IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁑ Impact Factor 8.066 ⁑ Peer-reviewed / Refereed journal ⁑ Vol. 10, Issue 7, July 2023

DOI: 10.17148/IARJSET.2023.10711

OPTIMIZATION OF STEAM AND ELECTRICAL ENERGY CONSUMPTION IN AN OPERATIONAL PETROCHEMICAL INDUSTRIAL ENVIRONMENT: A COMPREHENSIVE CASE STUDY OF INDORAMA ELEME PETROCHEMICAL LIMITED

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Abstract: The efficient use of utilities (electric energy, steam, and water) constitutes today's major problem in ensuring industry competitiveness and sustainability. The proposed study focuses on lowering the cost of steam and power generation at a petrochemical industry that uses a co-generation system to generate both electricity and steam. In this scenario, there is a trade-off between work and heat supply that cannot be easily characterized by heuristics or localized control loops. The use of an optimization model is provided based on the necessities of energy demands, and it is easily exposed the landscape that minimizes power and high-pressure steam level generation. There was a potential economy of 46 t/h in the generation of steam in boilers and a decrease of 6 MW in electric power usage.

Keywords: Utilities, Turbines, Steam, Optimization, Power, and Mixed Integer Programming

I. INTRODUCTION

The optimization of utility system has been explored regarding conceptual graphic tools that allows an steam network analysis and offer a better understanding of the interactions and could accelerate the application of an algorithm method (Strouvalis et al., 1998), aiding the decision of when is convenient to a factory to generate energy with an existent co-generation system or buy outer energy and heat, using MILP routine (Bojic & Stojanovic, 1998), helping the management of energy in a multi- period basis regarding a three/four level steam network, handling annual budging planning, investment decisions, electricity contract optimization, shutdown maintenance scheduling and fuel/water balance problems in a petrochemical plant with a site-model (Hirata et al., 2004), achieving benefits from an complex refinery co-generation system avoiding loss of energy in letdown valves and helping energy management problems basically using a solver tool from a common commercial spreadsheet (Milosevic & Ponhöfer, 1997).

The suggested study demonstrates the minimizing of steam and electrical power generation in a petrochemical firm that uses a co-generation system to produce electric energy and steam. The steam network in the case study consists of four pressure levels that supply either thermal (heat exchangers), process (strippers), or power (pumps, compressors, and electric energy) demands.

The use of an optimization model is provided in such a manner that it can easily show the scenario that minimizes power and high-pressure steam level production based on the description of needs for electric energy generation, processing loads, and heat from steam or separation demands.

II. AIMS AND OBJECTIVES

In an operating petrochemical industrial setting, especially at Indorama Eleme Petrochemical Limited, the goal of optimising steam and electrical energy usage is to improve efficiency, decrease costs, and boost sustainability.

The following is a list of potential goals for this all-encompassing case study:

- Performing an investigation on the present trends of energy usage at Indorama Eleme Petrochemical Limited.
- Exploring possible areas for optimisation in steam and electrical energy use.
- Coming up with plans to reduce energy use while meeting all of the necessary operating requirements.
- Implementing technology and practises that are more energy-efficient in order to minimise overall energy waste.
- Determining the monetary and ecological advantages of implementing energy-saving methods and practises.
- Making suggestions for ensuring the organization's continued success over the long term and fostering ongoing development.

The research intends to contribute to the overall sustainability goals of Indorama Eleme Petrochemical Limited by attaining these objectives, while also highlighting best practises that may be followed by other sectors that are analogous.

III. SIGNIFICANCE OF THE STUDY

In an industrial setting for petrochemical production, maximising the efficiency of the use of steam and electrical energy is essential for achieving both economic efficiency and sustainable development for the environment. The Indorama Eleme Petrochemical Limited provides as an ideal case study to investigate this topic in further depth. We are able to discover possible areas for development and establish methods to maximise energy usage if we thoroughly examine the patterns of energy consumption at Indorama Eleme Petrochemical Limited and then closely analyse those patterns. This may involve the use of technology that are more energy efficient, the improvement of insulation, the optimisation of operational procedures, and the investigation of renewable energy sources.

The relevance of this subject rests in the fact that it has the ability to lower operational costs, increase productivity, and lessen the impact that it has on the environment. Within the petrochemical sector, increasing energy productivity not only results in monetary savings but also helps bring about reductions in carbon emissions and the promotion of more environmentally responsible business practises.

