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Innovative Approach to Increase Name Plate Capacity of Oil and Gas Gathering Centre

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Abstract: Purpose: The oil and gas gathering and processing facility of Kuwait Oil Company is built with a nameplate capacity of X MBOPD (thousand barrels oil per day) with 50% water cut. However, the facility was operating with a water cut of 35%. This comprehensive technical study was conducted to evaluate possibility of increasing oil processing capacity of this facility in line with current lower water cut and other operational flexibilities available in the facility without utilizing its design margin. Topic: This paper shares an innovative approach to increase name plate capacity of oil and gas processing facility utilizing available operational flexibility and operational margins with minor modification. It shares a case study where facility capacity is increased by around 19% without utilizing design margins of equipment or pipeline. Method: The study includes theoretical verification and analysis of all major equipment and piping to identify available capacity and limitation, in order to utilize available additional margin and to propose debottleneck options to overcome limitations. Achievement: The study confirmed that, facility name plate capacity can be revised from X MBOPD (with 50% w.c (water cut)) to X + 32 MBOPD (with: 45% w.c) minor modification in separator and utilizing margin available in feed specification of desalter trains.

Key words: Debottlenecking, capacity enhancement, production.

1. Introduction

The design philosophy adopted for oil and gas facility is different than philosophy of a typical plant of refinery or a petrochemical complex. Unlike these units, oil and gas facility is always subjected to change in feed stream in terms of physical/chemical properties, water cut, GOR (gas oil ratio) etc. This unique characteristic of changing feed stream requires designer to ensure provision of adequate flexibility in design of oil and gas facility for forecasted changes of feed stream. However, it is observed that, such flexibilities are not utilized during initial years of operation of facility when the feed has not changed from its original specification especially in terms of water cut. The innovative approach adopted at Kuwait Oil Company to increase nameplate capacity of oil and gas gathering and processing center utilizes this available operational flexibility and additional margin of facility. However, it is ensured that, no design margin of equipment or piping is utilized in order to increase processing capacity of facility.

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2. Methodology

The methodology adopted for this systematic evaluation of facility to implement this innovative approach is listed below [1]:

(1) Review current oil and water potential of facility and compare it with forecasted figures;

(2) Review design capacity of each equipment of facility to identify its processing capacity and limitations;

(3) Identify equipment or piping with limitations for increase in processing capacity;

(4) Evaluate possible modifications to overcome limitations of these equipment or piping;

(5) Re-evaluate equipment for increase in processing capacity after possible modification;

(6) Establish a revised processing capacity of facility based on proposed process or operational modifications;

(7) Implement modifications once the viability is confirmed;

(8) Carry out separate performance testing of each equipment at higher established capacity;

(9) Carry out performance testing of complete gathering center and revise the name plate capacity.

2.1 Review Current Oil and Water Potential of Facility and Compare It with Forecasted Figures

The water cut of feed stream plays a vital role in this innovative approach. The water cut is the main parameter which changes significantly over years. Due to this, the facilities are always designed considering expected future water cut to be realized during life of facility or till new facility expansion is planned. This innovative approach makes use of the additional margin available to handle this water till actually realized.

In our case, the review of current and forecasted values of water cut revealed that, facility currently operates at much lower water cut than what is anticipated in future. Moreover, it was also noticed that, expected higher water cut will be realized after no. of years. This information played a vital role in deciding a way forward for utilization of available margin of water handling, for increasing crude oil processing.

2.2 Review Design Capacity of Each Equipment of Facility to Identify Its Processing Capacity and Limitations

The next step is to review design capacity of each equipment of facility, after establishing significant gap in current water cut and expected future water cut and the duration in realizing this water cut. The step is to evaluate processing capacity of each equipment for possible increase of oil processing, utilizing margin available due to lower water cut than design. All major equipment e.g., headers, separators, tanks, heaters, desalters, pumps, control valves, etc. are checked for possible increase in oil processing capacity utilizing available margin due to lower water cut. It required to review all relevant datasheets, P & IDs (process & instrument diagrams), current operating trends, design basis, etc. to identify design capacity of major equipment and pipelines. It may be required to carry out simulation of segments of facilities to get better understanding of capacity (e.g., common headers, piping etc.). Each equipment shall be evaluated for its processing or handling capacity of all the fluids, i.e., crude oil, water, gas and condensate as applicable and shall be tabulated for better analysis. Below is simplified table for LP (low pressure) separator developed during this analysis.

2.2.1 Separation Trains

The facility is equipped with three low pressure separation trains. The gas separated from separators is further handled in accumulator. Below Table 1 shows capacities of each main component of separation train.

It is required to develop similar tables for all equipment and piping of facility and carry out analysis for each of these equipment to understand the limitations and capabilities. Based on this, we need to identify most limiting units of facility which restricts the facility operation at higher capacity. During this evaluation, it was observed that, all equipments and piping have potential to increase oil processing capacity from current level of X MBOPD (thousand barrels oil per day) with 50% water cut to X + 32 MBOPD with 45% water cut or even more. However, the limitation was observed in oil and gas separator and desalter units which were limiting oil processing capacity to X MBOPD [2-8].

