Commissioning Integrated Process at Industrial Plants

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Abstract: This paper is a case study about the gasification system commissioning. After collecting data and information about this system analysis were made, related to TEXACO, SHELL, LURGI and E-GAS, then a flowchart was created. Simulations were made in the ARENA software for verification of commissioning performance. The results showed the importance of commissioning management in a standard commissioning process and other integrated proposed were compared.

Keywords: Commissioning; Gasification Process; Flowchart; ARENA Software

1 Introduction

Commissioning is a challenge for companies, because less time and warranty that all technical issues attended is the target, which will transform the enterprise in a competitive one. The results of enterprise's competitiveness is cost reduction, increase profits and improve the process. An industrial plant commissioning is very important to verify equipment's functionality which is part of systems inside the plant. If the commissioning were planned correctly, it is possible mitigate problems with main benefit cost and works reduction.

It is required to verify the activities of all involved disciplines. Sometimes it can be very hard to define which are those activities without rework, excessive duration, exceeding cost and a good relationship between disciplines. Bendiksen and Young [1] says that during commissioning phase erection problems show up and will be necessary increase the cost and time to repair those problems. So, changes and upgrades will be done in commissioning activities at the same time that they occur.

The gasification process is getting more attention in the last decades because of the high demand in clean fuels and the reduction in fossil fuels use [2] and the high demand of renewable fuels because of petroleum crises [3]. Gasification is a flexible, a safe process and a commercial technology that contributes to reducing the use of petroleum and natural gas, being a clean alternative to energy generation, fertilizers industry, and fuel and chemical industry. This process can convert any material that has high levels of carbon in syngas [4].

In order to understand the process will be presented a flowchart, which will allow customizing system, as project needs. Shafiee [5] says that configuration systems can support the decision process and show the product alternatives.

This paper aims to present and evaluate a gasification process flowchart that will reduce the time of the commissioning phase.

2 Background

Brito et al. [6] says that commissioning is a process that certify units. Equipments are tested, installed, designed and operated as client's installation operational requirements. Commissioning can be applied to new or existent plant.

Enterprises have general or particular procedures to attend each discipline process. At PG-25-SEQUIETCM/CEND from PETROBRAS [7] is shown remembrances to personal qualification, which will work in the commissioning phase. This document presents commissioning as a group that contains knowledge, practices, procedures and skills to become a unit operational according to desired performance requirements. This transfer needs to be done fast, ordered and safe, being certified in terms of performance, reliability and tracking information.

There is a possibility to deduce that commissioning practices have the main target to ensure the system operation and the Project requirements were attended in order to enable project's start up. This is the concept that is used in this paper. PMKB [8] divide commissioning in five phases, which are:

- Planning and Engineering: analyses of contract's requirements, engineering design and suppliers documents are done;
- Pre-commissioning: in this moment is verified equipment, systems and subsystems conformity, through inspections and unload tests;
- Commissioning: tests are executed as equipment/system operation;
- Start up: systems start up, maintenance, initial operations and performance tests are realized;
- Assisted Operation: operation team is trained, pendencies are solved and the unit is delivered to client.

These information are important to understand the process and to plan correctly. A flowchart is composite with many stages that has a free time between them.

A process is composed by activities sorted with start and finish well defined. So, a process is a mix of resources that brings value or results to the company.

To identify the flowchart is positive in order to establish priorities and to help decision-making in priority processes, those processes cause more impact and are complex [9]. Process management is required to ensure that processes reach their targets and be efficient. It is important to get view of the whole project and to have performance indicators to evaluate the flowchart according to enterprise objectives. Mapping processes gives support in identifies wastes and decisions making are done in visible flows, according Gomes and Souza [10].

This paper will present a flowchart of gasification process. Breault et al. [11] says that gasification is a technology that transforms any material with high level of carbon in syngas. ThyssenKrupp Uhde [12] presents gasification as partial oxidation process in high temperature to convert materials with high level of carbon in syngas, which contains carbon monoxides and hydrogen.