IV. MOTIVATION AND SUCCESS

In a petrochemical site, the production processes of a petrochemical industry and the accompanying second-generation industries use steam in a variety of different ways. These applications may involve machine drives, stream heating, or processes for separation (such as strippers and other similar devices). In addition, these applications call for distinct temperature as well as pressure conditions. For example, Super High-Pressure Steam (VS - 113 kgf/cm2g and 525°C), High Pressure Steam (VA - 42 kgf/cm2g and 400°C), Medium Pressure Steam (VM - 18 kgf/cm2g and 315°C), and Low-Pressure Steam (VB - 4.5 kgf/cm2g and 225°C) are all necessary for operation. In the case study that this work is based on, the petrochemical sector creates VS in the furnaces of the Process Units (which account for 70% of the mass) and in the boilers of the Utility Units (which account for 30% of the mass). Two steam turbo generators and a heavy-duty gas turbine are responsible for the generation of electricity; alternatively, electricity may be obtained from an off-site supply. The usual production of VS is around 1150 t/h, and the other levels of steam are created by the extraction of turbines that generate work with the feed of VS as well as by pressure letdown valves with desuperheater systems to supplement the demands of steam in the headers. The typical production of VS is approximately 11,500 t/h. The pressures in the VA and VM headers can be regulated by acting on the relation of extracted and exhausted gases from the machines or by using letdown valves. However, this control does not necessarily result in optimised sceneries.

The goal of optimization is to reduce energy costs as much as possible, where energy costs are defined here as the aggregate of the costs associated with the production of VS in auxiliary boilers, the production or importation of electricity, and the use of letdown valves. Nevertheless, the optimization of a steam and power system in a Rankine cycle with such dimensions and complexity is not a simple challenge (Milosevic & Ponhofer, 1997; Eastwood & Bealing, 2003). This is because there are multiple and diverse applications involved, and the linkages of the pressure levels. The dimension of the size of production in a petrochemical firm (an industry that requires a significant amount of capital) and owing to the continuous regime of production both contribute to the seeming magnitude of the potential for optimization, which is vast. Depending on the model, an annual savings of 2% to 5% of the energy cost might be realised. This would be in addition to the environmental benefits of reducing emissions and withdrawing superficial water (from a river), which would be realised.

DOI: 10.17148/IARJSET.2023.10711

When it comes to steam, the link between extraction and condensation in the turbo-machines (large process compressors and turbo-generators) is the most fundamental technique that can be utilised to administer the contractual relationship between the needs of many levels of steam and the creation of VS. This is the case for both the administration of the commitment and the generation of VS. This is done in order to either increase the readiness of VA or VM (in accordance with each machine) by extraction or to utilize all of the usable energy completing work (by expanding VS to exhaust steam), without extracting lower pressure steam whose low demand would induce the need for steam relief. This is accomplished through expanding VS. This relationship between extraction and condensation is not a free one; rather, there is a balance of these steam rates for a particular load (either electrical or mechanical) that is required by each machine. Within this connection and taking into account the performance and mechanical restrictions of the system and their equipment, however, it is possible to obtain an optimised distribution of steam needs for the generation of energy in each scenario, whether it be electric, thermal, or work. Alternating the operation of several distinct drives inside the same piece of equipment (for instance, using electric motors and steam turbines to power pumps) is another kind of optimization. However, the comprehensive optimization of the system is neither the aim of the existing control mechanism of the steam system, nor is it conceivable for the operation staff to do it in a way that is both practical and quick. However, the functionality of a computational tool that is able to present the best scenery (lower cost of generation of VS and electricity, avoiding usage of pressure letdown valves and the use of relieves) is highly valuable and can be created from specifications of each scenery input. This can be done. This article offers a proposal for the implementation of this tool, using the optimization of a real environment as a demonstration.

V. METHODOLOGY

The process makes use of a Steam Model and an Optimisation Model as its primary instruments. The initial step is to gather the process dependent variables, non-freedom degrees, and operational definitions. This is accomplished by importing data from the DCS system and making some human inputs. In order to reduce the number of inaccuracies caused by balancing problems, this tool was developed using a spreadsheet that is commercially accessible and was given the strictest feasible format. It was attempted to estimate this value indirectly by using mass and/or thermal balances, suppliers' performance curves, project data, and so on. This was done despite the fact that some steam measurements are not accessible in the DCS. A high precision balance is necessary if one want to reduce the amount of mistake that will be introduced into the data that will be transmitted to the optimisation model. To ensure that the steam balance is accurate and complete, these data have to be in a format that allows for the inclusion of any possible inaccuracies.

The second tool does the optimisation based on a created model of the steam and power system, equipment, and network limitations. It imports data from the Steam Model. The findings can either serve as a reference for engineers and operators in their day-to-day work or as a project tool, displaying the optimal configurations for alternative options. Both of these applications are possible.

The term "real scenery" refers to a certain condition of the steam network that is used in the petrochemical sector. This state is chosen at random. In the case study, it relates to the circumstance on June 6, 2005, at 6:00 PM, when it was generating around 1205 t/h of VS and it was seeing openings in VS/VA pressure letdown valves (42.5 t/h), VA/VM (50 t/h), and VM/VB (62.4 t/h). Figure 1 provides a visual representation of this scenario. However, there exist in the firm assessments of these usual daily needs, and the application of these values leads to a balance that properly represents the situation. This is the case for the majority of the steam flows at the VB level. Some steam consumers do not possess flow measurement, and this is the case for most of the steam flows. As a result, the definition of the steam material balance was based on the data that was available. Therefore, the modelling of the steam network takes into account the thermal requirements as well as the required amount of electricity for the machines operating at this time and date. After that, the data that was exported from the model will be input into an appropriate optimization algorithm, and the outcome will be compared with the steam balance that was observed in actual conditions. This will serve as a method of determining whether or not the potential revenues will be realised.