2.3 Identify Equipment or Piping with Limitations for Increase of Processing Capacity

Once design capacities for oil, water and gas are tabulated for all equipment and piping, it required to start evaluation in detail. All the equipments and

Table 1 Capacity of main components of oil and gas processing facility.

System	Equipment	Oil, MBOPD	Water, MBWPD	Gas, MMSCFD
Capacity for one separation train (three phase mode)				
Separator	LP separator	A	C	E
Control valves	Crude oil LCV	B	-	-
	Water LDVC	-	D	-
	Gas export PCV Flare PCV	-	-	F F
One separation train	Max. operating capacity of one separator train	A	C	F
Capacity of gas handling units D/S of separator				
LP gas accumulator	C-1202 A & B	-	-	G
Export pipeline	LP gas export pipeline	-	-	H
Three separation train	Max. operating capacity of three separator trains (in three phase mode)	A + A + A (limited by oil separation capacity of Sep.)	C + C + C (limited by water separation capacity of Sep.)	H (limited by LP gas export pipeline)

MBWPD—thousand barrels water per day, MMSCFD—million standard cubic feet per day.

piping which are designed to handle more oil, water and gas than overall capacity of facility shall be identified and extra margin available in each of these equipment, shall be tabulated separately. All the equipments which limit the processing or handling capacity of oil, water and gas with respect to current water cut or expected future water cut shall be identified and tabulated separately. During our study, we have identified that, LP separator and desalter are main equipments which restrict the overall processing capacity of facility. The observed limitation in these equipments is explained below.

2.3.1 Oil and Gas Separator

All LP separators in current configuration are designed for operation in three phase mode to process around X MBOPD with 50% water cut. However, these separators are currently operated in two-phase mode with water cut of around 35%. This has increased overall processing load on oil withdrawal piping and control valves of separators, as both oil and water are withdrawn from oil withdrawal piping in two phase mode of operation. Moreover, it was not possible to operate this separator in three-phase mode due to certain operational limitations. So, it was decided to identify a suitable modification to overcome this limitation [2-4, 7, 8].

2.3.2 Desalter

The desalter has design capacity to process oil X + 13 MBOPD with 10% water in feed stream. As our objective was to maximize processing capacity of desalter, which is most vital unit and controlling factor of facility for increasing processing capacity, so, it was decided to identify suitable option to further increase desalting capacity of this facility [5, 6, 8].

2.4 Evaluate Possible Modifications to Overcome These Bottlenecks of These Equipment or Piping

2.4.1 Oil and Gas Separator

It was decided to modify the control loop for liquid level and interface level of separator. The current configuration of interface level control by LDIT/LDCV (level differential indicator and transmitter/level differential control valve) (installed on water outlet line) and liquid level control by LIT/LCV (level indicator and transmitter/level control valve) (installed on oil outlet line) was modified. As per new modification, both LDCV and LCV were controlled by LIT (liquid level). This facilitated two-phase operation of separator with both oil and water outlet lines, in operation which subsequently increased liquid handling capacity of separator which was previously limited as all liquid, was withdrawn only from oil outlet line. There was a design flexibility available in this separator to divert liquid withdrawn from water outlet line either to effluent water tank or to wet crude oil tank. This flexibility allowed two-phase operation of separator with liquid withdrawn from both oil and water outlet lines. Below is simplified Table 2 developed for design capacity of separator trains to evaluate possible increase in capacity after proposed modification [2, 7, 8].

2.4.2 Desalter

The operational and quality parameters were checked to identify scope of increasing processing capacity of desalter. It was observed that, feed stream of desalter was containing around 0.5% water cut due to significantly higher residence time in wet tanks. Whereas, the desalter was designed to handle 10% water cut in feed stream. It was decided to utilize this additional margin to increase oil processing capacity of desalter. Below is a simplified table showing analysis of desalter system based on operation with 0.5% water in feed stream instead of 10% [5, 6, 8].

2.5 Re-evaluate Equipment for Increase in Processing Capacity after Possible Modification

After completing above mentioned steps, we need to reevaluate the capacity of these equipments to finalize revised capacity w.r.t water cut as tabulated in Table 3. Any limitation in gas handling capacity shall also be considered, if applicable, to finalize overall crude oil handling capacity.

2.5.1 Oil and Gas Separator

The processing capacity of oil and gas separator was reevaluated with this proposed modification of utilization of both oil and water outlet lines for liquid withdrawn in two phase operation. It was evident that, processing capacity of X + 32 MBOPD with 45% water cut can be achieved by these separators after this modification. The water handling capacity is limited to 45% due to utilization of some of the water handling capacity by oil and further limitation from wet tank filling line.

2.5.2 Desalter

The re-evaluation of processing capacity of desalter has confirmed that, utilization of available margin in water cut of feed stream, which is designed for 10% but realized as 0.5%, will increase processing capacity of desalter to X + 32 MBOPD. This reevaluation shall be carried out after detailed technical verification of system followed by no. test runs. We generally depend upon the historical operating data and laboratory analysis data for such evaluation. We can conclude that, water cut will not increase more than 0.5% based on historic data but care shall be taken because any increase of water cut above 0.5% will directly affect the crude oil export quality as desalter

Table 2 Revised capacities for LP separator trains (for two phase operation post modification).

