AL AYEN University

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Design of Natural Gas System for Operation of Steam Boilers of Thermal Power Plants

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بحث التخرج مقدم الى كلية هندسة النفط –قسم النفط جامعة العين وهو جزء من متطلبات شهادة البكلوريوس في هندسة النفط

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بسم الله الرحمن الرحيم

(يرفع الله الذين امنوا منكم
والذين أوتوا العلم درجات)

صدق الله العلي العظيم

شكر وتقدير

أتقدم بجزيل شكري وتقديري للدكتور المهندس صائب عبد الهادي فرعون لما أبداه من متابعة في انجاز هذا المشروع والله من وراء القصد.

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اهدي تخرجي الى معلم البشرية اجمعين الهادي الامين صلى الله عليه واله وسلم واهل بيته الطيبين الطاهرين

منذ الخليقة وجد الانسان نفسه على وجه الارض لا يستطيع العيش بمعزل عن الاخرين, ونجد بجميع مراحل حياتنا من هم يستحقون منا كل الشكر والتقدير اليك ايضا ايها القلب الحنون وخير مثال لرب الاسرة فلم ارك يوم تتهاون في توفير لنا سبل السعادة والخير ,اليك يا حبيبة القلب ,يامن وضع الله سبحانه وتعالى الجنة تحت اقدامك اليك يا امي .

دائما ما نسير في دروب الحياة ,ويبقى في اذهاننا في كل طريق نسلكه فلكم يا اصحاب الوجوه الجميلة زملائي واصدقائي واخواني ,وبداخلي كل تقدير وامتنان لكل شخص كان له الفضل في مسيرتي وقدم لي المساعدة ولو باليسر,ولا يمكن ان انسى اساتذتي الكرام الذين لهم الفضل الكبير والدور الاول في مساندتي وتوضيح لي العديد من المعلومات الهامة والقيمة بالنسبة لي .

فانا اليوم اقوم بإهداء لكم بحث تخرجي وانا اتمنى من الله ان يطيل لي في اعماركم ويرزقكم دائما بالخيرات .

Contents

Introduction

Many environmentalists view natural gas as a natural bridge fuel between the dominant fossil fuels of today and the renewable fuel of tomorrow. Within the hydro carbon family the latest growing hydrocarbon is a natural gas. Most estimate put the average rate of growth of 1.5 – 2%. For a given amount of energy , burning natural gas produces about half as much as carbon dioxide, the main cause of global warming as The demand for primary energy is ever growing. One of primarily consumption of NG is as a source of electrical generation, and it is increasingly becoming popular because it burns cleaner than oil. As the fuel burns world struggles to find new sources of energy, it is clear that the fossil fuel will continue to play a dominant role in the foreseeable future.

Natural gas is a gaseous fossil fuel usually found in association with petroleum, it contains methane 70 – 90 %,with small amount of other

difference in efficiency is about 11% higher than other fuels(boiler efficiency).

Natural gas is located for power generation so pipes are founded inside

power plants from natural gas refineries, it extends hundreds of kilometers from North Rumella station which is pumped to Gas receiving station (GRS) of Nassiriyah Thermal Power Plant at pressure equal to 42Kg/cm2, where the impurities and condensate droplets that may be present in gas are removed. The outlet pressure of (GRS) is equal to13Kg/cm2 enters another station called Gas metering station(GMS).

The outlet gas from (GMS) is going to boilers for combustion at pressure between 1.5 ± 0.2 Kg/cm2.

Natural gas requires much less air in combustion because it has relatively low amount of carbon and high amount of hydrogen in addition to the carbon dioxide emission (CO_2) .

Natural gas is highly flammable which means leaks can result explosion also toxic unless can go undetected.

Natural gas is environmentally friendly because it burns cleaner than other fossil fuels, as we said before ,burning natural gas for energy results in fewer emissions of nearly all types of air pollutants (CO_2) , so it is used in steam boilers for generation of electricity. The flame color in the

furnace of boiler should be always blue, clear, this means the system is running at its most energy efficient. A yellow color or even tint of orange not only means wasted energy ,it could be producing carbon monoxide (CO), yellow color comes from soot particles produced by flame. The input to (GMS) has pressure from $13 \pm 0.3 Kg/cm^2$,the output pressure to Gas Metering Station is designed to be $1,5 \pm 0.2 Kg/cm^2$.

It is designed to receive purified ,heated gas without gas condensate from (GRS). Determining the correct size of equipments and facilities in NG processing is key to achieving perfect engineering design and saving on initial and operating cost.

The first chapter of this project includes specification and explanation of GMS system.

The second chapter of this project includes operation of GMS.

The third chapter of this project is the methodology and data calculations of the design.

Finally, conclusions and proposals of the study are given.

Objective of the project

Installation of new Gas pipes lines for expansion of thermal power plant. The extension of another two lines for the system for extra addition of thermal units is necessary for getting the required load of the plant.

Chapter 1

Gas metering station system

Description

Gathering lines of NG are above ground surface coating for surface coating for corrosion prevention and possibly insulation may be required. Onshore compression station commonly called booster station is applied to pump NG from the field after treatment to power plant.

GMS is designed for reducing gas pressure value, pressure of gas after receiving station or input to GMS is equal to

13 $\pm$1.3Kg/Cm^2 and temperature 20^{0}C

Capacity of GMS to be design = 184,000m^3/hr

Gas pressure after GMS = 1.5$\pm$ 0.2 Kg/Cm^2

GMS is designed to receive purified heated gas without gas condensate from GRS, gas purification filters and heater are installed on the territory of GRS, the GMS equipment has 100% reserve after design.

