Structural Analysis and Design of Crude Oil Desalination Plant

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Abstract- *With oil field development, formation water may be extracted with crude oil, and itmay reach 90% of producing fluid in water flood field. So solving the crude oil dehydration problem is very important. In addition, when the oil and the water is extracted, large amount of salts from the formation also carried out, such as chloride, sulfate, carbonate, etc. And these salts tend to be dissolved in water, so the crude oil processing system needs both dehydration and desalination Crude oil will corrode the equipment and pipelines and make them scale. The saltsthat are most frequently present in crude oil are calcium, sodium and magnesium chlorides.If these compounds are not removed from the oil several problems arise in the refining process.Desalination is a process of removal of salts, solids and water from the crude oil which is excavated freshly.*

Keywords- Crude oil, Desalination plant, Structural Analysis.

I. INTRODUCTION

With oil field development, formation water may be extracted with crude oil, and it may reach 90% of producing fluid in water flood field. So solving the crude oil dehydration problem is very important. In addition, when the oil and the water is extracted, large amount of salts from the formation also carried out, such as chloride, sulfate, carbonate, etc. and these salts tend to be dissolved in water, so the crude oil processing system needs both dehydration and desalination.

Crude oil will corrode the equipment and pipelines and make them scale. The salts that are most frequently present in crude oil are calcium, sodium and magnesium chlorides. If these compounds are not removed from the oil several problems arise in the refining process.

Crude oil desalination is the importance process has to carry out during the processing of crude oil. Benefits of crude oil desalination is given below,

- Increase crude throughout
- Better corrosion control in CDU overhead
- Less erosion by solids in control valves, exchanger, furnace, pumps
- Saving of oil from slops from waste oil

The primary function of a production facility is to separate the product from the wells into saleable products and dispose of the rest in an environmentally friendly manner. Figure 1 shows a typical schematic of oil and gas production.

Desalting process:

Desalting is a process whereby fresh water is mixed with the crude oil. The fresh or low salinity water dissolves crystalline salt in the oil or dilutes the entrained produced salt water. When the oil is dehydrated, any entrained water left in the oil will be less salty, thus reducing the crude oil's salt content (PTB) to specification. This is the basic approach used by all field desalting system.

The desalting process is completed in following steps:

- Dilution water injection and dispersion
- Emulsification of diluted water in oil
- Distribution of the emulsion in the electrostatic field
- Electrostatic coalescence
- Water droplet settling

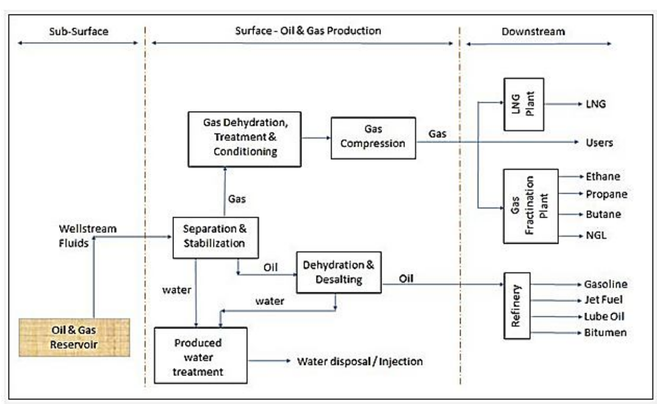


Fig 1.1 Typical oil and gas production schematic.

A desalting unit can be designed with single stage or two stages. In the refineries, the two stages desalting system is normally applied, that consists of 2 electrostatic Coalescers (Desalter).

Following type of separators are generally used in the industry:

- **Two Phase Separator;** A two phase separator is used to separate well fluids into gas and liquid mixtures.
- **Three Phase Separator:** This type of separator is used when the expected outlet streams are gas, oil / condensate, and water.

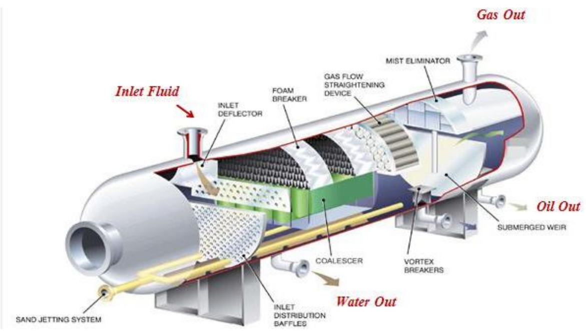


Fig 1.2 Typical three phase separator with internals.