VI. DEFINITIONS

Producing equipment: These act as the steam sources for the various steam levels that are now in existence, and their levels can be variable or fixed. Some of the aforementioned sources additionally serve as consumers of steam with a greater level, and as a result, they generate steam with a lower level through extraction. Fixed steam sources are connected to pieces of machinery that not only have a steam consumption that is constant and proportional to the loads placed on them by the process, additionally they produce steam with a lower pressure at the output. Then, in accordance with Figure 1, the following:

- VS is produced by the process furnaces (which contribute to standard generation) and supplementary boilers (which contribute to dynamic generation);
- Variable generation, or VA, may be produced by the turbines 12-TBC-01/21, 47-TG-01/02, and 112-TBC-01, as well as by the letdown valves 10-PV-51 and 46-PV-12;
- VM is able to be produced by the turbines 14-TBC-01/21 and 112-TBC-01, as well as the letdown valves 10-PV-52 and 46-PV-13 (variable generation), in addition to other fixed generations (for instance, 14-TBC- 02/22 and 48-B-01 B/C/D);
- VB is able to be produced by the letdown valves 10-PV-13, 110-PV-04, and 46-PV-14 (variable generation), in addition to various fixed generations (for instance: 12-TBB-11, 114-TBC-01);

Consumers: These illustrate the various requirements for the steam levels. These requirements might be:

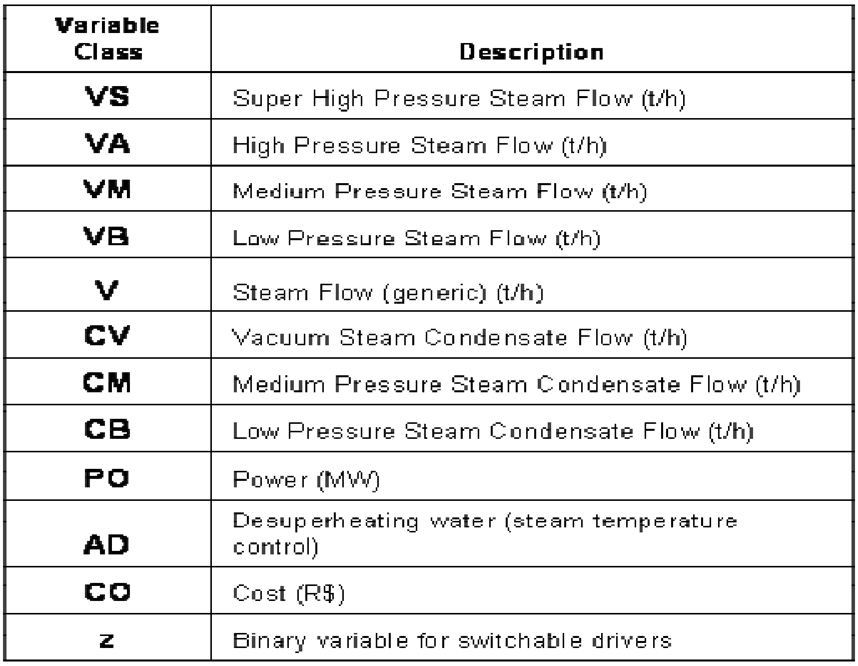
- Thermal — The process of heating another fluid using steam. These pieces of equipment are not regarded to be steam generators since the steam ultimately exits the system in one of two forms: condensate or exhaust steam.
- The process involves injecting steam directly into other pieces of machinery (such as strippers and ejectors). These consumers are no longer heating the equipment of the generators since the steam has left the system for good;
- Power: When extracted steam is created, the power consumers might also be steaming generating equipment.

Letdown Pressures Valves: These are types of valves with controls that, when combined with desuperheater systems, have the ability to change the pressure and temperature of some steam level. They accomplish this by directing surplus steam to a lower level or by feeding the level below it in order to raise that level's pressure. It is important to refrain from using letdowns since they lower the overall effectiveness of the entire framework.

Relief Valves: These are the relief valves for control that already exist in the levels of VS and VB, and their purpose is to regulate the maximum pressure of these headers by releasing steam to the environment. They are located between the VS and VB levels.

External Clients: This refers to all of the other companies and businesses in the area that the petrochemical firm serves by providing them with the utilities (in this example, steam) that they require. Customers from the outside are regarded to be permanent customers since the steam they require is process-dependent, and the steam eventually exits the company's system.

The syntax of the aforementioned groupings is shown in Table 1.