Technological equipment of GMS comprises;

- High pressure D=600mm, P = 16 Kg/Cm^2 gas pipe line.

- Two intermediate pressure, D = 800mm P ≤ 2.5 Kg/Cm^2 gas pipe line.

- Eight diameters 150mm control valves with membrane actuator ппх – 400 -60 -02

- Four reducing station lines (line)

- Eight pressure regulators with ПТ – 712Р

- Eight by pass remote control panels БПДУ- АТ.

- Thirteen electrically driven gate valves.

- One manually gate valve no.14.

- By pass D = 1000mm ,P ≤ 2.5 kg/cm2 gas pipe line of reducing station.

-Four safety valves type ППК- 4-150

- High pressure gas pipe line D630 x8 are designed for delivery gas from GRS to GMS with p =13 ±1.3Kg/Cm^2, high pressure gas pipe line is laid underground with corrosion proof coating.

- Intermediate pressure gas pipe line D800x8 are designed for providing the ТГМЕ206 boilers with gas under pressure equal to

1.5± 0.2 Kg/Cm^2 , each gas pipe line is designed to ensure gas supply of two boiler.

Natural gas is pumped through four lines (after modifications of the system) ,each line is equipped with 2 electrically gate valve,

actuator, pressure regulator the four lines are joined to become two lines 1,2 so the gas is sent to the furnace of steam boilers for four units , generally one line in operation and the other is stand by. Generally after the expansion of the station to four units.

Gas pipe line no.1 is deliver gas to main boilers, units 2&4.

Gas pipe line no.2 is deliver gas to main boilers no. units 1&3.

Ip gas pipe lines are laid overhead without insulation and pointed yellow.

- Control valves with membrane actuator are designed for reducing gas pressure on GMS outlet and to control its preset valve.

- Reducing station (RS) serves to reduce gas pressure from

13 KG/CM^2 to 1.5 KG/CM^2 ,one RS capacity is 92,000 M^3/hr , for two thermal units, provided $t = {}^0C$, P = 760mm of Hg column.

- Each (RS) delivers gas to two main boilers at 100% load when firing gas. Each (RS) mounts in sequence two controls valve and being in operation (second a long gas flow is normally close the other standby is normally opened).

RS no 1, 3 are main operating reducing stations, RS no 2 and 4 are stand by.

Operating valves 2e, 4e of stand by RS are adjusted to keep gas pressure after themselves within the range of 1.3 ±0.12 Kg/cm^2

Stand by valves 2d,4d are adjusted to keep gas pressure of

1.3 ±0.12 Kg/cm^2, operating valve 1e, 3e of main RS are adjusted to keep gas pr. Of 1.3 ±0.12 Kg/cm^2

- Manual valve no. 14serve to manually control gas pressure

On GMS outlet through D = 1000mm by pass gas pipe line is designed to deliver gas to boiler passing by RS. In case of failure of all the four or three (repair work on them and impossible to transfer boiler into stand by fuel (crude oil or mazut).

- Safety valves are designed to decrease excessive gas pressure from IP gas pipe line , they are installed on IP gas pipe line,

two valves on each gas pipe line, Safety valve are so adjusted that can be opened at 2.40 Kg/cm2, maximum gas flow with completely opened valve is 7200 m3/hr.

- All pipelines within GMS have noise insulated coating.

GMS comprises compressed air for purging pipeline for free vents, controlling medium pipeline of control over membrane actuator mechanism of control valves.

- Compressed air from compressor plant after valve no.1 to all RS, after their inlet gate valves to valve 15, 16 (after them).

- Compressor air for purging and testing of gas pipe lines and safety valves in case of putting the equipment and gas pipe line under repair also for feeding for control panel.

GMS has free vent after and before valve no.1, after each control valves, used for discharge gas and air mixture into atmosphere, when purging gas pipe line or when filling them with gas on completion of repair or other work on gas pipe line equipment.

- Controlling medium pipe line for control valve membrane actuator mechanism control is of Dc = 12 and connected with compressed air Dc = 50 pipe line.

-Controlling medium, affect the control valves membrane and supply devices which enable automatic keeping of gas pressure set valve on GMS outlet.

Controlling medium pipe line , isolating filter (5) valves, control valve (1), self cleaning filter(1), free vent (2).

Interlock of GMS

1- Normally opened control valve full stroke time for closing 45 second, for opening 80 second.

Normally closed valves for closing 80 second , for opening 45 second.

2 –When gas pressure increases in no.1 gas pipe line on GMS outlet more than 1.5 Kg/cm2, stand by control valve (3d) of operating RS is switched into operation.

3 – When gas pr. Increases on GMS outlet on line in line no.2 gas pipe line more than 1.5 Kg/cm2, the stand by control valve (1d) of operating (RS) switch in operation.

4 – Gas pressure increases on GMS outlet in no.1 pipe line more than 2 Kg/cm2, the operating RS operates the automatic change over to reserve. In this case inlet gate valve no.6 of stand by RS is being opened simultaneously with closing of inlet no.5 of operating no.5, i .e change over to stand by take place.

5 –When gas pressure over 2Kg/cm2 increases on GMS outlet, gas line no.2, the automatic change over (ACO) operates, the inlet gate valve no.4 of standby (RS) is opened simultaneously

With closing of gate valve no.3 of operating (RS) , thus change to standby(RS) .

6 – When gas pressure decreases below 1.1Kg/cm2, gas pressure decreases on GMS outlet line no.1, Automatic change over to reserve of operating RS start to operate, valve no.6 of standby is opened. In this case both RS will remain in operation.

