DECOKING AT REFINERY HEATERS

THESIS SUBMITTED TO HINDUSTAN INSTITUTE OF TECHNOLOGY AND SCIENCE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

BACHELOR OF TECHNOLOGY

IN

CHEMICAL ENGINEERING

Submitted by

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I hereby declare that the thesis entitled submitted **DECOKING AT REFINERY HEATERS** by me to Hindustan Institute of Technology and Science, for the award of the degree of **BACHELOR OF TECHNOLOGY** in Chemical Engineering is a record of bonafide research work carried out by me under the guidance of **Dr. GOVINDARAJAN** during the period 2021 – 2022 and has not formed the basis for the award of any degree, diploma, associateship, fellowship, titles in this or any other University or other similar institution of higher learning

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ABSTRACT:

Cleaning and inspecting heaters on a regular basis improves their dependability and continuity. Knowing the remaining tube wall thickness offers you control over the heaters/furnaces' life cycle and prevents unexpected shutdowns.

But the constant build-up of coke deposits along the inner wall of heater tubes is one of the key issues faced by plant operators. These coke layers thicken without service and maintenance, impeding the flow of process fluids and increasing pressure across the heater. Coke deposits also act as an insulator, slowing heat transfer from the tube to the process fluid. As a result, heater efficiency suffers and operating expenses rise. So, to prevent such issues we use mechanical decoking, often known as pigging, in regular basis, is a popular cleaning process in a variety of sectors. It is less likely to cause pipework to get strained, and it does not have the large environmental expenses associated with chemical cleaning. Pigs are flexible scouring plugs that are inserted in this process. They scream through the piping, scouring it clean with nodules on their sides. Water assists in pushing them through and flushing out debris.

The advantages of using mechanical decoking that all coke is removed from the inside of tubes, more environmentally safe than steam air decoking - no venting to atmosphere or ground. “Pigs” do not erode or damage inside of tubes. Mechanical decoking performed faster than steam air decoking. Clients have reported longer run lengths after mechanical decoking compared with steam. Requires outside vendor to perform decoking procedure so client operating staff can devote more time on turnaround activities.

Keywords: Decoking, coke deposits, furnace, debris

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INTRODUCTION

1.1 DECOKING

The removal of coke/scale build-up from the process tubes of fired heaters and boilers is known as decoking. Chemical cleaning, steam-air decoking, in-line spalling, and mechanical pigging are the most popular methods for cleaning heater tubes internally. Each method's efficiency varies. The classic decoking procedure is known as steam-air or thermal decoking. The shrinkage and breaking of the coke deposits inside the tubes is caused by a combination of steam, air, and heat. While the tube walls are heated externally, a steam and air mixture is passed through the coke deposits inside the tube walls. It's excellent for radiant tubes, although it doesn't always ensure complete removal of coke. If this is the case, tubing may need to be dismantled, which is an expensive and destructive cleaning approach. This treatment should only be carried out by professional, experienced workers, as faulty methods could cause the tubes to overheat, resulting in catastrophic heater damage.

1.1 Mechanical decoking

The classic decoking procedure is known as steam-air or thermal decoking. The shrinkage and breaking of the coke deposits inside the tubes is caused by a combination of steam, air, and heat. While the tube walls are heated externally, a steam and air mixture is passed through the coke deposits inside the tube walls. It's excellent for radiant tubes, although it doesn't always ensure complete removal of coke. If this is the case, tubing may need to be dismantled, which is an expensive and destructive cleaning approach. This treatment should only be carried out by professional, experienced workers, as faulty methods could cause the tubes to overheat, resulting in catastrophic heater damage.

Mechanical pigging eliminates the issues that come with steam-air decoking and on-line spalling, such as waste gas leaking to the atmosphere and coil rupturing owing to high-temperature operation. Pigging removes practically all of the coke from the coils,

and it is a speedier cleaning operation with longer run lengths than other cleaning methods.

1.2 DESCALING

Descaling is the removal of oxide deposits from a heated stock, which can be done before or during forging processes. During heat treatment techniques, scales form on a metal surface. Oxide scales stain the metal surface and obstruct subsequent finishing procedures. Descaling is a metal cleaning procedure that eliminates undesired surface deposits from metals in order to give a smooth surface finish. It is one of the pre-finishing operations that also includes cleaning, stripping, and pickling. Cleaning and pickling are two of the procedures used to remove scale. Pre-finishing is essential for electroplating and other finishing operations. Some finishing techniques necessitate a high level of cleanliness, while others necessitate only the bare minimum.Wire brushes, extra blows, scraping devices, polishing, and blasting are all physical procedures for descaling. Acid descaling and alkali descaling are two chemical procedures for removing scale.