Variable Class	Description
VS	Super High Pressure Steam Flow (t/h)
VA	High Pressure Steam Flow (t/h)
VM	Medium Pressure Steam Flow (t/h)
VB	Low Pressure Steam Flow (t/h)
V	Steam Flow (generic) (t/h)
CV	Vacuum Steam Condensate Flow (t/h)
CM	Medium Pressure Steam Condensate Flow (t/h)
CB	Low Pressure Steam Condensate Flow (t/h)
PO	Power (MW)
AD	Desuperheating water (steam temperature control)
CO	Cost (R$)
z	Binary variable for switchable drivers

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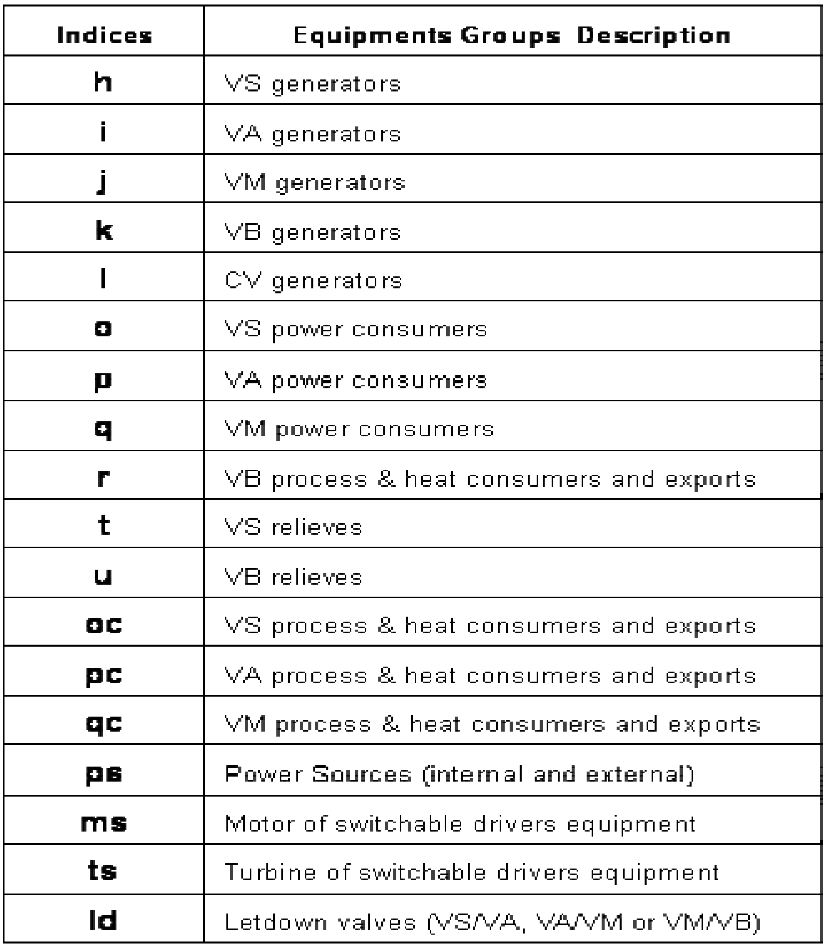
Table 1: Syntax definitions for the variables applied in the model optimization



Indices	Equipments Groups Description
h	VS generators
i	VA generators
j	VM generators
k	VB generators
l	CV generators
o	VS power consumers
p	VA power consumers
q	VM power consumers
r	VB process & heat consumers and exports
t	VS relieves
u	VB relieves
oc	VS process & heat consumers and exports
pc	VA process & heat consumers and exports
qc	VM process & heat consumers and exports
ps	Power Sources (internal and external)
ms	Motor of switchable drivers equipment
ts	Turbine of switchable drivers equipment
ld	Letdown valves (VS/VA, VA/VM or VM/VB)

FORMULATION OF AN OPTIMIZATION MODEL

As previously stated, the goal function to be minimized is the cost of energy. This is defined as:

$$\text{Min}\left(\sum_{h=1}^{Nh} CO_h \times VS_h + \sum_{ps=1}^{Nps} CO_{ps} \times PO_{ps} + \sum_{ld=1}^{Nld} CO_{ld} \times V_{ld}\right)$$

The steam header balances, turbines modelling equations, and energy balances all contribute to the definition of the equalities constraints.

Material Harmony within the Boundaries of the Control Envelope (Company Steam Network):

$$\sum_{h=1}^{Nger} VS_h = \sum_{l=1}^{Nger} CV_e + \sum_{pc=1}^{Ncons} VA_{pc} + \sum_{qc=1}^{Ncons} VM_{qc}$$
$$+ \sum_{rc=1}^{Ncons} \boldsymbol{VB_r} + \sum_{t=1}^{Naliv} \boldsymbol{VS_t} + \sum_{u=1}^{Naliv} \boldsymbol{VB_u} + \sum_{oc=1}^{Ncons} \boldsymbol{VS_{oc}}$$

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[VS Generations] = [Steam Condensations] + [steam exportation] + [steam injections in processes] + [losses] + [relieves]