7 – When pressure of gas decreases to1.1Kg/cm2 on GMS outlet in no.2 gas pipe line operates the ACO to reserve of operating RS, valve no.4 of standby RS will open and GMS outlet is kept

by control valves of both RS, this mean both RS continue to operate.

Protection

1- Four safety valves are automatically operated when pressure increases.

2 – When pressure of gas in the inlet of GMS increases to 11.1Kg/cm2 or increases to 14.5Kg/cm2, a signal appears in control room.

3 – When pressure of outlet gas from GMS decreases to 1.1 Kg/cm2 or decreases to 2 Kg/cm2 ACO take over.

4 – Devices on GMS panel for temperature, pressure, flow for gas inlet to GMS, gas pressure on line and 1and 2.

Chapter 2

Preparation for operation of gas metering station

Before start;-

- Electric valves energized, free vent are opened.

- Gate valve no. 1,2,3,4,5,6,14 are closed.

- Gate valve no.7,8,9,10,11,12,13,15,16 are opened.

- Control key of valves 3,4,5,6 are put into " operation" position.

- All compressor air pipe line are plugged.

- Fill the HP line with gas up to gate valve no.1, for this purpose purge D600 through vent before no.1 until all air is purged from pipe line.

- Analysis of O_2% in gases not more than1%, close free vent.

- Open valve no.1 and filling the line to valves 3, 4 ,5 ,6 of RS with gas purge all air through free vent, then completion of purge , close free vents.

- Slightly open manual valve 14 and by filling by pass section from gate valve no. 12, 13 to gate valve no.2 with gas.

Purge it through free vent on by pass, between valves no2 and 14, on complete purging close gate valve no.14.

- Open partially gate valve no.2 by filling with gas bypass section from HP pipe line to gate valve no.14, purge it through the same vent on by pass, on complete purging , close the valve of free vent and gate , so GMS is ready for operation.

Preparation for starting up auxiliary equipment

- GMS should disconnected from GRS outlet gate valves and be shutoff valves on GRS pipe lines should be closed.

- Inlet gate valve no.1 on HP line should be closed.

- Free vent valves on HP pipe line and RS should be opened.

- Remove metal plug on controlling medium D 55mm pipe line to MT- 712-T devices.

- Install detachable junction pipe on the compressed air D50mm pipe line and fasten it.

- Open valve on compressed air D50 pipe line from compressor house and purge gas pipe line with compressed air.

- when being cleaned from gas, the gas pipe line should be purged with air until removal of gas, completion of purging is defined by analyzing samples in which the residual gas compound of purging air should not exceed 1/5% of gas

explosion lower limit which is equal to 5%. Taking analyzing of gas sample at chemical laboratory of thermal power station.

Preparation for operation of controlling Medium system

-After filling up pipe line with gas purge , the controlling medium pipe line with gas into atmosphere.

- Open controlling medium D50 pipe line valve from HP pipeline.

- Open the controlling medium valve on D 12 pipe line.

- Adjust pressure by ДПП-1-65 regulator to 4 – 6 Kg/cm2.

- Open valve on D 12 pipe line before and after MT-712P devices.

- Switch on MT – 712T devices and purge each MT- 712T devices and purge each MT-712 device as well as by pass panel БПДУ at with gas during1-2 mint under manual control.

When in manual operation regime the handle of the БПДУ at change over cock is in manual position.

Completion of purging MT-712 device put the handle of change over cock in manual position.

Check up Interlock& Protection

Check it before start ;

- Put the control key of gate valve no.3,5 in operation position, gate valve no.4,6 in stand by position.

- Put БПДУ at change over key of control valve "1e" in manual position .

- Increase gas pressure over 1.7Kg /cm2 on GMS outlet following switching in operation of standby control valve "1d"

- Decrease gas pressure below 1.1 Kg/cm2 on GMS outlet,

Observe the standby RS no.2 and follow operation of control valves 2e, 2d on response of interlock and switching into joint

operation of two RS , make a reverse transfer, close valve no.4, put key in operation..

- Put control key of valve no.4 into " standby" position.

- Increase gas pressure over 2Kg/ cm2 on GMS outlet.

- Carry out a reverse transfer to operation by control element no.1 and put change over key of all 8 БПДУ, in automatic position, control key of the valves4,6 in standby position.

Start up from different conditions

Cold start; after maintenance or after long stand period.

Hot start ; After stoppage for period of time.

- MT-712P and БПДУ equipments in auto position

- Open inlet gate valves no.3,5 of RS 1,3 so for this purpose press start button on panel 17 of mazut pump house of the above valves.

- When gate valve are completely opened , a red lamp is lighted up, the green one is switch off .

- Measure gas pressure in GMS, inlet & outlet temperature and flow of gas by meter.

Supervision & Normal operation , Servicing.

- GMS work either automatically or remote for keeping gas pressure outlet.

- When automatic is being put in operation, the switch of БПДУ

in Automatic position so controlling medium "feeding" comes successively through the general outside reducer ДПП-1-65type

which reduce its pressure down to 4- 6 Kg /cm2 through general outside filter and come to reduce of each bypass БПДУ , at panel which pressure is reduced down to 0.4 – 0.14Kg /cm2, after that controlling medium comes to pneumatic rectifier of

installed manometer with control element MT-712, which transducer pressure of feeding into alternative pilot pressure and comes through the bypass БПДУ at panel to the control valve MAM With Pressure of 0.2 – 1.0 kg /cm2.

- When switch БПДУ put in "manual position" this is a remote control, by switch position MT712P is disconnected from regulation system and the feeding pressure is controlled bypass

БПДУ of panel with manual rotation of БПДУ at reducer regulating screw. pressure in MT- 712P device line is controlled by БПДУ .

