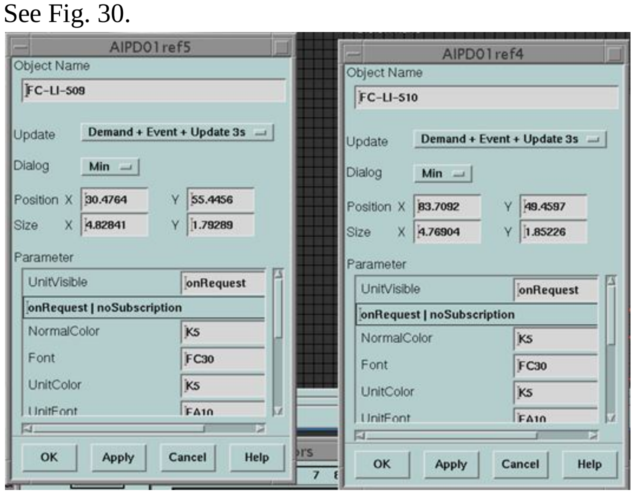

Fig. 30 Position and Assignment Dialog Box

F. System Certification

To verify the true behavior of the system, we proceeded with the measurement of the contents of the hoppers at different times. The data obtained were recorded in a comparative table and the simultaneous values measured with the radar were compared with those obtained by the operators manually with the tape measure. The results are shown below.

Radar (Ton)	Tape-Measure (Ton)
189,10	187,68
204,03	202,74
214,60	212,37
81,52	80,52
19,90	19,83

Table 2: Levels Hopper FC-D-504 (Radar and Manual)

Radar (Ton)	Tape-Measure (Ton)
48,60	46,73
67,17	65,79
74,01	73,42
85,82	85,28
91,50	91,21

Table 3: Levels "Fresh Hopper FC-D-505" (Radar and Manual)

After reading and interpreting the measurement data obtained and recorded in Tables 2 and 3, the following interpretation of results was obtained

1) The difference between the measurements of the radar against the tape measure is not more than two (2) tons in both hoppers, this being a low value for the requirements of the plant
2) The difference between tape and radar after making technical adjustments was reduced to less than one (1) ton making the measurement more reliable and safe.
3) At the end of the technical adjustments, it was obtained that the measurement error was 0.45%, showing good reliability in the system.
4) The measurement accuracy of the instrument according to the data obtained was 99%, which means that the measurement is very reliable.

V. RESULTS AND DISCUSSION

It was designed and built an instrumentation system consisting of two radar sensors which are responsible for making the measurements in the field and then displayed on the screens / display of the Distributed Control System (DCS). After configuration of the instrumentation system in the Distributed Control System (DCS) and the configuration of the FMR-250 Micropilot Radar with its respective connection, a real time catalyst level indication of the "Hopper Hopper" FC-D-504 "and the" Cool Hopper FC-D-50 ". Fig.31 shows the final display of the system in which it can be seen that the level signals for each hopper are independently configured in their entirety.

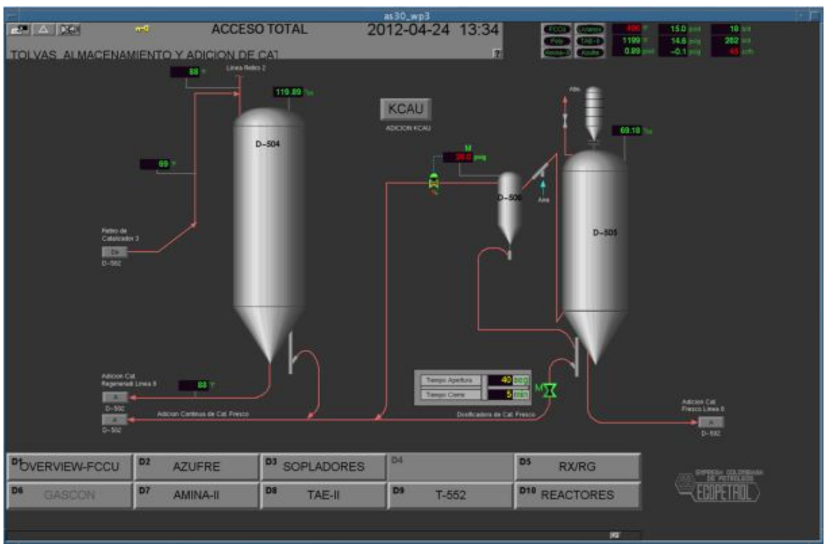

Fig. 31 Finished System Dialog Box

It was possible to control emissions of polluting waste to the atmosphere, because the new automated system operates fully closed and does not require constant opening to perform manual measurement as before. With the new system, it was possible to have inventory data in real time during the filling and emptying processes, without stopping the processes to perform the level checking maneuver.

VI. CONCLUSIONS AND RECOMMENDATIONS

An automated radar-sensing instrumentation system was implemented to perform the catalyst level measurements on the "FC-D-504 Spent Hopper" and the "Fresh Hopper FC-D-505" from the cracking plant at a refinery of oil in Cartagena.

It was possible to implement a data transmission system that communicates the radar sensor with the field concentrator "Junction Box" and from it to the "Distributed Control System - DCS".

In the "Man-Machine Interface - HMI" of the "Distributed Control System - DCS", it was possible to configure the measurements of the sensor installed in the hoppers, which show catalyst levels, trends and historical data. The new automated system was achieved by minimizing the occupational hazards to the unit operators since the exposure to the particulate material of the catalyst was reduced when performing the measurements manually.

Emissions of particulate matter to the environment were reduced due to the implementation of the automated operation of the system in a closed circuit.

It was achieved that the accuracy of the radar reached a 99% of effectiveness with a 0.45% error causing the radar installed to obtain a high reliability.

In order to obtain a more reliable measurement and to avoid interference errors, it is advisable to carry out the mapping of the hoppers when they are without product so that the sweep is complete and thus eliminate any possible interferences in the measurement.

As the inventory movements of hoppers in normal operation are not very frequent it is recommended to continue to perform measurements and comparisons "radar vs tape measure" to obtain more measurement data and give a greater reliability to the system.

In order to perform the online loss visualization, it is recommended to reset the automatic catalytic addition system, since with the manual system the system cannot be fed to perform the calculation.

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