Material Equilibrium in Every Steam Header:

$$\sum_{h=1}^{Nger} VS_h = \sum_{o=1}^{Ncons} VS_o + \sum_{t=1}^{Naliv} VS_t + \sum_{oc=1}^{Ncons} VS_{oc}$$

$$\sum_{i=1}^{Nger} VA_i = \sum_{p=1}^{Ncons} VA_p + \sum_{pc=1}^{Ncons} VA_{pc}$$

$$\sum_{j=1}^{Nger} VM_j = \sum_{q=1}^{Ncons} VM_q + \sum_{qc=1}^{Ncons} VM_{qc}$$

$$\sum_{k=1}^{Nger} VB_k = \sum_{r=1}^{Ncons} VB_r + \sum_{u=1}^{Naliv} VB_u$$

Material Distribution and Performance Curve for Two-Stage Turbines. For a generic condensation-extraction turbine:

Material Balance: $VS_{turbine} = VA_{turbine} + CV_{turbine}$
Performance Equation, for given rotation and power: $VA_{turbine} = a.VS_{turbine} + b$
Real data were used to model each degree of freedom turbine, defining the parameters 'a' and 'b'.

Power Balance:

$$PO = [\text{Process dependant POWER}] + [\text{Switchable drivers motor POWER}] = \sum_{ps=1}^{Nps} PO_{ps}$$

Two of the available power sources (ps) are turbine generators, which are also optimized models, and the power variable is the second degree of freedom.

In addition to material balances in steam let-down valves and condensate flash containers, the optimization model takes into account additional material balances.

Establish physical constraints and project or operation boundaries. This is relevant for turbines, valves, and intakes. For instance, in a standard turbine and VS/VA discharge valve:

$$0 < VS_{turbine} < 195$$
$$5 < VS/VA_{\text{-valve}} < 310$$

Binary Variables: With only a 1 or 0 value, this variable allows selection between available devices for the same apparatus. Consequently, it is feasible to optimize the steam and electricity situation. The balances in question are:

a. The amount of power that switchable driving equipment motors consume:

$$[\text{Switchable drivers motor POWER}] = \sum_{ms=1}^{Nms} z_{ms} \times PO_{ms}$$

b. Steam used by switchable drives (SD) turbines:

$$[\text{VA/VB SD turbine}] = \sum_{ts_{p,k}=1}^{Nts_{p,k}} z_{ts_{p,k}} \times VA_{ts_{p,k}}$$

$$[\text{VA/VM SD turbine}] = \sum_{ts_{p,j}=1}^{Nts_{p,j}} z_{ts_{p,j}} \times VA_{ts_{p,j}}$$

$$[\text{VM/VB SD turbine}] = \sum_{ts_{q,k}=1}^{Nts_{q,k}} z_{ts_{q,k}} \times VM_{ts_{q,k}}$$

c. Demand for switchable-driver equipment: The Steam Model calculates the number of operational pieces of equipment. As a result, the following condition must be satisfied:

$$[\text{Number of SD operating equip.}] = \sum_{ms=1}^{Nms} z_{equipment_{ms}} + \sum_{ts=1}^{Nts} z_{equipment_{ts}}$$

When the objective function is examined, the following form emerges:

$$f(x) = \sum_{i=1}^{r} c_i x_i$$

$$\text{with} \quad \chi_i \geq 0 \;; \quad i = 1,2,\ldots,r$$

and,

$$\sum_{i=1}^{r} a_{ji} x_i + \sum_{k=1}^{s} c_{jk} y_k = b_j$$

$$\text{with } y_k \in Y = \{0,1\} \;;\; j = 1,2,\ldots,m \;;\; k = 1,2,\ldots,s$$