- When four units are in operation the main boiler and start up boiler operate on gas, the two main reducing station no.1 and 3 and both gas pipe lines to boiler should be in operation , the other two RS are standby, valve no.11,14,2 closed, control key of valve no.3,5 should be in " operation" position , those of gate valve no.4, 6 in standby position, valve no. 7,8,9,10,12,13,15,16, should be opened. Control key of operating RS inlet gate valves should be in" operation "position ,reserve RS in "reserve" position

- In case any of the RS is under Repair operation with section gate valve no. 11 opening is permissible.

- When main boiler no.1and start up boiler operate on gas one main RS no.3 or no.1 and both gas pipelines to boiler are in operation, one of the two stand by RS no.4 or no.2 is in reserve.

Control over GMS equipment operation

- Inspection of GMS by operator and shift electrician of automation.

- Shift engineer inspect the equipment not less than once a day.

- Make sure (visually inspection) no leaks, indication of control and measuring devices, fitness of GMS, lighting net work, availability of fire fighting equipments, area is clean, absence of

foreign objects, condition of fittings, support, , flange, safety valves, earthing, insulations.

- Result of fault should be note in log-book.

Maintenance (servicing of GMS equipment)

- GMS in automatic mode , not required staying of the technician permanent.

- If a signal appears in control room" failure in GMS equipment operation" see the reason in the panels of control room.

- At automatic change over to standby operation for gas pressure increase (p= 2Kg /cm2) and decrease to p = 1.1Kg /cm2 on GMS outlet verify the reason (change in pressure of inlet to GMS, rupture of membrane. If no failure is found , after agreement with shift engineer, a reserve transference to main RS

Check the stand by and put control key in "operation" position.

Put the key of the inlet valve in reserve.

- Continuous operation ,the control valve needs not less than once a month checking up of its adjustment also lubrication of grinding surfaces.

- Replacement of a charts during 24 hours once a time.

- Check safety valves adjustment not less than once each two month.

- revision of maintenance of pr. Regulator not less than one year.

Stoppage of GMS

-To put main RS into standby condition (in case of transference of a part of boiler into operation on standby fuel (Mazut or crude oil).

-Open gate valve no.11.

- put valveno.4 (no.6) control key of one of the stand by RS 2 and no.4 in operation position.

- Close inlet gate valve of RS being put in standby.

- When putting GMS equipment out of operation for a long period of time, preserve GMS equipment for this purpose.

- Switch off GMs equipments.

- Close inlet valve no.1 on HP pipe line.

- Purge GMS equipment with compressor.

- Install steal plugs after gate valve no. 1and 2, after stoppage and purging of GMS equipment and gas line with air, vents remain opened.

- When putting entire GMS equipment into standby for a small period of time (for example tripping by protection of all the operating on gas boilers)

- Close inlet valve no.1 on the gas line.

- Put all control keys of gate valve no.4,5,6,3 in operation position.

-Close by remote all gate valve no.3,4,5,6 of RS by means of pressing " Closed" button of the gate valves on control panel, when slide valve is completely closed , green lamp should be lit up. Warn shift engineer about the stoppage of GMS.

Stoppage for repair

When putting under repair the fittings (change of washers,

disassembling of control valves) or gas pipeline within GMS connected with their un tightness do as below;

- Transfer boilers into standby fuel or into GMS operation .

- Close inlet valve no.1 on IP line.

- Open valves of free vents on RS and HP gas pipe line after valve no.1.

- Purge gas pipelines and GMS equipment with compressed air.

- Install steel plug after valve no.1

- When GMS operates through RS bypass (D = 1000mm) do as-
- Valves no.12& 13 should be opened.

- Gate valves no.15, 16 on IP gas pipe lines should be opened.

- Open valve no.2.

- Gas pressure on GMS outlet should be done by opening and closing of manual valve no.14.

- Gas pressure ≤ 205 max outlet.

Emergency stoppage

As soon as GMS is stopped emergency (rupture of gas line, un tightness in flange junctions), make a report to shift engineer (T&B department and to SSE about the damage.

- immediately isolate the damaged section of pipe line with gate valves before and after(along with gas flow) installed on

the damaged pipe line section.

- Open valves of vent on damaged line.

- Prepare according to SSE warrants, put under repair damaged equipment.

GMS is not allowed to operate;

- If gas leaks appear.

- In case of fire in boilers which is dangerous for gas pipe lines, so gas supply should be immediately stopped to this site.

- It is not allowed to use gas pipe line and its support as a mean of suspending weights and lifting tackles, electric cables and

wires (voltage, lighting, telephone, welding as well as connection of protection earthing for electrical welding.

Chapter 3

Methodology

NG is considered to be one of the most important energy resources.

For research purposes, literature overview was conducted using the most relevant scientific database with references.

In this research Russian model from Technopromexport company is designed and additional information of expansion of natural gas is added, data is collected from Russian natural gas construction and design for the above company.

The aim of this project is to present an overview and systematic analysis that deal with design and consumption of NG after expansion of plant.

Metal of pipes

NG pipes line is made of high strength low alloy steel, metal is mixture of steel contains 0.5% carbon and has higher concentration of alloying element to increase hardness and high temperature strength, also contains element such as nickel, chromium, molybdenum.

Operation state

First of all, as indicate in figure.**1** , there is one line which supply gas to the two units (boilers) with capacity of the gas 90m3/hr, by pass of this line is with manual valve.(2x200MW) units capacity.