1.3 Types of Descaling

- **Mechanical cleaning**

Means Physical procedures are used to descale metals that react with chemicals. Wire brushes and scraping devices such as wool pads can be used to remove oxide scale deposits. Descaling can also be done by abrasive blasting and water jet spraying.

- Aqueous alkaline cleaning

For cleaning the metal surface and eliminating the oxide scales, mild alkaline solutions such as sodium hydroxide, sodium phosphate, sodium metasilicate, and sodium carbonate can be employed. The cleaning process is accelerated by increasing the alkali concentration. Mechanical cleaning procedures are frequently used after this cleaning process.

Acid Cleaning (Pickling)

Another method for eliminating oxide scale deposits from a metal surface is acid cleaning, often known as pickling. It's also utilised to get rid of any leftover alkalis from the cleaning process.

This cleaning procedure is appropriate for ferrous, aluminium, and copper alloys. Descaling the metal surface is done with an acid solution known as pickle liquor. Pickling sludge is a waste product that results from the pickling of metals.

CR ASIA – DECOKING TECHNOLOGY (CDT)

The CDT service is meant to clean coke and scale out of furnace tubes. The build-up of coke and scale inside the tubes of furnaces is a regular problem caused by the operational plant's procedures. In the past, the most frequent solution was to employ Steam Air Decoking (SAD). However, there are a few concerns to consider when it comes to SAD, including:

- Incomplete removal of coke
- Increased risk of tube erosion
- Heat damage to tubes
- Potential fire hazard
- Environmental emission
- Long shutdown times
- Decreased (refining) run lengths

All of these problems can be handled by utilising the CDT service, which is a tried-and-true technology. The CDT service is a secure and affordable option. High temperatures, high pressures, or chemicals are not used in the procedure.

Piggs are powered by water at a pressure of around 150 psi, and all operations are carried out at or near ambient temperature, avoiding the risk of tube damage that comes with high-temperature steam-air decoking.

2.0MATERIALS AND METHOD

2.1 CDT Furnace Decoking

- The CDT Service is a proven process that removes even the hardest coke and scale from furnace tubes. Numerous projects have proven the system to be more effective than steam – air-decoking or chemical cleaning thereby offering customers the benefits of lower run lengths, longer tube life , lower fuel usage and improved furnace reliability.

- The cleaning methods involve the use of relatively low water pressure that drives the flexible pigg through the tube allowing metal studs to scrape the deposit loose. A portion of the water flows around the pigg and passes the cleaning studs which flushes loosened deposits ahead of the pigg and into collection tank.

- Piggs are driven by pressure typically 70 psi eliminating the danger of tube damage that is typically encountered with the high temperature, thermal shock based steam-air decoking method.

- CDT Piggs negotiate short radius elbows and U-bends that have long prevented the use of conventional pigs. In addition, CDT's bi-directional control allows us to use different size to clean furnace tubes with reducers and changing diameters.

- In the end, the CDT system is a much faster, safer and more environmentally friendly cleaning system offering complete assurance of achieving a thorough cleaning of the fired heater tubes.

2.2 CDT/FURNACE DECOKING PROCESS

- Setup begins. Hookup all the required hoses, ball valves & launchers & parallel do trial run of the equipment.
- After everything is OK, filling up the heater with water, then follow with before pigging, Flow test being conducted for 100, 150, 200 psi.
- Foam Piggs are inserted into the Heater tubes in order to obtain the coke build up profile on chart recorder of Heater tubes & external marking/scratches on the pigg. It also help to determine if there is any obstruction (like thermal couple) in the heater by having cleaning making on the foam pigg. Depending on the profile & external marks suitable pigg size with proper appendages is selected for cleaning operation. (Normal Piggs for u tubes & Plug type for Plug headers).
- After repeated number of pigging runs operation the pipe is cleaned after observing the profile. The 7% oversize pigg of the tube id is being inserted for 100% cleanliness.
- Foam Piggs are being inserted into the Heater tubes to observe the external profile. if the sponge is in good shape without scratches then it is understood that the tube is clean.
- After pigging flow test being conducted for 100, 150 200 psi. Connect one of the lines to air compressor with 750 cfm capacity or to 7 kg/cm2 air line (if small heater) in order for the dewatering.
- Do the inspection whenever required as per customer requirements.
- Remove setup

2.3 BENEFITS OF USING CDT PIGGING TECHNOLOGY VERSUS STEAM AIR DECOKING

CDT Pigging guarantees removal of the furnace coke unlike steam air decoking. CDT provides a reliable, safe and environmentally friendly operation resulting in extended run length for the heater between shut down.