Chiu et al. [13] says that should be considered the life cycle of a product and how this production will affect the environmental. This sustainable product can be categorized in: reduction of product quantity, expansion service, reduction of energy consumption, improvement of resource sustainability and reduction of the environmental damage risk. According to U.S. Department of Energy [14] the benefit of gasification to environment are the low emissions of oxides and particulates from burning coal, because of the treatment after burning fuel. It is also possible the use of garbage the energy generation with two processes, incineration and gasification. Transform the uses of non-recycle materials in electricity reduce the amount of waste in landfill in order to prevent is and water contamination [15].

After all these information's about gasification, it will be presented the processes that were studied in order to create a flowchart.

In TEXACO gasification process petroleum and steam are mixed inside the boiler. This blend goes into the gasifier together with oxygen. The syngas with impurities goes through two scrubbers until leaves the process as a clean syngas [16]. The Figure 1 shows a simplified diagram of this process.

The second process is from SHELL. The Shell Gasification Process (SGP) has the advantage to convert different materials in syngas, including heavy and viscous oil and with high level of sulfur [17]. In Figure 2 is presented SPG Diagram.

Higman and Burgt [16] say that the gasifier from SHELL is vertical and contains many intermediate burners. This process reuses the heat which would be lost, first is used in syngas cooling and later in boiler feed water. The gas partly rusty when it leaves the gasifier a small amount of free carbon. This carbon is removed with ashes in two stages of washing with water. After this process, the syngas leaves with a temperature of 40^{o}C.

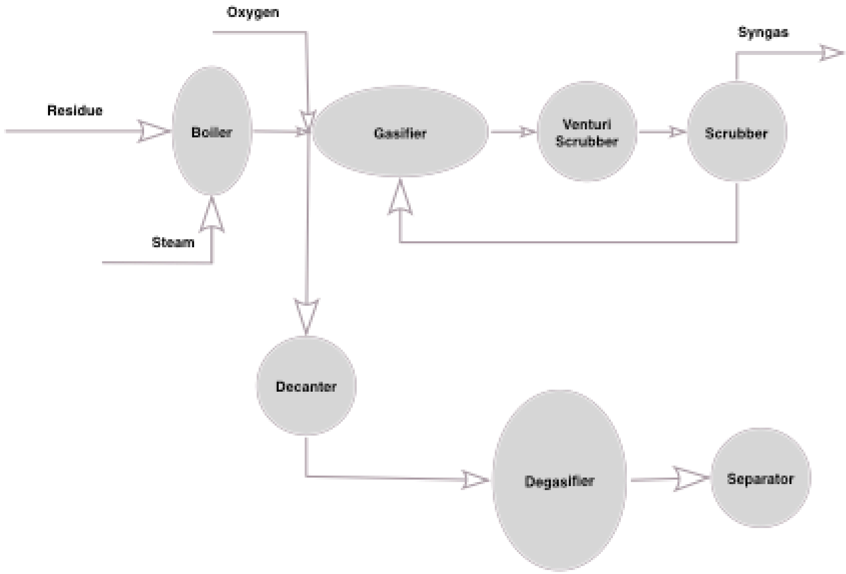

Figure 1
TEXACO's Simplified Diagram

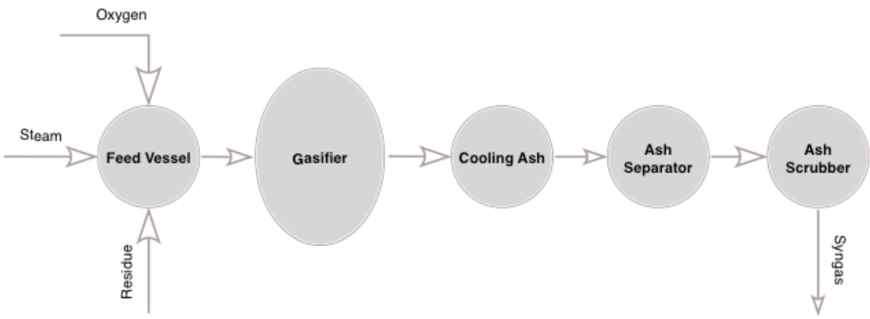

Figure 2
SGP Diagram

The third process is from LURGI. In this process is possible to be done with natural gas or recycle gases, which are preheated before entering the reactor. Oxygen is also preheated using a small amount of high-pressure steam that comes from the heat recovery boiler. A purification water tower removes traces of soot, hydrocyanic acid and ammonia. In this process, the soot formation in process is extremely low, not requiring extra filtration [18].