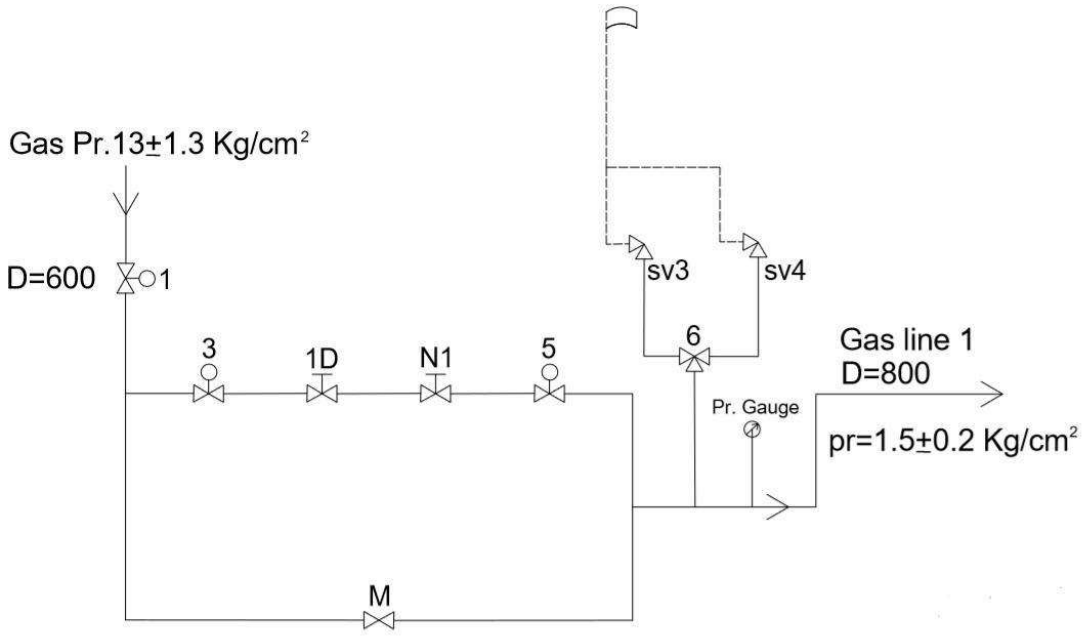

Figure no.1 natural gas lines old design

Because the station is worked on three types of fuel (natural gas, mazut, crude oil) so changing of the fuel to another one depending on the available quantity. When the main line of gas station is stopped for any reason, taking into consideration there is no alternative fuel, the supply of NG to boiler is done manually by opening manual valve (M) and control the pressure

of gas to boilers about 1.3± 0.2 Kg/cm2. And this is critical state for operation of plant and may cause stoppage of the plant.

Procedures & Modifications

In figure **2 ,** by replacing manual valve with electric valves and regulators on the same gas line (bypass), we can control gas pressure automatically. This is more save for operation of the plant.

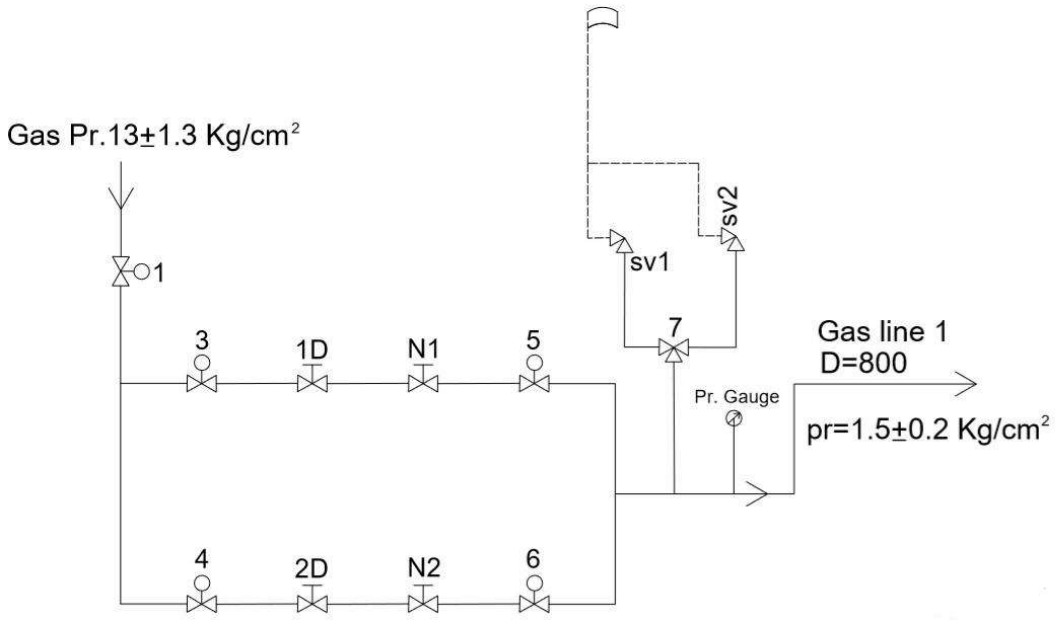

Figure.2 Redesign of natural gas lines

Expansion of thermal power plant to four boilers (units) 4x200MW needs to add another two lines with all necessary electric valves and actuators with protection devices and interlock. By adding another gas line (D = 8oomm) for operation of four units on gas with capacity 180m3/hr and