Pigging produces no air pollution and very little water discharge. Steam air decoking usually produces great quantities of hot water with high solid content.

Pigging allows maintenance work inside the furnace on refractory brick or burners while the tubes are being cleaned thereby decreasing precious downtime..

2.4MECHANICAL DECOKING TECHNOLOGY

The most effective method of removing internal fouling, coke, and scale from the inner surface of fired heater and boiler process tubes has been proven to be mechanical decoking, also known as "pigging."

For delayed coking, mechanical decoking, also known as pigging, has become popular. Although mechanical decoking necessitates a heater shutdown, some facilities have devised isolation processes that allow specific heater boxes to be isolated and heater passes to be decoked without a full shutdown. Mechanically decoking a heater takes about the same amount of time as online spalling a heater. Because pigging is relatively simple, several facilities have chosen to solely clean their coker heaters mechanically. This decoking procedure can remove tough inorganic solid foulants from coker feed solids. Inorganic materials tend to foul the heater's higher radiant area, as well as the convection section. Because it is difficult, if not impossible, to spall coke in the upper area of the heater, a method of pigging the delayed coker heater was created.

Online spalling has become the most effective method of decoking, but it is not always practicable due to the mechanical arrangement of the heater and the size of the

coker. This strategy will be more difficult for a small delayed coker with few tube runs than for a large coker with several drums and heaters. This approach is appealing since it does not necessitate a shutdown and minimises throughput loss and reliability issues.

2.5 MECHANICAL PIGGING IS A RELATIVELY NEW TREND.

In the past, the most important way was Decoking with steam and air was utilised where the coke was burned In a controlled environment, furnace coils decoking technique using an air-steam combination circulated at a rise in temperature On-line spalling was created in order to increase the number of days spent on-stream Units for visbreakers and cokers Nowadays, mechanical devices are widely used Pigging is a technique for removing waste. Deposit on the surface of the coil pumping water into a pigin the same way that it was done pipelines both on and off the coast systems of transportation Pigging has become a popular pastime. In the refining and petrochemical industries, this is the preferred procedure industries to get rid of coke scale buildup on the walls since it is made up of furnace coils more efficient and quicker than steam-air decoking and on-line spalling. The type of pig to be selected for a specific pigging operation depends on the following factors.