In Figures 3 and 4 are presented possible diagram to this process, because LURGI's gasification can be done in two different options according the cooling system chosen.

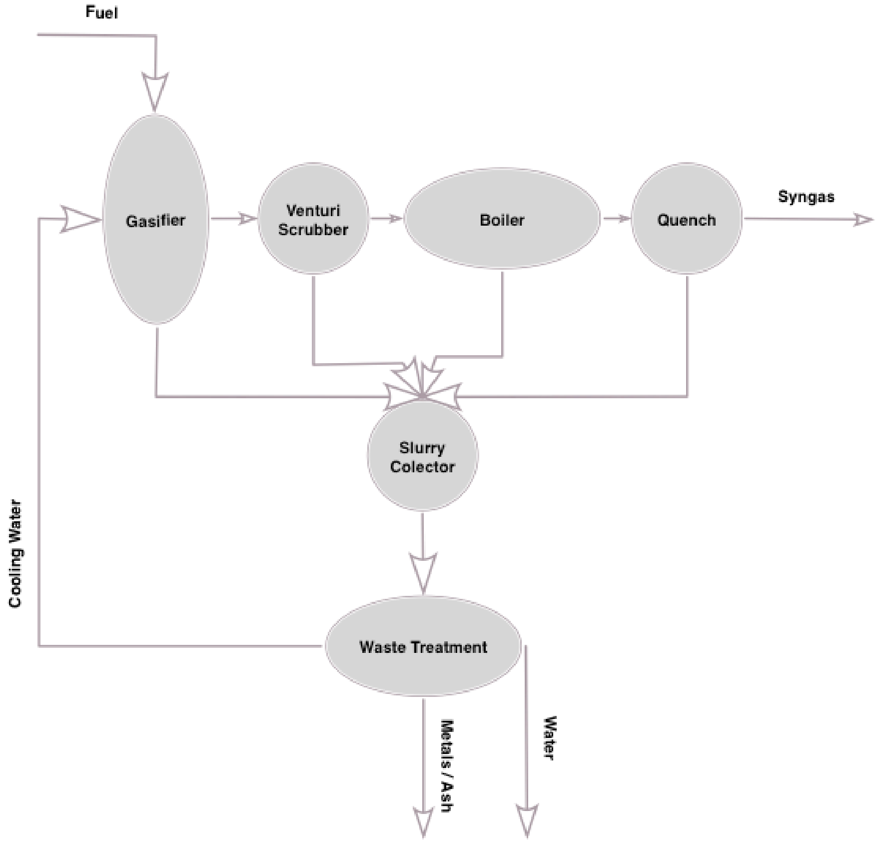

Figure 3
LURGI Process with Water Cooling System

The last process that will be presented in this paper is from E-GAS. The first stage is the treatment of the fuel before gets inside the gasifier. The fuel can be petroleum coke or coal, which are smashed and mixed with water and transform this in slurry. The E-GAS gasifier is multiple stages; this will increase the efficiency of the process and reduce oxygen consumption. When syngas leaves the gasifier, it is quenched and the heat is recovered and high pressure steam is produced. The gas is filtrated in order to remove all the ashes. These ashes are recycle and returned to the gasifier. In the end of the process, the hydrogen with high level of syngas is burned inside a turbine to energy generation [8]. E-GAS diagram is shown in Figure 5.