pressure 1.5 ± 0.2 Kg/cm2. Total information illustrates in figure.3

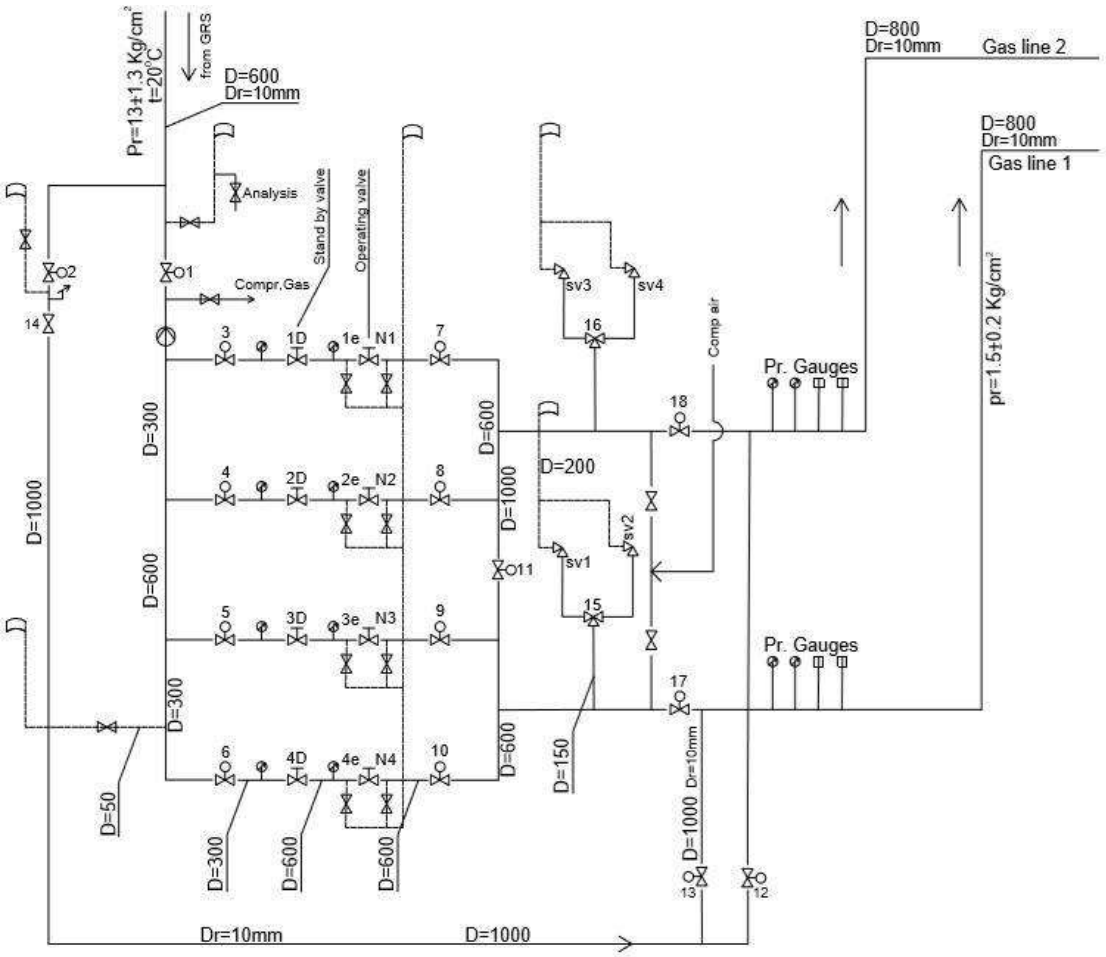

Figure3. natural gas lines scheme for 4x200MW, complete design for four thermal units.

Operational data

GMS is designed to receive purified heated gas without gas condensate from GRS, gas purification filters and heater are installed on the territory of GRS, the GMS equipment has 100% reserve (manual line).

Technological equipment of GMS comprises;

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- Two intermediate pressure, D = 800mm P ≤ 2.5 Kg/Cm^2 gas pipe line.

- Four diameters 150mm control valves with membrane actuator ппх – 400 -60 -02

- one reducing station line.

- Two pressure regulators with ПТ – 712Р

- Three electrically driven gate valves.

- One manually gate valve (bypass).

-Two safety valves type ППК- 4-150

- High pressure gas pipe line D600 x8 are designed for delivery gas from GRS to GMS with p =13 ±1.3Kg/Cm^2,

- Intermediate pressure gas pipe line D800x8 are designed for providing the ТГМЕ206 boilers (units) with gas under pressure

equal to 1.5± 0.2 Kg/Cm^2 , each gas pipe line is designed to ensure gas supply of one boiler.

- Control valves with membrane actuator are designed for reducing gas pressure on GMS outlet and to control its preset valve.

- Reducing station (RS) serves to reduce gas pressure from

13 Kg/Cm^2 to 1.5 Kg/Cm^2 ,one RS capacity is 90,000 m^3/hr , provided t = ^{0}C, P = 760mm of Hg column.

operating valve N1, RS are adjusted to keep gas pr. Of 1.5 ±0.12 Kg/cm^2

by pass gas pipe line **Fig.1** is designed to deliver gas to boiler In case of failure of the main line(repair work on them and impossible to transfer boiler into stand by fuel (crude oil or mazut).- Safety valves are designed to decrease excessive gas pressure from IP gas pipe line , they are installed on IP gas pipe line,

two valves on each gas pipe line, Safety valve are so adjusted to decrease excessive gas pressure that can be opened at 2.40 Kg/cm2, maximum gas flow with completely opened valve is 7200 m3/h .GMS comprises air for purging pipeline for free vents, controlling medium pipeline of control over membrane actuator mechanism of control valves. - Compressor air for purging and testing of gas pipe lines in case of putting the equipment under repair.

- Compressor air for purging and testing of gas pipe lines in case of putting the equipment under repair.

Data calculations

A secondary data of the field gas from Oil Pipelines Company(Southern Operations Authority in Basrah) was obtained and empirical and empirical study was carried out to determine the nature of the gas.