Separator can be either horizontal or vertical configuration,

- Horizontal separator: Horizontal separator is preferred for low Gas Oil Ratio well fluids and three phase separation. Table below shows the advantages and disadvantages of horizontal separators
- Vertical separator: Vertical separator is preferred high GOR well fluids and two phase separation Table below shows the advantages and disadvantages of vertical separators.

Production separators of all types are sized according to the following parameters, to suit product specifications:

- Fluid flow rates
- Operating Pressure and Temperature
- Oil in Water Specification (500-1000 ppm)
- Water in Oil Specification (1-3% vol)
- Liquid losses to vapor stream (subject to demister type)
- Liquid droplet size in gas outlet (150 microns and larger droplets can be removed when internals are not used)

At the design stage of crude oil separation train, an increased water production should be considered. Separators must be sized for the worst operating case, or alternatively, adjustments may be made to existing separator internals and level control set points in order to change the hold-up times of the two phases.

STRUCTURAL ANALYSIS OF THE ONSHORE CRUDE OIL DESALINATION:

For the analysis of offshore structure preliminary requirement is to study the process involved the design. From the best suitable layout is selected and the loads coming on the structure are selected. And also the material to be used in the construction can be finalized. Then the appropriate structural system is selected. Initial member size is selected and analysis is carried out to calculate the force on the structure. The design is carried out if any material are failed and connection design is done.

Analysis of the onshore Crude oil Distillation plant is very complex since the various loads have to be considered in the analysis. The dead weight of the equipment such as structural weight of equipment’s has to be considered in the operating and no operational condition. And also since the structure in the onshore the wind load has to be considered.

For the design requirements of the onshore crude oil platforms the IS-800:1984 guidelines and certain company standards in the oil industry are followed.

OBJECTIVE OF THE STUDY:

1. Study the desalination of the crude oil
2. Prepare the layout of the crude oil desalination plant
3. Modeling of the desalination plant considering the load from the different component and environment loading
4. Analysis of the structural System
5. Design of the member as per IS-800:1984 codal requirement

II. LITERATURE SURVEY

E. Aryafarda, M. Farsia, M.R. Rahimpoura, ,S. Raeissia”,Modeling electrostatic separation for dehydration and desalination of crude oil in an industrial two-stage desalting plant”

In this study a mathematical model to predict water and salt separation efficiencies in an industrial two stages crude oil desalting process. The considered process consists of mixing valve and electrostatic drums connected in series. The simulation result shows that increasing flow rate of fresh water from 3% to 6% decreases salt content in the treated crude oil from 2.06 to 0.71 PTB.

Ayman M. Atta Electric Desalting and Dewatering of Crude Oil Emulsion Based on Schiff Base Polymers as Demulsifier

The effect of electric desalting on dewatering process was studied in this paper. Some surfactants are used as demulsifiers for destabilization of emulsions of crude petroleum. They have developed new Schiff base polymers for such use; their chemical structures were determined by FTIR and 1H NMR. The solvent mixture improves the diffusion of the molecules of the Schiff bases in the petroleum phase of the emulsion and acts as a co-additive.

Juan Pereira, Ingrid Velasquez, Ronald Blanco, Meraldo Sanchez, Crude Oil Desalting Process

In this paper, Desalting is a water-washing operation performed initially at the production field and thereafter at the refinery site for additional crude oil cleanup. Salt and water content specifications are even more rigid because of their negative effect in downstream processes due to corrosion, and catalyst deactivation. All formulation parameters, such as solvent, alcohols, kind and concentration of demulsifier, among others, can be explained for proportional and saturation regimens.

III. MODELLING

The system for the desalination of crude oil is selected in the present work is two phase separator. The flow chart of the process is given below. This arrangement is taken into the consideration and the modelling of the structure is made in the STAAD Pro.

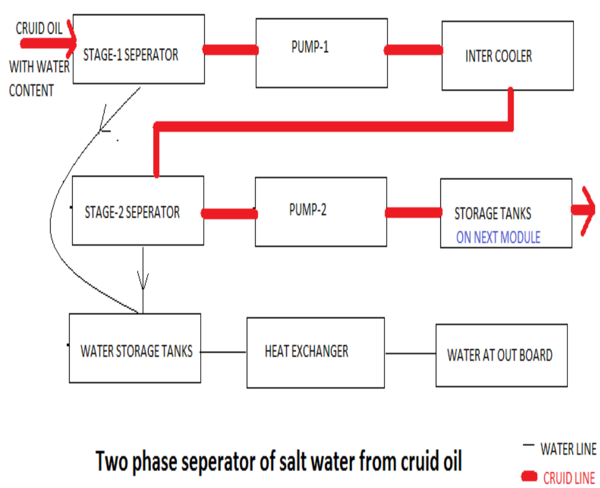


Fig 3.1 Process of the plant.