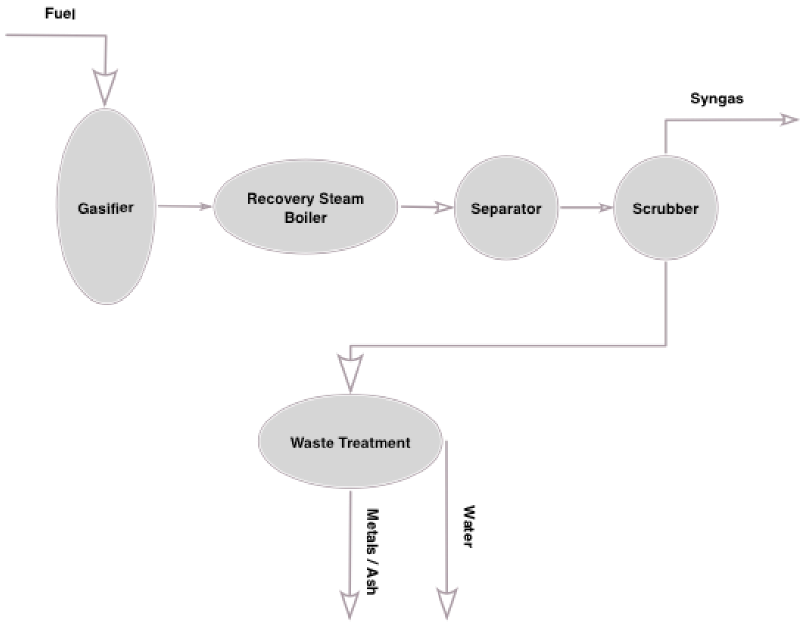

Figure 4
LURGI Process with with Syngas Cooling System

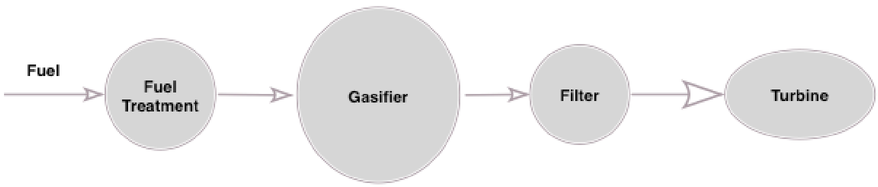

Figure 5
E-GAS Gasification Process

TEXACO process is pioneer in the use of oil derivate as fuel to the gasifier and this moment existed a boiler to burn the feed. In chronological order, SHELL presented a few years later, a multiple stages gasifier that increase the efficiency at the system and allow the use of different materials.

LURGI gasifier uses inside the reactor only natural gas and doesn't use wastes from the process and does wastes treatment. This avoids the reuse of water in the cooling system.

Another technology is presented at E-GAS enterprise, which petroleum coke feeds the gasifier to generate syngas that will be used in a turbine to energy generation.

The study of different gasification systems, which use petroleum derivate as fuel, allowed understanding and seeing resemblances between them and which are the main equipments. Those informations were necessary to elaborate a flowchart.

3 Flowchart

To map the gasification process is relevant, because it is possible to understand and to allow a global view of the project [9]. Mapping activities is to search for operational excellence and to create an improvement continuous cycle, according to Carmo [9]. Aleu and Aken [20] say that continuous improvement is a planned, organized and systematic approach that increases the organization performance. To model is to do a deep analysis to reach a target. This paper aims to optimize the gasification process commissioning. When the process mapping is done, it is possible to know the positive and the negative points of the process. Knowing these points allows to reduce costs, failures, to get simple and optimized process.

The application of product configuration system is possible to obtain these benefits, according to Hvam [21]:

- Lead time is the time between the beginning of specification process until it be finished;
- On-time delivery is the percentage of how many specifications were completed in the agreed time;
- Resource consumption for making specifications is the analysis made with the aim to reveal the resources consumption;
- Quality of specifications can be the evaluation of the client that is difficult of measure or this can be the quantity of errors in the specification;
- Optimization of products and services in specification processes occurs when configuration system is used to optimize products according to customer requirements.

After the processes analysis, it is possible to perceive a resemblance between processes. With those information's, an abridgment of the biggest flows is made with concept of flowchart and minimizes stages. In Figure 6 is presented a diagram with main equipment's.