The gas flow rate, pressure, temperature was collected and used to design the gas pipe line.

Composition of natural gas by Gas chromatography (TDC,FID) , based on ASTMD 1945, GPA2286,IP345.

The sizing, design pressure, collapse pressure, burst pressure, hydro test pressure, pipe diameter, thickness etc were calculated using appropriate design equations.

Natural Gas due to its storage difficulties need to be transported to its need destination as soon as produced from the reservoir.

There are number of options for transporting natural gas energy from oil and gas fields to market (Guo Buoyan et al.,2005).This includes Pipeline Natural Gas (PNG), Compressed Natural Gas (CNG), Liquefied Natural Gas(LNG) and gas to solid (GTS) . Gas pipelines are connected pipes which are installed for the purpose of transmitting gas, liquid, slurries, etc., from sources of supply to one or more distribution centers or to one or more large volume customers; a pipe installed to interconnect sources of supply to one or more distribution centers or to one or more large volume customers; or a pipe connect to interconnect sources of supply.

(Lyons W;2011). Pipes are tube with around cross section conforming to the dimensional requirements for nominal pipe size.

Gas pipeline design is a process or plan to show the look and function of gas pipeline before it is constructed. The design consist of hydraulic design, mechanical design, geothermal design and operating, maintenance design (Mike Y,2010).

Several codes and standards have been developed as a guide for the design, construction and operations of pipelines.

The objectives of this codes and standards are to ensure the safety of the personnel and general public by minimizing the risk of high pressure pipelines (Cult et al,2008).

The properties and compositions of the gas must be determined in order to design an appropriate gas pipe line. Gas reservoir properties such as carbon contents, gas specific gravity, gas compressibility factor , gas viscosity, critical temperature and pressure, gas density, etc; must be determined to select the grade of pipeline.

Pipeline route and profile survey is also required to a certain the minimum and maximum elevation of pipe line, to know if there will be creek/ river crossing and to understand the environment condition of such of such terrain.

In this paper, a case study of atypical marginal field will be undertaken to design a natural gas transmission pipeline. The terrain is fairly flat and accessible. A secondary data of the field gas will be obtained and empirical study will be carried out to determine the nature of the gas .

The gas flow rate, pressure, temperature will be collated and used to design the gas pipeline.

Data collection and analysis for pipeline design

A secondary data of the gas sample from the field were collected for analysis as shown in table. 1 below.

Feed Gas to Power Station; Test Report		
Location; Nahr Bin Umer	Report No.12	Request Date; 19.1.2020
Beneficiary: (هيأة عمليات الجنوب) شركة خطوط الأنابيب النفطية		
Beneficiary Request No 91	Beneficiary Request Date; 13.1.2020	Beneficiary Request Date 19.1.2020

Composition of Natural Gas by Gas Chromatography(TDC,FID),Based on ASTM D 1945,GPA2286,IP345

Source of Sample	Feed Gas to North Rumaila power Station/ **Iraqi Line.**	Feed Gas to North Rumaila Power Station/ **Iranian Line**
Date of Sampling	16.1.2020	16.1.2020
Date of Analysis	16.1.2020	16.2020
Pressure (bar)	34	21
Temperature (^{o}C)	24	32
Sample no.	BOC-RC-02-S-26-2019	BOC- RC - 02- S -2019
Compound	Normalized Mole% Analysis	
Nitrogen (N_2)	1.214	1.144
Carbon Dioxide (CO_2)	1.494	1.501
Hydrogen Sulfide (H_2S)	0.0002	0.0001
Methane	76.705	76.389
Ethane	16.955	17.002
Propane	3.049	3.243
Iso Butane	0.147	0.152
Normal Butane	0.318	0.337
Neo Pentane	0.001	0.001
Iso Pentane	0.045	0.050
Normal Pentane	0.045	0.051
Hexanes	0.015	0.018
Heptanes	0.001	0.006
Octanes	0.001	0.015
Nonanes	0.002	0.043
Decanes+	0.008	0.048
TOTAL	100.000	100.000

Specific Gravity and Calorific Value and Main Molecular Weight of Gases,GPA2172,ASTM D3588

Characteristics	Results	
Specific Gravity at 60 ^{0}F (Air= 1)	0.6943	0.7007
Calculated Molecular Weight,(g/mol)	20.1104	20.2945
Calculated Density, (LBS/SCU.ft)	0.0528	0.0533
Calculated Net Calorific Value,(BTU/CU ft) (UHV)	1061.4604	1071.7015
H_2S content, By Drager Tube ,ppmv	0.5	0.5
Water content by Drager Tube, mg/L	0.7	0.5
Calculated Molecular Weight Of C6+	105.0224	121.6382

Table.1 Gas composition data

Compound	Mole fraction(Yi)	Molecular weight g/mole	Yi x Mi
Nitrogen	0.01214	28.01	0.34005
Carbon dioxide	0.01494	44.1	0.6588
Hydrogen sulfide	0.0002	34.08	0.006316
Methane	0.7670	16.04	12.3026
Ethane	0.1695	30.07	5.0968
Propane	0.03049	44.10	1.3446
Isobutane	0.00147	56.108	0.08247
Normal butane	0.00318	58.12	0.1848
Neopentane	0.00001	72.15	0.007215
Isopentane	0.00045	72.15	0.03246
Normal pentane	0.00045	72.15	0.03246
Hexanes C6	0.00015	86.18	0.012927
Heptanes	0.00001	100.21	0.0010021
Octanes	0.00001	114.23	0.001142
Nonanes	0.00002	128.2	0.002564
Decanes	0.00008	142.29	0.011376
Total	1,000		20.117

Table.2 Gas molecular weight computation

Gas pressure, temperature, flow rate

The flowing head pressure, temperature, and flow rate from the pipe line were measured with the aid of pressure gauges , temperature recorder and orifice meter respectively, and the following parameters were obtained.