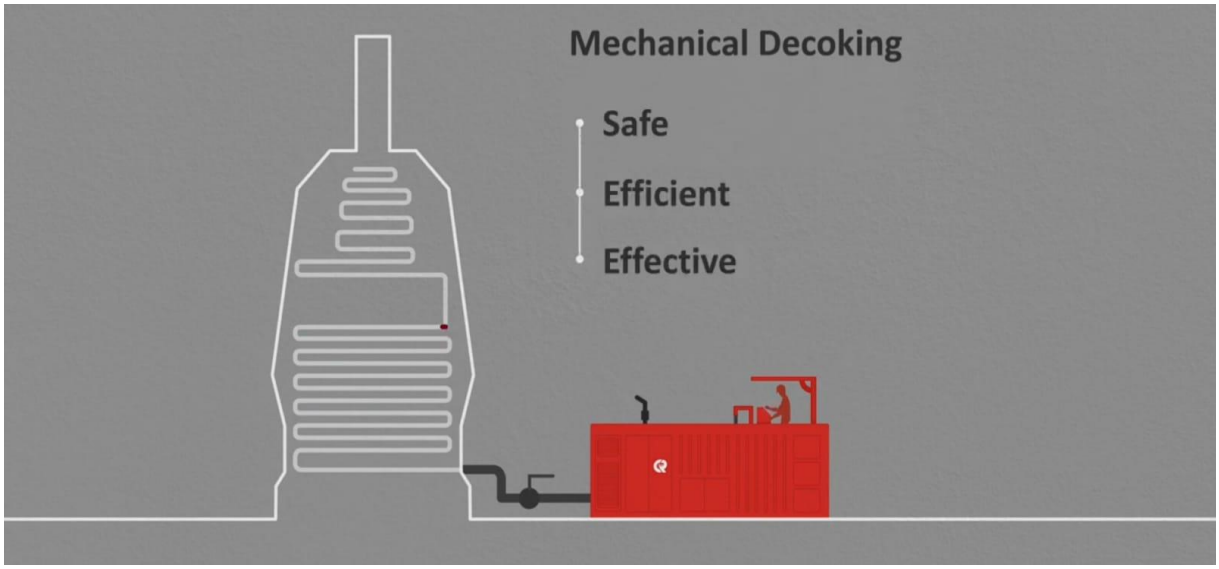

Fig: 1 Decoking Mechanical cleaning

2.6 PIGS ARE USED TO CLEAN.

- A cleaning pig is a cylinder of plastic foam with pins evenly spaced around its surface.
- When these pins make contact with the inside wall of a coil, they scrape coke and other substances off the inside.
- Characteristics Decoking using steam and air Spalling on the internet Function of mechanical pigging Coke should be removed from the coils. While the furnace is running, remove the coke. Coke should be removed from the coils. Prior to pigging or decoking, measure coil to extend the furnace run length using "intelligent" pigs. The coke is burned away from the furnace coils. A high-velocity jet is used to remove coke. Coke is removed by running an air-steam mixture through a metal-studded pig in a controlled decoking process while thermally compressing foam or plastic pigs with water in the coils.

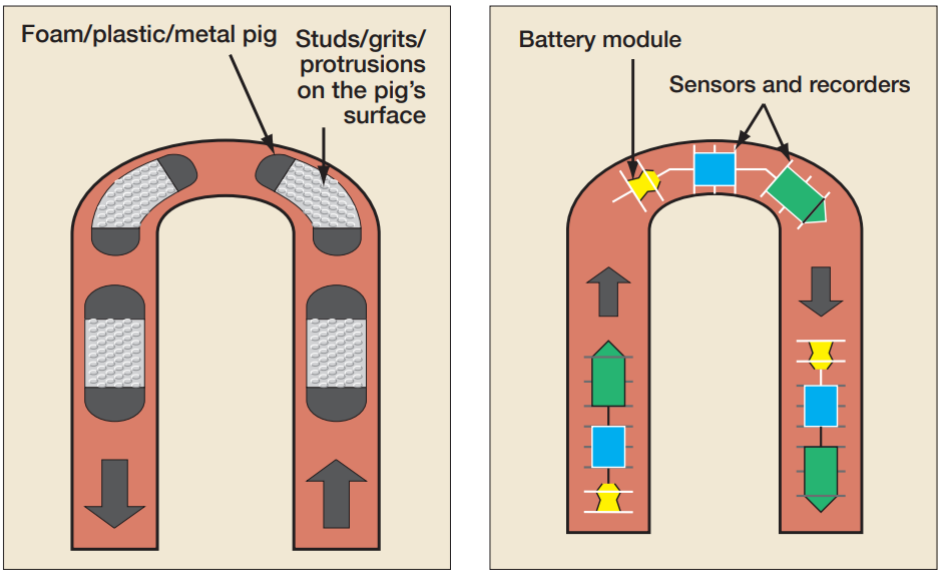

Fig:2 Pipe Cleaning using Pig

2.7COKEBUSTERS DECOKING

THE SET-UP PROCESS

• Once the business side of things is taken care of, the Cokebusters get to work. At the agreed-upon hour, the equipment comes on site.

• The crew was given a site-specific safety introduction.

• Equipment is positioned next to the decoking furnace.as agreed with the Refinery Maintenance Team of the Client

• The machinery is fully resourced and equipped with launchers. All water circuit connecting tubing in the right diameters

• Furnace flanged inlets are linked to launchers. horizontal outlets The link is connected to the water circuit tube. From the Pumping Machine to the Launchers

• Once all of the connections have been made and the machinery has been checked and set up,After then, the first two furnace passes can be decoked.