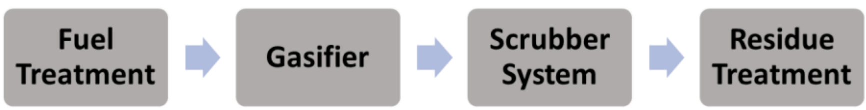

Figure 6

Gasification Process Diagram

This flowchart allows to adapt the gasification process and to customize it according project needs. Bonev et al. [22] explains that this customization aims to use configuration systems, adjustable products, flexible process and adaptive organizations. Another point presented by Bonev et al. [22] is that common platforms provide an alternative to standardization strategy of traditional construction.

4 Results

The simulation resorts a flowchart to model's methodology base, the system identification becames easier to identify. An analysis was done with entrance data, which cross the system using available resources [23].

Two simulations were made; the first one is to compare two-studied process (SHELL and TEXACO) in order to get in touch with the behavior in time and resources use of complexes processes. These two were chosen because they have necessary data to accomplish the simulation and better activities descriptions. The second simulation was made comparing SHELL process with the flowchart presented in Section 4, the objective is to measure the behavior of the flowchart created and compare it with a real process.

The simulations were made considering 8 hours of labor per day and total duration of 120 hours, this time was important to bring forth enough data to a statistic analysis.

At Figure 7 is presented the model based at SHELL process. This model counts with three entrance data (oxygen, residue and steam) and these are mixed inside the gasifier. To simulate was necessary the volume data that enter in the gasifier. The volume required to each process were presented at Higman & Burgt [16]. The fuel leaves the gasifier and passes by cooling process and ashes treatment to delivered syngas.

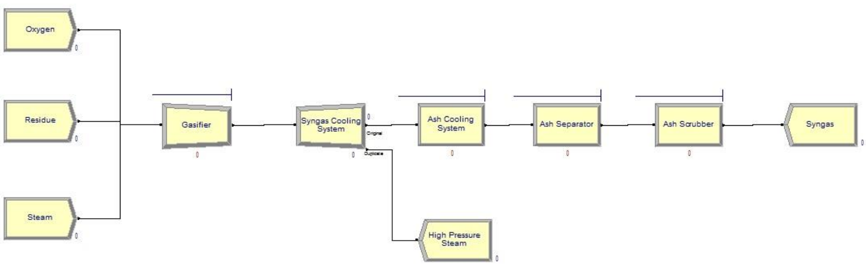

Figure 7
SHELL Gasification Process Model

The Figure 8 shows the TEXACO gasification process model. This process uses, also, the same three entrance data and the volume is shown at Table 1. In this process steam and residue enter in the boiler and this mixture gets into the gasifier with oxygen, then it goes to a scrubber process and leaves as syngas.

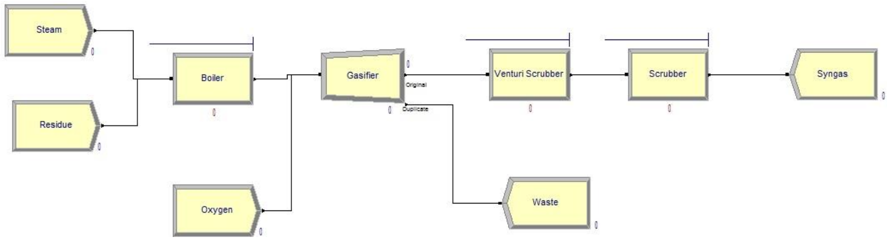

Figure 8
SHELL TEXACO Gasification Process Model

At Tables 1 and 2, it is presented the time required to fuels cross the system, since the beginning of the process until it leaves as syngas.

Comparing both models, it is possible to realize an increase of 37% in the oxygen that remains inside the process, 0.2% in the residue that remains and 1% in the steam that remains. These results show that there is not a meaningful difference of time between processes, it happens a balance in process duration and in the time that oxygen crosses the process.