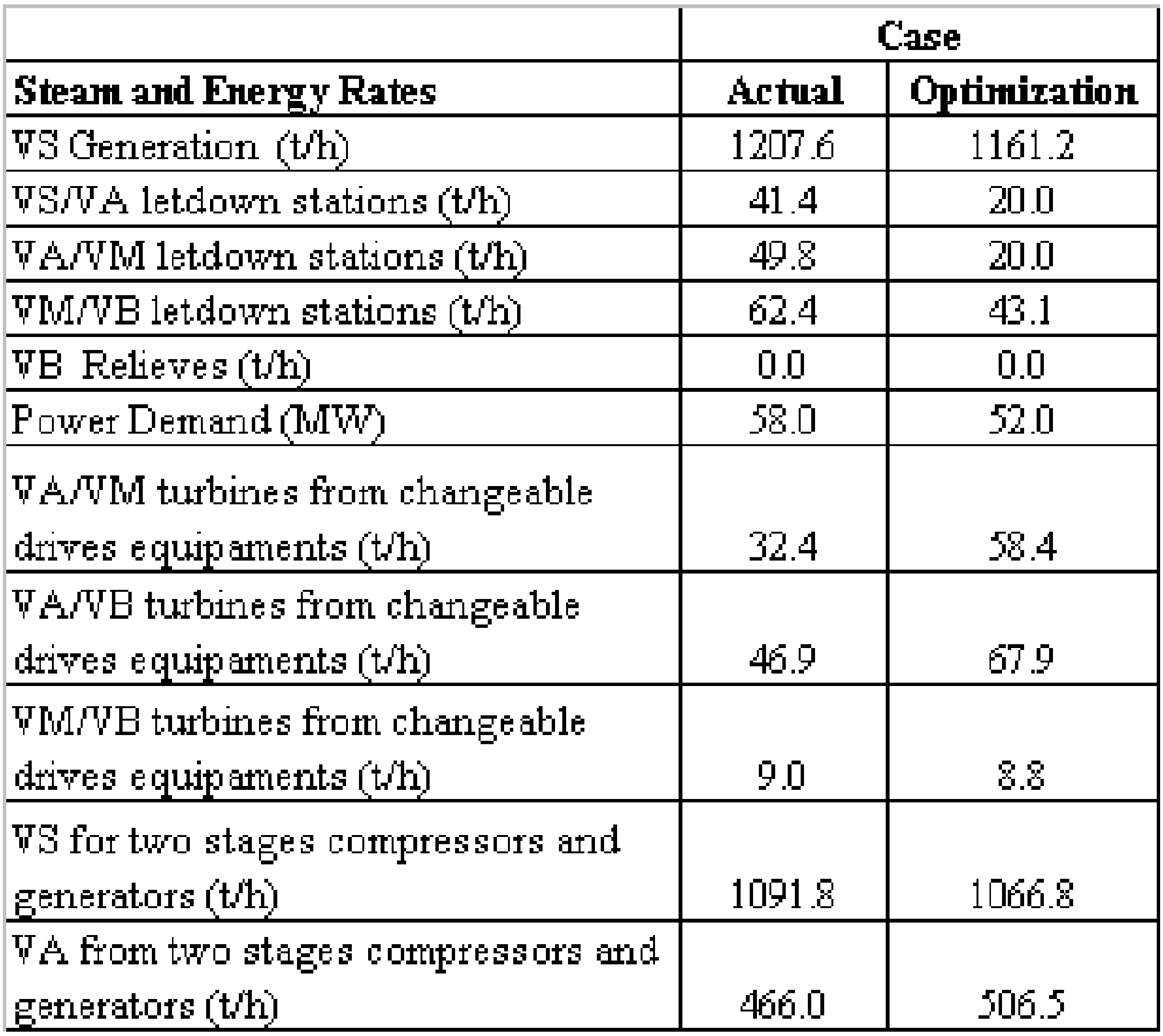
and,

$$\sum_{i=1}^{r} a_{ji} x_i \geq b_j \qquad \text{with} \quad j = m+1,\ldots,p$$

This is a problem involving mixed-integer linear programming, or MILP for short. Solvers for MILP techniques are widely available on the market now in a variety of flavors and configurations. For the purpose of this work, the computer program GAMS served as the basis for the Optimization Model. GAMS is a platform for optimization that enables users to construct a problem using a specialized language and then solve that problem by using an optimization procedure. In order to solve this particular issue, the branch and bound strategy was applied using the solver OSL.

You may see a summary of the solution for the investigated setting in Figure 2 and Table 2. If the extraction-to-condensation ratio of the turbines (primarily the utilities' turbogenerators) were further studied, it would be possible to realize savings of 46 t/h of VS, as can be seen. These savings would be realized by the utilities. In this scenario, the consumption of the turbines was lower, but the VA extraction was higher. Additionally, the generation of condensate was lower, which resulted in a state that was more efficient in reference to the cycle. In some pumps, compressors, and fans, it was possible to replace the electric motors with steam turbines, which led to a reduction in the amount of electricity that was used, which was another goal that was accomplished.

It is important to keep in mind that the formulation takes into account the same load for process compressors, but it allows the model to select the best way to generate energy, given the price per MW in each power generator or offsite purchasing – in this particular scenario, the power load of the turbogenerators was decreased from 27 to 18 MW due to the reduction in power consumption as well as an increase in the amount of power that was purchased offsite. It is also essential to emphasize that the optimized scenery results in a scenario in which the utilization of letdowns was cut down to its bare minimum, with the exception of the VM/VB, which had its real value cut down to 70% of what it was originally.



	Case	
Steam and Energy Rates	**Actual**	**Optimization**
VS Generation (t/h)	1207.6	1161.2
VS/VA letdown stations (t/h)	41.4	20.0
VA/VM letdown stations (t/h)	49.8	20.0
VM/VB letdown stations (t/h)	62.4	43.1
VB Relieves (t/h)	0.0	0.0
Power Demand (MW)	58.0	52.0
VA/VM turbines from changeable drives equipaments (t/h)	32.4	58.4
VA/VB turbines from changeable drives equipaments (t/h)	46.9	67.9
VM/VB turbines from changeable drives equipaments (t/h)	9.0	8.8
VS for two stages compressors and generators (t/h)	1091.8	1066.8
VA from two stages compressors and generators (t/h)	466.0	506.5

Table 2: A summary of the primary differences and similarities between the real and optimized scenarios for the analyzed landscape (6th of June, 2005).