(a)

(b)

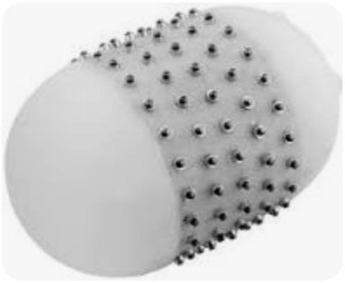

Fig: 3 Types of pigg

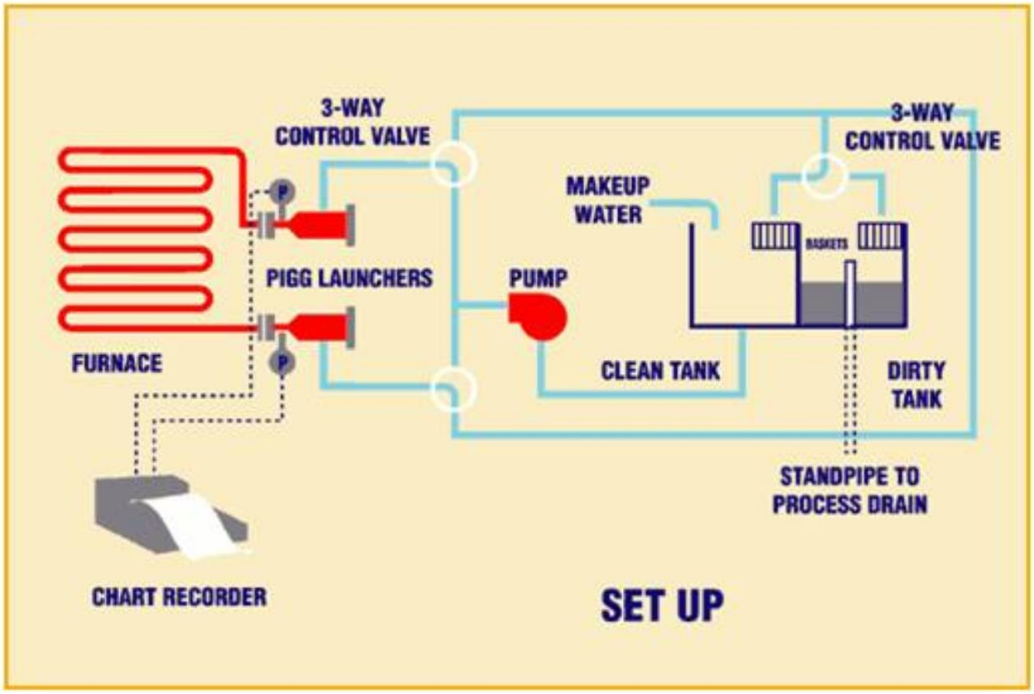

Fig: 4 process of mechanical cleaning.

2.8 MECHANICAL DECOKING WORK

- Coke is scraped from the inner wall of process tubes by propelling a studded plastic "pig" via water as a motive force.

- The studded pig is propelled in such a way that it scrapes the coke from the inner wall of process tubes without destroying or compromising the tube wall's integrity. Pigs are slightly smaller than internal tube diameters.

- Pigs are usually pumped through each tube numerous times, forward and backward, until the overall differential pressure throughout the tube (inlet to exit) is restored to its original or new "un-fouled" condition.

ADVANTAGES:

• All coke is removed from the inside of tubes, more environmentally safe than steam air decoking - no venting to atmosphere or ground.

• “Pigs” do not erode or damage inside of tubes Mechanical decoking performed faster than steam air decoking.

• Clients have reported longer run lengths after mechanical decoking compared with steam.

• Requires outside vendor to perform decoking procedure so Client operating staff can devote more time on turnaround activities.

Perceived DISADVANTAGES:

• Requires furnace to be taken fully out of service

• Disposal of “discoloured” water required.

• Specialist decoking Practitioner needed

2.9DEWATERING PROCESS FOR CDT

Method Statement

- Dewatering proceed can be done after the pigging work is completed and before the CDT attachment (CDT launcher, receiver, ball valves and spool-pieces) are rigged down. This is to avoid double work.
- Close both the ball valves on the convection inlet & radiant outlet.
- Disconnect one of the 3" water pressure hose from the pigging machine.
- Connect this water hose to outlet of an air compressor. This will be the inlet of the compress air to the launcher, whereby a 2lbs soft foam pigg will be inserted for the dewatering process.
- Ensure that the valves on the pigging machine are set to allow the return of the water from the heater into the machine's tanks.
- The drain tank's hoses are set to the sewer.
- Operator will go round to check the system's connection to ensure that everything is in order before starting up the air compressor.
- Operator will assign one man at the air compressor to operate the valve.
- He will be stationed at the pigging machine's control room to control the return elbow.
- Dewatering can now be commenced: open the air compressor valve to allow air to travel to the launcher to push the 2lbs soft foam pig into the heater.
- The movement of the pig will displace off the water from the heater into the pigging machine's tanks.
- The total duration of dewatering can varies from 10mins to 30mins depending on the size of the heater.
- When there is a big gust of air returning from the return elbow, it means that the 2lbs soft foam has already came into the receiver.
- Operator will order his helper to close the air compressor's outlet v/v.
- Retrieve the foam pig from the receiver and the dewatering process will be completed.

