A PROJECT REPORT

ON

"DESIGN OF FLOATING ROOF TYPE CRUDE OIL MAIN STORAGE TANK FOR STORAGE OF BOMBAY HIGH OFFSHORE TYPE OF HIGH WAXY CRUDE OIL"

Submitted by

SHAIKH MUBARK ALI	**13ME53**
VAIBHAV TIWARI	**13ME60**
FEROZ SHAIKH	**13ME47**
NITISH YADAV	**13ME63**

In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

PROF. SV RANADE

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

UNIVERSITY OF MUMBAI

ACADEMIC YEAR 2016 - 2017

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL

(Approved by AICTE, recg. By Maharashtra Govt. DTE,

Affiliated to Mumbai University)

PLOT #2&3, SECTOR 16, NEAR THANA NAKA, KHANDAGAON, NEW PANVEL,NAVI MUMBAI-410206,
Tel.: +91 22 27481247/48 * Website: www.aiktc.org

CERTIFICATE

This is to certify that the project entitled

"DESIGN OF FLOATING ROOF TYPE CRUDE OIL MAIN STORAGE TANK FOR STORAGE OF BOMBAY HIGH OFFSHORE TYPE OF HIGH WAXY CRUDE OIL"

Submitted by

SHAIKH MUBARAK ALI	**13ME53**
VAIBHAV TIWARI	**13ME60**
FEROZ SHAIKH	**13ME47**
NITISH YADAV	**13ME63**

To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

Internal Examinar — (Prof.)

External Examiner — (Prof.)

Head of Department — (Prof.)

Principal — (Dr.)

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL

(Approved by AICTE, recg. By Maharashtra Govt. DTE,

Affiliated to Mumbai University)

PLOT #2&3, SECTOR 16, NEAR THANA NAKA, KHANDAGAON, NEW PANVEL,NAVI MUMBAI-410206,
Tel.: +91 22 27481247/48 * Website: www.aiktc.org

APPROVAL OF DISSERTATION

This is to certify that the thesis entitled

"DESIGN OF FLOATING ROOF TYPE CRUDE OIL MAIN STORAGE TANK FOR STORAGE OF BOMBAY HIGH OFFSHORE TYPE OF HIGH WAXY CRUDE OIL"

Submitted by

SHAIKH MUBARAK ALI	**13ME53**
VAIBHAV TIWARI	**13ME60**
FEROZ SHAIKH	**13ME47**
NITISH YADAV	**13ME63**

In partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering, as prescribed by University of Mumbai approved.

(Internal Examiner) **(External Examiner)**

Prof. Zakir Ansari ____________________

Date: __________

ACKNOWLEDGEMENT

After the completion of this work, we would like to give our sincere thanks to all those who helped us to reach our goal. It's a great pleasure and moment of immense satisfaction for us to express my profound gratitude to our guide **Prof. (000000)** whose constant encouragement enabled us to work enthusiastically. His perpetual motivation, patience and excellent expertise in discussion during progress of the project work have benefited us to an extent, which is beyond expression.

We would also like to give our sincere thanks to Head Of Department, **Prof. Zakir Ansari** and Prof. **Rizwan Shaikh** from Department of Mechanical Engineering, Kalsekar Technical Campus, New Panvel, for their guidance, encouragement and support during a project.

I am thankful to **Dr.Abdul Razzak Honnutagi** , Kalsekar Technical Campus New Panvel, for providing an outstanding academic environment, also for providing the adequate facilities.

Last but not the least I would also like to thank all the staffs of Kalsekar Technical Campus (Mechanical Engineering Department) for their valuable guidance with their interest and valuable suggestions brightened us.

SHAIKH MUBARAK ALI 13ME53
VAIBHAV TIWARI 13ME60
FEROZ SHAIKH 13ME47
NITISH YADAV 13ME63

ABSTRACT

This project includes the designing of the floating roof tank and impeller in order to restrict the sludge formation inside the tank for storage of hard waxy crude oil. This crude oil results in settling when left undisturbed for longer duration which results in causing of the hard sludge. This sludge thus formed is then removed by cleaning which brings many hazardous situation in play. In order to restrict this, impellers ability to create disturbance inside the tank is studied on ansys fluent cfd. Side entry impeller is an efficient converter of energy into fluid motion. Unlike jet mixer systems, they do not suffer significant energy losses at the pump, in the pipework, in the bends, or most significantly, at the jet nozzles. In addition, capital costs are lower and access to in-tank components is not restricted, while the problem of frequent, urgent maintenance on tanks that must be emptied and cleaned, is eliminated.