Table 1
SHELL Model Results (units in hours)

SHELL			
Fuel	Average	Minimum Value	Maximum Value
Oxygen	5.527	3.529	7.380
Residue	5.924	4.046	8.111
Steam	5.812	3.957	8.072

Table 2
SHELL TEXACO Model Results (units in hours)

TEXACO			
Fuel	Average	Minimum Value	Maximum Value
Oxygen	4.011	2.278	6.304
Residue	5.913	3.441	8.757
Steam	5.875	3.632	7.841

It was also done a simulation to evaluate the using of resources. It was considered engineers and technicians of four disciplines – mechanical, electrical, process and instrumentation & control. As it is a general evaluation, it was considered that the four disciplines work a the same amount of time in each equipment, if it were a real Project it would be a rare situation, but in this studied it is a limit for do not need to quantify and rating differences between disciplines. The quantities of amount hours occupied and requested were generated by ARENA, based on each equipment's interaction.

In the Tables 3 and 4 are presented the results about the using of resources, in other words, the amount requested.

Table 3
Amount Requested - SHELL Model

Resources	Amount Resource Requested
Mechanical Engineer	1,658
Electrical Engineer	1,658
Process Engineer	1,658
Instrumentation & Control Engineer	1,658
Mechanical Technician	1,658
Electrical Technician	1,658
Process Technician	1,658
Instrumentation & Control Technician	1,658

Table 4
Amount Requested - TEXACO Model

Resources	Amount Resource Requested
Mechanical Engineer	1,926
Electrical Engineer	1,926
Process Engineer	1,926
Instrumentation & Control Engineer	1,926
Mechanical Technician	1,926
Electrical Technician	1,926
Process Technician	1,926
Instrumentation & Control Technician	1,926

The TEXACO model requests more resources, perhaps in this process exists one extra equipment (boiler), which is absent at SHELL process. This equipment requires more resources to verify and to calibrate. Beside these informations, the SHELL process was chosen to do the comparison with the integrated flowchart.

In Figure 9 is presented the integrated model, which is composed by the minimum stages of gasification process. There is only one entrance data, which will be called slurry, because it was considered that the fuel was treated before the entrance into the gasifier. This step can be modified according to project/system needs.

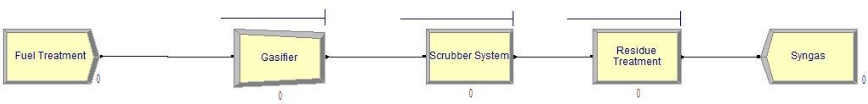

Figure 9
Integrated Gasification Process Model

The time that fuel takes to the beginning of the process until it leaves as syngas is described in Table 5. The results present the average, the minimum and maximum duration.

Table 5
Gasification Integrated Process Model Results (units in hours)

Gasification Integrated Model			
Fuel	Average	Minimum Value	Maximum Value
Slurry	4.512	3.064	6.189

Analyzing the SHELL model (Table 1) and the integrated one (Table 5), the difference of duration was 1.412 hours, in other words the integrated model corresponds to 76.2% of the duration of SHELL model. This duration is smaller, because there are less input data, steps and interactions.

In Table 6 are shown the differences between input and output data that shows fuel losses during the processes.

Table 6
Process Losses

SHELL Model			
Fuel	Entrance	Output	Losses
Oxygen	2,010	1,929	-81
Residue	207	202	-5
Steam	605	585	-20
Integrated Model			
Fuel	Entrance	Output	Losses
Slurry	490	478	-12

Total fuel losses in SHELL model were 106 units and in integrated model were 12 units lost, it is a reduction of 88.7%. In this simulation, ARENA foreseen a reduction in the amount of fuel consumed, which indicates a possible cost reduction with raw materials.

It was also made a simulation with possible needed resources. Engineers and technicians of four disciplines were considered. To compute the value of each engineer worked/hour, it was considered that the commissioning professional has experience of five years and his salary is the double of the one determined by CREA-RJ [24] and the technician salary was considered the one determined by CREA-RJ [24]. At Table 7 is presented the value of each work/hour.

Table 7
Engineer and Technician Cost per Hour

	Salary	Cost per Hour
Commissioning Engineer (R$)	14,960	85
Technician (R$)	6,600	37.50

The simulation was made for SHELL and integrated model. In the Table 8 shows worked hours to each resource in SHELL model.