MATERIALS:

Structural Steel Material has been adopted in the Design are listed in Table .

For Structural analysis purpose of plates and rolled sections, thickness less than 16mm are considered a yield strength of 345N/mm2 and thickness greater than or equal to 16mm are considered a yield strength of 325N/mm2.

For structural steel the material properties are assumed as follows.

- Density : 7850 kg/m3
- Young's Modulus, E: 208000 N/mm2
- Shear Modulus, G : 80000 N/mm2
- Poisson's Ratio: 0.3
- Coefficient of Thermal Expansion
  0.0000117 (°C)-1
- Friction Coefficient (steel to steel),m 0.3

Table 3.1: Material Types and Properties.

Member Type	Thickness	Minimum Yield Strength
	t (mm)	MPa
S (50J @-40)	t<25	355
	25≤t≤40	345
	40<t<63	335
Primary Members	t≤16	355
	16≤t≤40	345
	40<t<63	335
Secondary Members	t≤16	355
	16≤t≤40	345
	t≤40	265

MODEL GEOMETRY DESCRIPTION:

The structure consists of N-1three-dimensional full welded rigid steel bearing cage frame. The overall model Dimensions are 22m in Length, 15.4m in Width and 14m in Height.

The Primary & Secondary structures consist of hot rolled steel flanged sections shape beams. Major process equipment's supported by the module structure include Separators, Intercoolers, pumps etc. The configurations of the structure are shown in the Fig 3.1 and 3.2. The structure is analyzed to ensure the integrity of all the installed equipment under the loads and actions generated in the operating condition as per IS code Standards. The primary and secondary beams are placed to primarily support the equipment's as well as to support the grating which are used for providing support to the access ways.

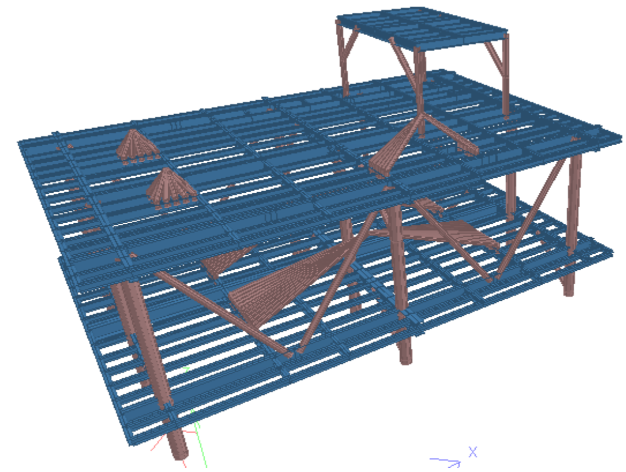


Fig 3.2 Desalination plant 3D Model.

ORIGIN OF COORDINATES:

Table 1.2 shows the local co-ordinate system used in STAAD.

Table 1.2: Local Co-Ordinate System.

	Axis	Direction
X	Longitudinal axis	Towards Bow
Y	Transverse axis	Starboard (SB) to Portside (PS)
Z	Vertical axis	Vertically upward from ship's bottom (keel)

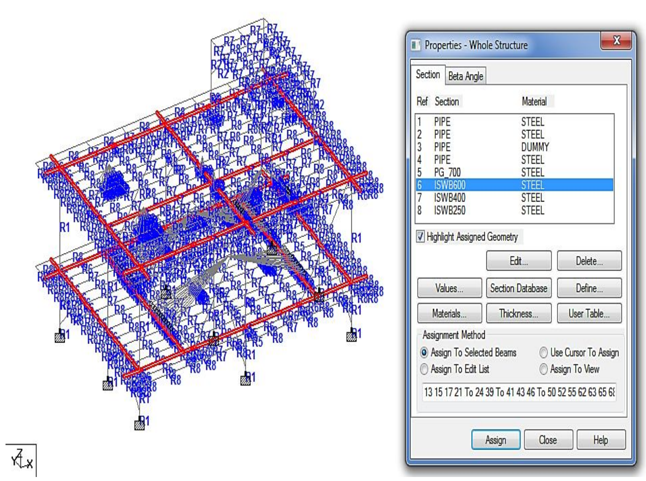
SUPPORT CONDITIONS:

Boundary conditions for structure as shown,

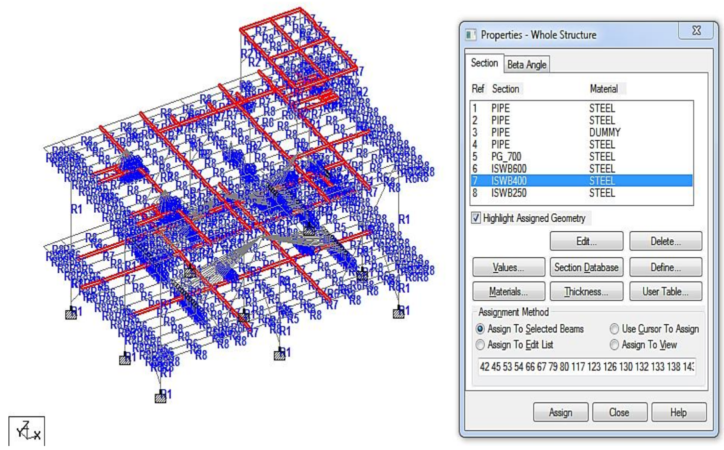
Support Indication	Support Condition
	Fixed connection

SECTION PROPERTIES:

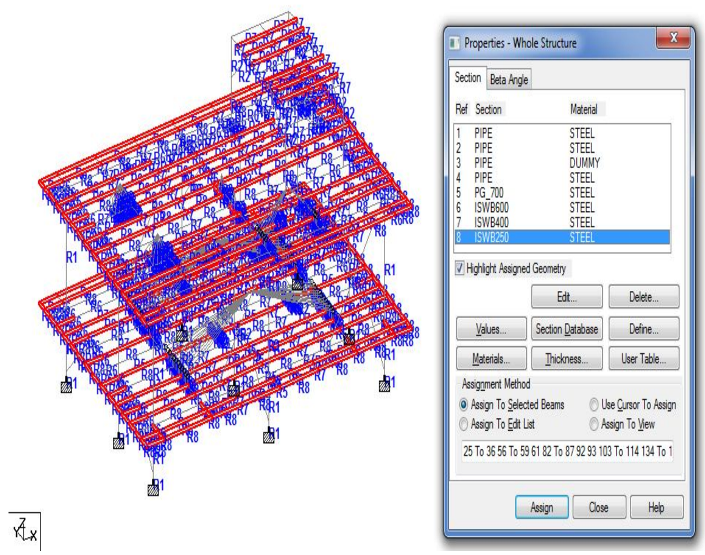
1. ISWB600



2. ISWB400



3. ISWB 250



IV. ANALYSIS AND RESULT

The structure is analysed for the load cases and load combination for the operating condition to know the critical forces in the member. The members are designed as per IS800 for the conservative design. The result of the analysis and design are summarized in the chapter

RESULT SUMMARY

The maximum forces developed in the member for different load combination (L/C) are tabulated below. The figure shown below represent the member forces such as bending, shear and axial forces for the critical load combinations.

Table 4.1 Maximum forces in the member

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	2234	116	1314	1587.05	145.96	3.10	1.13	-6.13	154.07
Min Fx	1583	117	983	-460.28	0.89	-195.95	0.02	129.25	0.11
Max Fy	1225	116	941	717.36	340.28	1.07	0.00	-0.54	170.14
Min Fy	5	116	3	1235.40	-373.60	-10.03	-0.39	-23.30	-17.75
Max Fz	70	118	48	-1.36	5.74	466.63	-0.24	-1303.17	13.50
Min Fz	319	118	1277	298.45	3.08	-917.41	1.45	-630.37	-1.52
Max Mx	1	118	2	693.50	-131.85	-0.21	6.07	-1.51	78.94
Min Mx	318	117	184	121.71	1.64	-333.44	-5.34	-169.72	0.13
Max My	1258	117	52	6.69	0.69	367.56	-0.08	1397.29	-2.39
Min My	72	118	48	-0.38	-9.59	-504.35	0.25	-1303.18	20.13
Max Mz	2234	118	1314	1551.96	190.58	2.06	1.41	-4.97	218.49
Min Mz	2237	118	1277	1539.08	190.58	2.06	1.41	0.92	-325.63

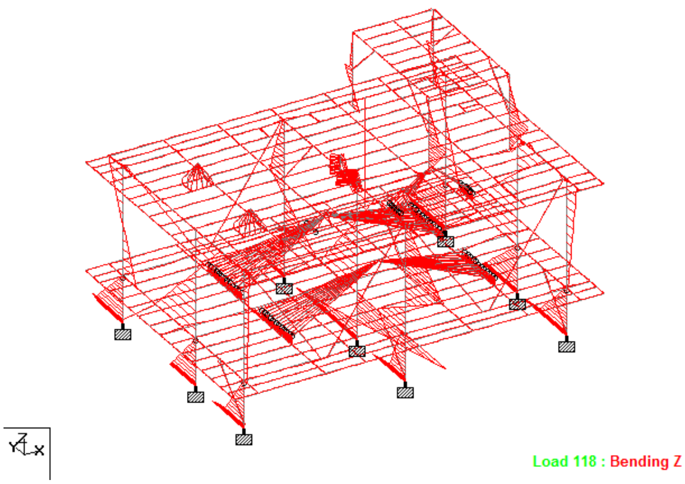


Fig 4.1 Variation of Bending Moment Mz for(L/C 118)