System	Equipment	Oil, MBOPD	Water, MBWPD	Gas, MMSCFD
Capacity for one separation train (two phase mode)				
Separator	LP separator	A	C	E
Control valves	Crude oil LCV	B	-	-
	Gas export PCV Flare PCV	-	-	F F
One separation train	Max. operating capacity of one separator train	A	C	F
Capacity of gas handling units D/S of separator				
LP gas accumulator	C-1202 A & B	-	-	G
Export pipeline	LP gas export pipeline	-	-	H
Three separation train	Max. operating capacity of three separator trains (in two phase mode)	A + A + A + 32 or X + 32 (limited by desalter capacity of Sep.)	C + C + C (limited by water separation capacity of Sep.)	H (limited by LP gas export pipeline)

Table 3 Review of current capacities.

System	Equipment	Normal flow, MBOPD	Remarks
Heater	Four no. of heaters	X + 37	
Desalter	Two no. of desalters	X + 15 (if feed water cut is 10%)	If the feed water cut to desalter is 10% then overall capacity of desalter will remain limited to X + 15 MBOPD
		X + 32 (if feed water cut is 0.5%)	However, as the current w.c. is around 0.5%, the effective desalter capacity will increase to X + 32 MBOPD utilizing extra margin available for water
Desalter back pressure control valve	Two no. of PCVs for two trains	X + 63	

shall be operating at its max. handling capacity utilizing extra margin available for water processing. It may be possible to take a conservative approach of considering 1% water cut in feed stream instead of 0.5% to give some margin for unexpected operational disturbances in the facility [1].

2.6 Establish a Revised Processing Capacity of Facility Based on Proposed Process or Operational Modifications

The whole facility was reevaluated for revised processing capacity based on proposed modifications. During this step, most limiting figures of oil, water and gas are considered for the equipment which will define the overall capacity of facility. It was established that, whole facility is capable to process X + 32 MBOPD oil with 45% water cut and with GOR of 600. All equipments are capable to process even more oil and water, but the limitation of X + 32 MBOPD is based on max. possible processing capacity of desalter and limitation 45% water cut is from separation capacity of oil and gas separator/wet tank. The limitation for gas handling capacity is based on limitation of gas export pipeline [1].

2.7 Implement Modifications Once the Viability Is Confirmed

The main modification of change in control loop of separator was implemented after complying company procedure of management of change. The formal study was conducted to evaluate any adverse impact on separation operation due to this modification. The study and review was jointly conducted by engineers from production operations team, technical services team, maintenance team and health, safety & environment team. The change was mainly related to logic configuration change on DCS (distributed control system) so there was no major cost or time impact due to this physical change.

There was no physical change in desalter unit, so it was decided to test desalter at higher capacity during performance test. The actual test was critical for desalter to ensure actual capability of these units to handle higher crude oil flow and also to ensure all quality parameters of salt in crude oil and BS & W (base sediments & water) are met.

2.8 Carry out Separate Performance Testing of Each Equipment at Higher Established Capacity

The next step is to verify findings of study by conducting actual field tests. It is recommended to carry out performance tests of each equipment in isolation to ensure each of these equipment is capable of processing higher flow of oil, water and gas. This will also eliminate the risk of any major problem in facility, if a limitation is faced during testing, as only one or two equipments will be processing higher flow rates of fluid. It is required to record all performance parameters while testing to ensure smooth operation of equipment within operating envelop meeting all quality requirements. It shall be ensured that, no design margin of any equipment or piping is utilized during performance testing. The testing shall be started only after proper planning is done and required coordination between all concerned teams is established.

2.9 Carry out Performance Testing of Complete Gathering Center and Revise the Name Plate Capacity

The complete testing of whole facility will start once individual testing of each equipment is successfully completed, and the results show no limitation in any of the equipment or piping. If the results show any limitation during testing of individual equipment, then the study report shall be revisited for necessary amendments based on actual observations made during testing. It will also require to identify the bottleneck area in the system which was not identified during study phase. A detailed analysis is required to be conducted to find any option to eliminate this bottleneck. The option shall be implemented and again performance testing shall be carried out. If we cannot find any option to eliminate bottleneck then the capacity of this equipment and whole facility shall be revised for new figures. In brief, all steps from step B to step H shall be carried out again.

In our case, the whole facility shall be tested at required production level (e.g., X + 32 MBOPD) to confirm capability of complete facility to process X + 32 MBOPD with 45% water cut. It is also required to record all performance parameters while testing to ensure smooth operation of facility within operating envelop meeting all quality requirements. The name plate capacity can be revised after successful completion of testing of whole facility.

3. Conclusions

It is concluded that, most of the oil and gas facilities have potential to increase its name plate capacity (without utilizing design margin) in the early years of facility operation, when the forecasted figures of higher water cut, etc. are not realized, by implementing minor modifications and utilizing operational flexibilities available in the facility. Such innovative approach will result in significant financial/production gains for any organization.

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