Side Entry impellers are also more efficient than top entry impellers, and are significantly less expensive for larger diameter tanks. Side Entry mixers are ideal for use on tanks with floating roofs where practical considerations preclude the use of top entry mixers. To control or prevent the accumulation of bottom sludge and water pockets (BS&W) especially in crude oil storage tanks at refineries, or terminals. High velocity circulation is necessary to scour completely the bottom of the tank by maintaining the heavy solids, water and corrosive salts in suspension. The developed jet flow is used to lift the BS&W into the body of the crude oil to maintain a relatively clean tank floor.

TABLE OF CONTENTS

Abstract…………………………………………………………...v

Table of content……………………………………………...vi

List of tables ……………………………………………..vii

List of figure…………………………………………….viii

Chapter 1: Introduction……………………………………1

1.1 General……………………………………………………………………...1

1.2 Motivation…………………………………………………………………….3

1.3 Importance…………………………………………………………………….3

1.4 Organization of report……………………………………………………………4

1.5 Special Credits…………………………………………………………………...4

Chapter 2: Literature Review…………………………………………………….5

2.1General………………………………………………………………………….5

2.2 Literature Reviews…………………………………………………………..5

2.3 Aim of the project…………………………………………………………..13

2.4 Objective……………………………………………………………………….13

2.5 Scope…………………………………………………………………………..13

Chapter 3: Methodology…………………………………14

2.1 General……………………………………………………………………...14

2.2 Use of solid works 2015……………………………………………………14

2.3 Use of ansys fluent cfd ……………………………………………………..17

Chapter 4: Case study…………………………………………………20

2.1 General…………………………………………………………………..20

2.2 Design of tank…………………………………………………………….20

2.3 Design of impellers……………………………………………………….23

Chapter 5: Conclusion……………………………………………25

5.1 General…………………………………………………………………….25

5.2 Propeller velocity vector………………………………………………….26

5.3 Streamline in the tank…………………………………………………….26

5.3.1 Case 1 height of 3m……………………………………………………..27

5.3.1 a) Velocity vector in tank………………………………………………..

5.3.2 Case 2 height of 6m……………………………………………………..28

5.3.2 a) Velocity vector ……………………………………………………….

5.3.3 Case 3 height of 9m……………………………………………………..30

5.4 Comparing of the results with standard ………………………………….31

References…………………………………………………………..32

List of tables

Table 2.1…………………………………………………………………..12

List of Figures

Sr NO.	Fig No.	Fig Name	Page No.
1	1.1	Fire accidents	3
2	1.2	Fire accidents	4
3	2.1	Types of tank	6
4	2.2	Single deck roof	7
5	2.3	Double deck roof	7
6	3.1	Impeller model	15
7	3.2	Tank model	15
8	3.3	Tank domain	18
8	3.4	Tank meshing	19
10	3.5	Impeller enclosure	19
11	3.6	Impeller mesh	20
12	5.1	Velocity vector of impeller	25
13	5.2	Velocity profile	25
14	5.3	Streamline flow at height 3m	26
15	5.4	Velocity vector at height 3m	27
16	5.5	Vertical view of flow	27
17	5.6	Streamline flow at height 6m	28
18	5.7	Velocity vector at height	29

		6m	
19	5.8	Velocity vector at height 9m	30
20	5.9	Streamline flow at height 9m	30
21	5.10	Vertical view of flow	31

Chapter 1

1. Introduction

1.1. General

Floating roof tank is not a new technology or equipment's and it had been widely used over the world in many industries. Storage tanks are designed, fabricated and tested to code and standard. There are a variety of codes and standards stating the similar common minimum requirements and some additional requirements from company standards or specifications.

Engineer or tank designer who do the preliminary and detail design are normally not familiar or not exposed to the actual site condition. Their designs are basically based on the code and standard requirements and basic theory from reference book. Some would only rely on the commercial software for the basic design, they have limited knowledge on the actual tank operation which limit them on cost effectiveness and even safety detail design, particularly on the floating roof tank.

There is limited procedure and rules in design the floating roof. These had resulted lots of floating roof failure in the industry. Hence industry, tank owner and also the tank designer or engineer need to have a simple rules and formula to ensure the floating roof is adequately designed and strong enough for the various loading during operation.

Beside of the procedures and rules, understanding of how the stresses behave in the tank material is essential for a complete safe design.

Floating roof tanks are usually built in a gigantic size and this would involve various disciplines such as civil, chemical, mechanical, fire safety, construction, inspection, commissioning and operation.