STEAM AND POWER OPERATION METHOD IN PETROCHEMICAL INDUSTRY

In the petrochemical sector, both steam and power are essential to the functioning of a wide variety of processes. The transport of heat, the production of electricity, and the catalyzing of chemical processes are only few of the many uses for steam. In order to better understand how the steam and power operating technique works in the petrochemical sector, below is a simple explanation:

DOI: 10.17148/IARJSET.2023.10711

- Generation of Steam: Steam may be generated by heating water in boilers with a variety of fuel sources, such as natural gas, coal, or oil. This process produces steam. The boilers are constructed to produce high-pressure steam, often at temperatures that are more than 500 degrees Celsius.

- Steam Distribution: After it is produced, the high-pressure steam is sent through a system of pipes and valves so that it may be used in various parts of the petrochemical complex. These pipes deliver steam to various units, such as distillation columns, heat exchangers, and reactors, according to the particular operational needs that are necessary for those units.

- Transfer of Heat: Steam is an effective medium for the transfer of heat energy. In heat exchangers, it may be used to either raise the temperature of process streams or lower the temperature of particular processes. Steam is able to assist in the maintenance of ideal temperatures for a variety of chemical reactions and processes by exchanging heat with a variety of fluids.

- Generating of Electricity: In addition to its use in heat transmission, steam is frequently put to work in the field of electrical generating. Steam turbines take in high-pressure steam and turn it into mechanical energy by converting the heat energy they receive from the steam. The turbines are wired to electrical generators, and the facility's entire production of petrochemicals is powered by the electricity that they produce.

- Condensation and Recycling: Once the steam has completed the tasks for which it was designed, it is recycled by being condensed back into water using equipment known as condensers. After being cleaned, the water that has been condensed is put back into the boiler system so that it may be transformed into steam once more. This method reduces the amount of water used in production, making the petrochemical sector more environmentally friendly.

It is essential to be aware that the steam and power operations in the petrochemical sector are quite complicated and might be different from one facility, process, and piece of equipment to another. Engineers and operators are always keeping a close eye on these systems to ensure that they are running effectively and safely.