Fig :5 Dewatering Process

2.10DECOKING OPERATIONAL STEPS PERFORMED FOR RIL-PATALGANGA AS BELOW PER PASS:

- Filling up water for respective heater pass.

- Initial Flow/Pressure Test Taken at 50 PSI, 100 PSI & 150 PSI.

- 6.0" Initial Foam was launched to ascertain the condition of the tubes based on the condition of the foam, we decided to start of the decoking operations with135mm stud pig.

- The tubes were pigged starting from above size of pig, progressively increasing the size of pig from 135mm. 140mm, 149mm, 153mm to158mm.

- The tubes were generally in fair condition except for some hard deposits atthe bottom radiation zone tubes.

- After assurance of cleanness. new 6" Final foam was launched into the pass.

- The Final foam was checked respect to tube cleanness inside tube
  .
- Final flow/Pressure test taken at 50 PSI, 100 PSI & 150 PSI.

- Dewatering of each pass was carried by using 7" swab with plant air.

2.11DECOKING TESTING AND DECOKING AT COKEBUSTERS

• Pressure and flow tests are performed at the start and end of each decoking pass, allowing for a valuable assessment of the decoking operation's efficiency.

• Once a pass has been determined to be clear, decoking can begin.

• Scraper pig speed, direction, and location are all controlled by the operator and recorded for further study and inclusion in the Operations Report.

• The coke is visibly extracted and the volume is measured.

All coke particles larger than 750 microns are collected during primary and secondary filtration of coke returns.

• The removed coke is collected in an on-board tank for safe disposal by the client

Fig: 6 Cleaning of pipes after the process.

Result:

Table:1 **DETAILS OF D-1041 HEATER:**

Description	Radiant Section	Convection Section
No. of Passes	2	2
No. of Tubes perPass	18	15
Length of Tubes	6559	3809
O/D of Tubes	168.3	168.3
1/D of Tubes	152.3	152.3

ACTION BY DATES:

22nd Mar - Gate-pass procedure have comp lete -d for manpower including for safety andmedicals.

23rd Mar - Materials & pigging M/c were brought into refinery and unloaded at site.And for the same preparation was done.

A) Heater-D1041 Pass *II 2:*

Date: 24/03/2022 Start - 10:25 End -16:30 (Total duration: 06:0SHr)

B) Heater-D1041 Pass *II* 1:

Date: 25/03/2022 Start - 08:50 End -15:00 (Total duration: 06:lOHr)

25th Mar - Pigging M/c and material were demobilized from site

Table:2 INFERENCE RELATED TO HEATER

Heater No	**D-1041**	**D-1041**
PASS NO	1	2
TOTAL HOURS	06:10	06:05
TOTAL PIGG USED	9	9
COKE COLLECTED (KG)	6.8+ Powder coke	3.8+ Powder coke

Table: 3 **Flow Table Of Heater With Pass No:1**

Pressure	Initial Flow	Final Flow	Flow Gain	**Ave.** Flow Gain
50	490	535	45	60
100	670	735	65	
150	830	900	70	

Table:4 **Flow Table Of Heater With Pass No:2**

Pressure	Initial Flow	Final Flow	Flow Gain	**Ave.** Flow Gain
50	508	550	42	74
100	675	755	80	
150	830	930	100	

CONCLUSIONS

After complete the job furnace tubes cleaned &ready to start next production.

• All coke is removed from the inside of tubes, more environmentally safe than steam air decoking - no venting to atmosphere or ground.

• “Pigs” do not erode or damage inside of tubes Mechanical decoking performed faster than steam air decoking.

• Clients have reported longer run lengths after mechanical decoking compared with steam.

• Requires outside vendor to perform decoking procedure so Client operating staff can devote more time on turnaround activities.

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