- Inlet pressure = 34 bar = 493 PSI

- Inlet temperature = 24^0C

- Volumetric flow rate = 200,000m3/hr =200,000 x 0.59= 118,000 MSCF

From table no.2

Where Yi = mole fraction, Mi = Molecular weight

M_g = (Yi x Mi) = 20.117 g/mole

The Apparent Molecular Weight of the gas = 20.117 g/mole.

Calculations for design

The following calculations is essential for the design of gas line;

1 - Determination of gas gravity (G)

G = Mg / Ma where

Mg = Gas molecular weight

M_{air} = Molecular weight of the air = 28.9625

G = 20.117/ 28.96 = 0.69

2- Determination of gas Deviation factor

Calculating the pseudo –critical temperature

$Pc = 677 + 15G – 5G^2$

$= 677 + 15(0.69) – 37.5(0.69)^2$

$= 677 +10.35 -17.853 = 669.05$ PSI = 47Kg/ Cm^2

$T_c = 168 + 325G – 12.5(G)^2$

$= 168 + 325(0.69) – 12.5(0.69)^2$

$= 168 + 224.25 – 5.951 = 386.3\ ^0R$

3-Calculating the pseudo-reduced temperature and pressure

$Tr = T / Tc$

$T = {}^0F + 460$

$T = 75.2 + 460 = 535.2\ {}^0R$

Where $24^0C = 75.2\ {}^0F$

$Tr = 535.2 / 386.3 = 1.38$

$Pr = P / Pc$

$P = 493$ PSI $= 34$ bar

$Pc = 669.5$ PSI

$Pr = 493 / 669.5 = 0.7$

4-Estimating the (Z) factor using Katz and Standing chart

Compressibility factor $Z = f(T_{pr}$ and $P_{pr})$

From compressibility gas chart at $T_{pr} = 1.38$ and $P_{pr} = 0.7$

$Z = 0.92$

5 -Determination of gas density

$PV = ZnRT$ but $n = m / M$

$PM = \rho ZRT$

$\rho = PM / ZRT$

Where $R = 10.73 ft^3$ psi / lbmol.^0R

$P = 491 \times 20.117 / 0.92 \times 10.73 \times 535.2$

$= 1.91$ lb/ft$^3 = 30.56$Kg/m3

5-Determination of Gas viscosity, μ

From the graph of temperature vs. molecular weight, at temperature of 75.2 ^{0}F (24^{0}C) and molecular weight 20.117,

μ1 = 0.02 Cp

μ / μ1 at (Tpr = 1.38 and Ppr 0.7) = 1.15

so; μ = 1.15 μ1

μ = 1.15 x 0.02 = 0.023

Pipeline sizing

6-Determination of pipe diameter

Superficial velocity equation for sizing gas stream pipes is given as follow;

$$D = \frac{\sqrt{3.5\ xQhxTA}}{\mathrm{PA}}$$

Where

D = Pipe diameter, Q_h = Flowing capacity (MSCF/D),

T_A =Absolute temperature, P_A = Absolute pressure.

T_A = 75.2 + 460 = 545.2 ^{0}F

P_A = 493 +14.7 = 507.7 PSI

Qh= Flowing capacity= 200,000m3/hr = 200,000 /1180=

169.5 MSCF.

D = (3.5 x 169.5x 545.2/507.7)$^{0.5}$

= 25 inch =25x25.4 =635mm +1.5 allowance

7-Determination of pipe nominal thickness

The nominal wall thickness can be calculated using Barlow equation.

$t_{nom} = P_d D / 2£_w \eta \delta_y F_t + C_a$

where

t_{nom} = Nominal wall thickness mm. P_d Design internal pressure.

C_a= Correction thickness, $£_w$ = Weld efficiency factor, it is 1.0 for seamless. Arc Weld (SAW or DSAW). δ_y = specified Minimum Yield Strength, η = design factor, which is 0.72 for pipeline.

F_t = temperature rerating factor which is 1 for temperature under 250^0C .

Minimum yield strength for steel = 40,000PSI (from chart)

Let corrosion thickness allowance be 4.00mm.

So

t_{nom} = 493 x625 / 2x 40,000x0.72x1 + 4.00mm

= 5.347 + 4.00mm

= 9.349 = 10mm

8 - Determination of Reynolds number

$N_{Re} = 20 q_h G / \mu D$

= 20x 169.5 / 0.023x10

=4,739

Since $N_{Re} > 2000$. The flow is turbulent.

Conclusion

1 – A gas transmission pipeline was designed using appropriate design equations from ASME and API codes/standard for calculating the appropriate diameter, wall thickness, pressure and temperature, Reynolds number.

2 – Before the construction of power plant, studies are needed for estimation the amount of NG required to fulfill the maximum load.

3 – Increasing the numbers of units in the plant means increasing the quantity of gas flow to the boilers and therefore increasing the capacity of the units (more units are added).

4 – NG needs detailed design requirements, control and protection devices and tightness of the system because gas is capable for explosion, so it is necessary to achieve safety precautions.

5 – Burning of NG in the boiler forms sufficiently bright flame, with highest temperature in the furnace and low contaminants.

6 – Design of NG system is accompanied with design of control and protection system.

7– The project idea fits into the frame work of general conditions and industrial development of the country.

LIST OF FIGURES

LIST OF TABLE

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