Table 8
Worked Hours – SHELL Model

Worked Hours			
Resource	Average	Minimum Value	Maximum Value
Mechanical Engineer	25,073	0	32
Electrical Engineer	25,073	0	32
Process Engineer	25,073	0	32
Instrumentation & Control Engineer	25,073	0	32
Mechanical Technician	25,073	0	32
Electrical Technician	25,073	0	32
Process Technician	25,073	0	32
Instrumentation & Control Technician	25,073	0	32

Tables 9 and 10 present the quantity of hours worked and the amount of resource requested for the integrated model.

Table 9
Worked Hours – Worked Hours – Integrated Model

Worked Hours			
Resource	Resource	Resource	Resource
Mechanical Engineer	4,552	0	12
Electrical Engineer	4,552	0	12
Process Engineer	4,552	0	12
Instrumentation & Control Engineer	4,552	0	12
Mechanical Technician	4,552	0	12
Electrical Technician	4,552	0	12
Process Technician	4,552	0	12
Instrumentation & Control Technician	4,552	0	12

Table 10
Amount Requested – Integrated Model

Resource	Amount Resource Requested
Mechanical Engineer	487
Electrical Engineer	487
Process Engineer	487
Instrumentation & Control Engineer	487
Mechanical Technician	487
Electrical Technician	487
Process Technician	487
Instrumentation & Control Technician	487

The results show that more input data and more activities result in a bigger number of interactions and a greater need of resources. The founded values allowed evaluating the cost of labor work in both models. In the Tables 11 and 12 are presented the cost to SHELL model and integrated model.

Table 11
Each Engineer and Technician Cost – SHELL Model

	Hour Cost	Amount Used	Total Cost
Each Engineer Cost	R$ 85	41.570,21	R$ 3,533,467.43
Each Technician Cost	R$ 37.50	41.570,21	R$ 1,558,882.69

Table 12
Each Engineer and Technician Cost – Integrated Model

	Hour Cost	Amount Used	Total Cost
Each Engineer Cost	R$ 85	2216,824	R$ 188,430.04
Each Technician Cost	R$ 37.50	2216,824	R$ 83,130.90

Therefore the cost of the four disciplines in SHELL model would be R$20,369,400.45 and in the integrated model it would be R$1,086,243.76. This is a difference of R$19,283,156.69 and the cost of the integrated model would correspond a 5.3% of SHELL model.

This difference shows that excessive amount of activities represents a cost increase, in other words, when the project has more activities, more input data that will be required it spends more money to attend the resources needed. Thus have the knowledge of gasification system and to do an integrated commissioning permits reducing the cost at the end of the project. It is important to remember that according to gasification process chosen this cost difference cannot be so meaningful, because the integrated process has the minimum stages quantity and depending of process complexity can exits more stages, which will increase the cost.

In this section were presented the results founded at ARENA simulation, the object of this was evaluate the commissioning duration comparing processes. The differences founded represent the bigger number of items and by consequence this increases in commissioning hours and final cost.

Conclusion

An integrated commissioning is an excellent option to reduce cost and time. It is very common to introduce a commissioning team only at the final project's steps before plant startup. This practice leaves commissioning oversized, because many hours are used to understand and evaluation of the process by commissioning team.

This study comes up with a minimum team that works in the project since the beginning, this team can support basic and detail engineering and when commissioning officially starts, this group already has information to do the integrated commissioning, which processes are grouped and the commissioning activities are focused only in power up and start up the plant.

Gasification is a flexible process, which can be used in different kinds of industry, like energy generation, chemical industry, products fabrication, etc.

Through flowchart could be noticed the importance of prepare and choose feed fuel of the gasifier. It needs to be analyzed each case to understand each project's peculiarities. Doing a fuel treatment adequate, there is a reduction in entrance data that results time, the using of resources and volume of fuel required. These reductions were noticed at software ARENA simulation. It is also very important turn the attention in waste generated in the gasifier.

At ARENA simulation, it could be noticed that the use of the flowchart brought a reduction of commissioning time, which shows how important is to analyze an industrial process and commission the main equipment. It allows also perceiving the difference in time and cost when there is a model with excessive amount of activities and multiple input data. It shows that depending on gasification system can have an overkill of activities that requires more time and professionals, for consequence the commissioning will spend more resources and time.

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