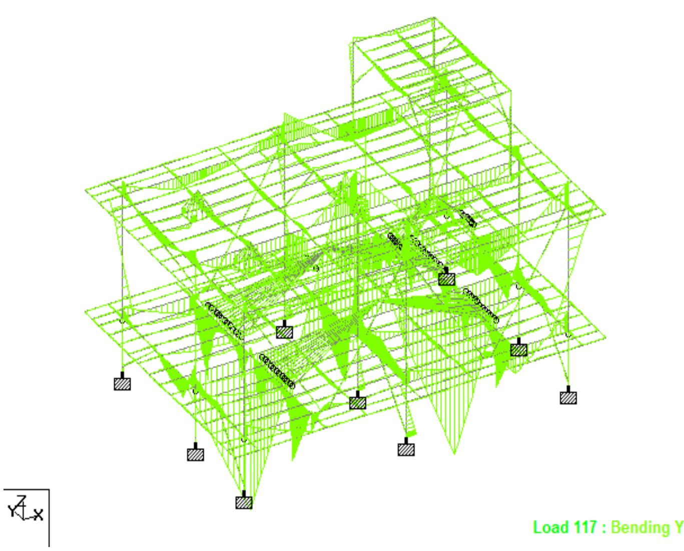


Fig 4.2 Variation of Bending Moment My for(L/C 117)

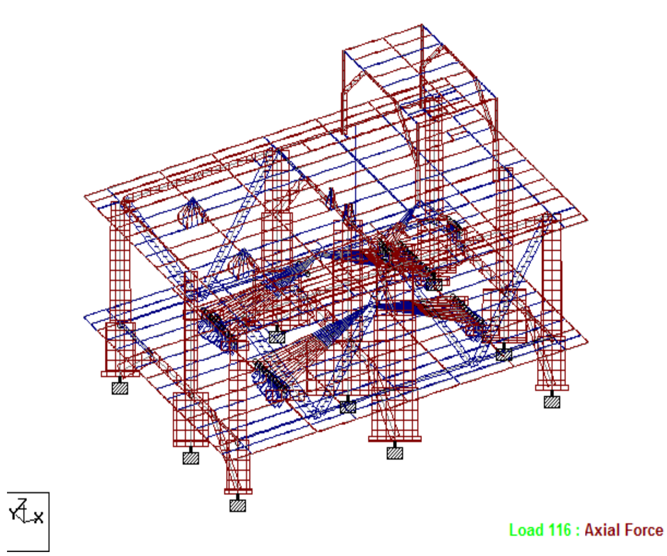


Fig 4.3 Variation of Axial force Fx (L/C 116)

Table 4.6 of Node Displacement Summary

			Horizontal		Vertical	Resultant
	Node	L/C	X mm	Y mm	Z mm	mm
Max X	1261	102	11.059	-2.665	-4.983	12.419
Min X	1262	117	-17.496	-5.199	-6.361	19.329
Max Y	940	108	4.119	3.147	-5.428	7.505
Min Y	1201	118	-3.234	-12	-5.237	13.486
Max Z	351	118	-0.002	-1.314	6.598	6.728
Min Z	949	118	0.088	-1.077	-14.09	14.131

V. RESULTS AND CONCLUSION

Desalination is the important operation in refining of crude oil. In this project the structural model of the desalination plant is modeled and analyzed for the different forces acting on it. After analysis the modeled is designed for the forces acting on the structure.

The analysis is done using STADD Pro and the design is done as per S 800-1984. And it is concluded that ,the structural strength and stiffness of the total steel structure is suitable and sufficient to withstand all prescribed conditions.

The stress levels developed in the structure are within the envelope specified by the applicable rules. The Nodal displacements for serviceability conditions are checked and the values are within allowable limits.

VI. CONCLUSION

The study shows the efficiency of a new desalting apparatus developed for heavy oils and this process consists on various washing steps of the oil. It was found that desalination in various steps is efficient and that there was no significant loss of organic compounds during the process. It was required from three to four washes of the oil to reduce their salt content to values around 329 mg per kg in sodium chloride.

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