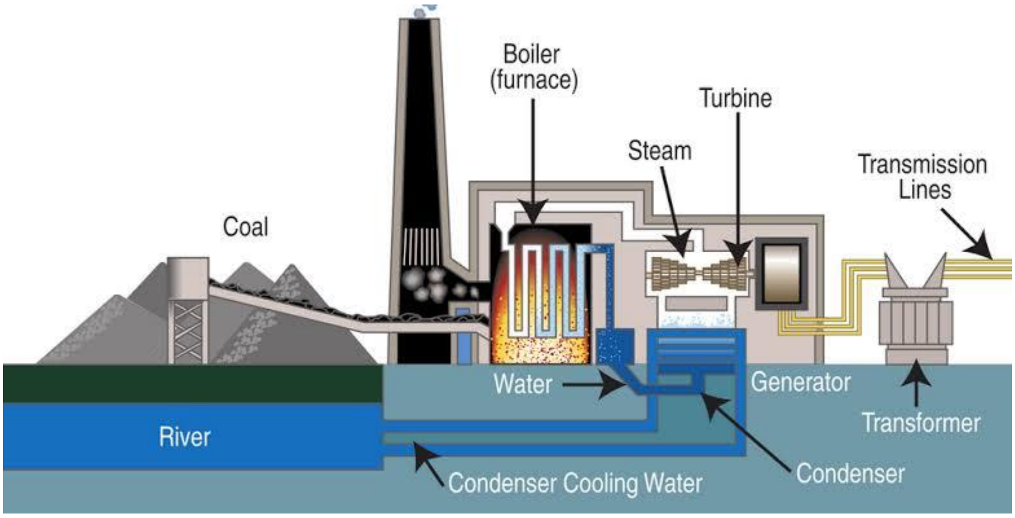


Fig 1: Steam power plant cycle

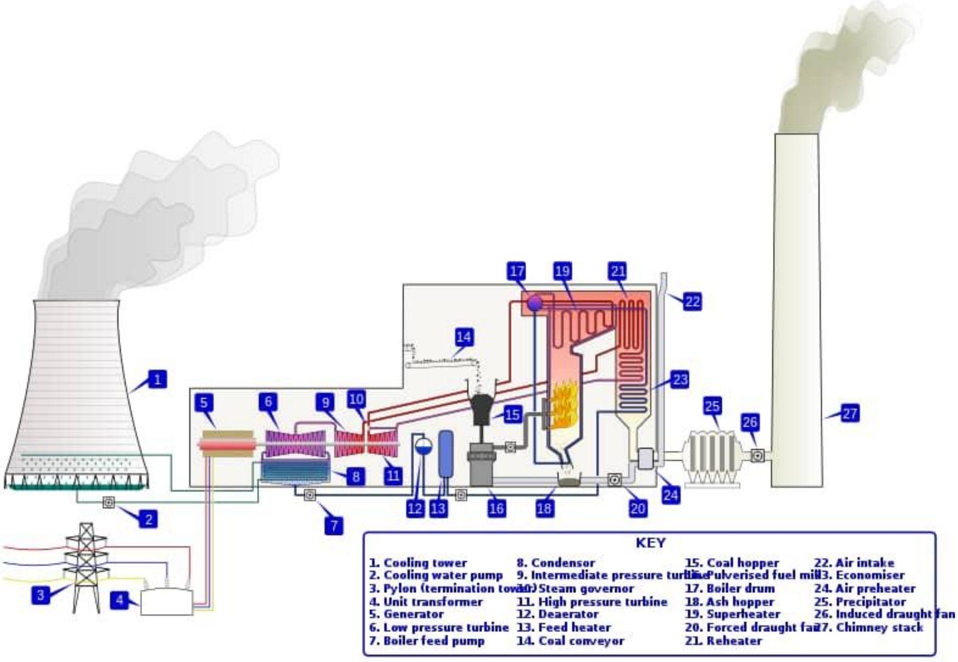


Fig 2: Steam cycle power plant

Fig 3: Indorama Eleme Petrochemical Plant

CONCLUSION

The strategy for solving the issue of optimizing the utilization of a particular landscape demonstrates that it is feasible to increase revenues from a better adaptation of the steam system, even without making any further financial investments. The steam model, which constitutes one of the most difficult instruments for development in this work, was well successful in giving the algorithm for optimization with rigorous precision acquired data, and it can be built with any chosen landscape. This turned out to be one of the most complex aspects of this work. An engineer or operator may gather the data with a simple sequence of steps, then export these numbers to the optimization model, and it will immediately offer the optimum way to run the system. This model will provide the answer quickly. As a tool to orient the workers in a conveniently usable format, this may be utilized on every day's schedule or even from shift to shift depending on the circumstances. The next phase will be the construction of an improved interface between the steam model and the optimization model. This will allow for a more automated form of the processes of data collecting and optimization to take place.

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RECOMMENDATION

Based on an in-depth analysis of Indorama Eleme Petrochemical Limited's business practices, the following are five suggestions for improving the efficiency of steam and electrical energy consumption in an operating petrochemical industrial setting:

- Carry out an exhaustive energy audit: To begin, examine the patterns of energy usage that occur within the building. Locate areas of inefficiency, such as leaks, obsolete equipment, or high energy utilization, and investigate these areas. This audit will give a starting point for improvement and will assist in the prioritization of activities to save energy.

- Put in place a monitoring system that operates in real time: Install sensors and intelligent meters to provide continuous monitoring of energy use. You will be able to identify energy-intensive processes and equipment with the help of these statistics, which will enable you to make educated decisions about the optimization of operations and the reduction of waste.

- Upgrade to equipment that is more energy efficient: Look for possibilities to replace old or inefficient machinery with newer, more energy-efficient options. This involves changing energy-intensive gear like boilers, pumps, compressors, and other devices to versions that consume less energy while preserving or enhancing performance.

- Implement initiatives for process optimization: Optimize operational conditions and processes to reduce overall energy usage. This might include increasing heat transfer efficiency, lowering steam pressure, optimizing process temperatures, or introducing advanced control systems to ensure optimal energy consumption throughout the production process.

- Education and participation of workers in energy-saving projects, as well as involvement of workers in these activities. Train them on the best practices for energy efficiency, such as the correct way to operate and maintain equipment, energy-conscious habits, and effective ways for managing energy. Encouraging staff participation will result in the creation of a culture of energy efficiency, which will ensure sustained success in lowering overall energy use.

ACKNOWLEDGMENT:

The authors would like to express their gratitude to the researchers and academics who have made important, trustworthy, and accurate material on all areas of Petrochemical Industry readily available. This contributed to the overall success of the study's development.

CONFLICTS OF INTEREST:

The Authors declare that they have no conflict of interest.

AUTHORS CONTRIBUTION:

The first author wrote the draft under the guidance of the second author on the theme and content of the paper.

FUNDING STATEMENT:

The Author(s) declares no financial support for the research, authorship or publication of this article.

REFERENCES

[1] Bojic, M., B. Stojanovic (1998). MILP Optimization of a CHP Energy System, Energy Convers. Mgmt, 39 (7) 637-642.

[2] Eastwood, A., C. Bealing (2003). Optimizing the Day-to-Day Operation of Utility Systems, Linhnhoff March, Northwich, UK.

[3] Hirata, K., H. Sakamoto, L. O´Young, K.Y. Cheung (2004). Multi-Site Utility Integration – an Industrial Case Study, Computers and Chemical Engineering, 28, 139-148.

[4] Milosevic, Z. (1997). Refinery Improves Steam System with Custom Simulation / Optimization Package, Oil & Gas J., Aug. 25.

[5] Rodríguez-Toral, M.A., W. Morton, D.R. Mitchell (2001). The Use of New SQP Methods for the Optimization of Utility Systems, Comput. Chem. Eng., 25, 287-300.

[6] Strouvalis, A.M., S.P. Mavromatis, A.C. Kokossis (1998). Conceptual Optimization of Utility Networks using Hardware and Comprehensive Hardware Composites, Comput. Chem. Eng., 22, 175-182.