The work scope of each disciplines would have a direct effect on the tank design, one example is the tank foundation which is designed by the civil staff. The foundations are to be designed to withstand the load of the tank with its content. Improper design would result in foundation sagging or excessive soil settlement which in turn induces extra stresses to bottom of tank and tank shell.

Hence it is essential for the engineers or tank designer to know how and what effects each inter-discipline’s design would have on one’s tank that affected the tank integrity, and taking all these consideration into his design.

1.2 Motivation

It has been seen in cases that floating roof tanks are facing huge problem of sludge formation inside the tanks which becomes hazardous to the safety of the tank and working personal. The basic removal steps involve tank cleaning which brings various type of risks. Many dangerous situations can occur during tank cleaning and working in confined spaces such as hazards like ignition, chemical exposure, oxygen deficiency, physical hazards etc. Tank cleaning is an extremely hazardous activity. When working in a confined space personnel are exposed to a number of hazards that in some cases have led to injury or even death. The cleaning of a tank having contained a flammable material presents specific hazards. If a flammable mixture of vapor and air exists inside a tank, then the introduction of a source of ignition may cause a fire and explosion. Whenever we remove the manways on a tank containing flammable material, the hydrocarbon rich vapor within the tank becomes diluted with air and the mixture approaches the flammable zone. It is imperative that we eliminate any potential source of ignition. Beware that in tanks where sludge or scale is present, disturbing the sludge on man-entry can release trapped vapors. This may cause the atmosphere to re-enter the flammable zone. In some cases toppling of roof inside the tank is also seen which becomes more dangerous as the tank has the capacity of 60000 In order to make environment safe we had took steps to restrict sludge formation.

1.3. Importance

Design and safety concern has come to a great concern as reported case of fires and explosion for the storage tank has been increasing over the years and these accident cause injuries and fatalities. Spills and tank fires not only causing environment pollution, there would also be severe financial consequences and significant impact on the future business due to the industry reputation. Figure 1.1 shows the accident of the tanks that caught on fire and exploded. Lots of these accidents had occurred and they are likely to continue unless the lessons from the past are correctly learnt.

Fig 1.1: Fire incidence in tank

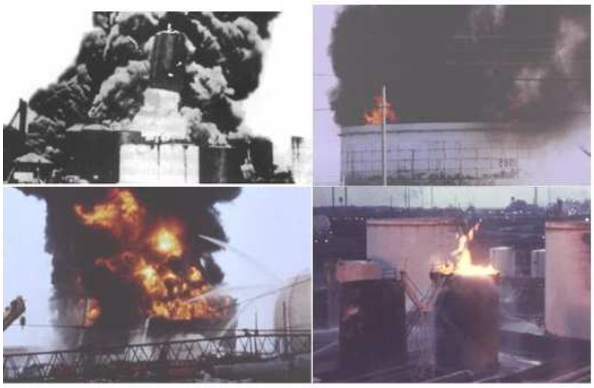

Figure 1.2: Fire Incidence in Tank

1.4. Organization of report

The report is organized as follows. Chapter 1 presents a brief introduction highlighting the study, chapter 2 presents most vital backbone of the project, chapter 3 presents methodology adopted and chapter 4 presents a case study. Finally concluding remarks and suggestions are mentioned in chapter 5.

1.5. Special Credit

It gives immense pleasure to acknowledge and express our sincere gratitude to Mr. SV Ranade professor AIKTC new Panvel for giving us the whole project idea. The study presented here is carried under his supervision. We are deeply indebted towards him for his kind support and valuable guidance during the entire work.

CHAPTER 2

2. Literature Review

2.1 General

Here in this chapter we will be discussing about floating roof tanks, its types, types of decks, literature review of the project.

2.2 Literature Review

Storage tanks had been widely used in many industrial established particularly in the processing plant such as oil refinery and petrochemical industry. They are used to store a multitude of different products. They come in a range of sizes from small to truly gigantic, product stored range from raw material to finished products, from gases to liquids, solid and mixture thereof.

There are a wide variety of storage tanks, they can be constructed above ground, in ground and below ground. In shape, they can be in vertical cylindrical, horizontal cylindrical, spherical or rectangular form, but vertical cylindrical are the most usual used.

In a vertical cylindrical storage tank, it is further broken down into various types, including the open top tank, fixed roof tank, external floating roof and internal floating roof tank.

The type of storage tank used for specified product is principally determined by safety and environmental requirement. Operation cost and cost effectiveness are the main factors in selecting the type of storage tank.

2.2.1 TYPES OF STORAGE TANK

Figure 1.3 Shows the following types of tank are used in industry.

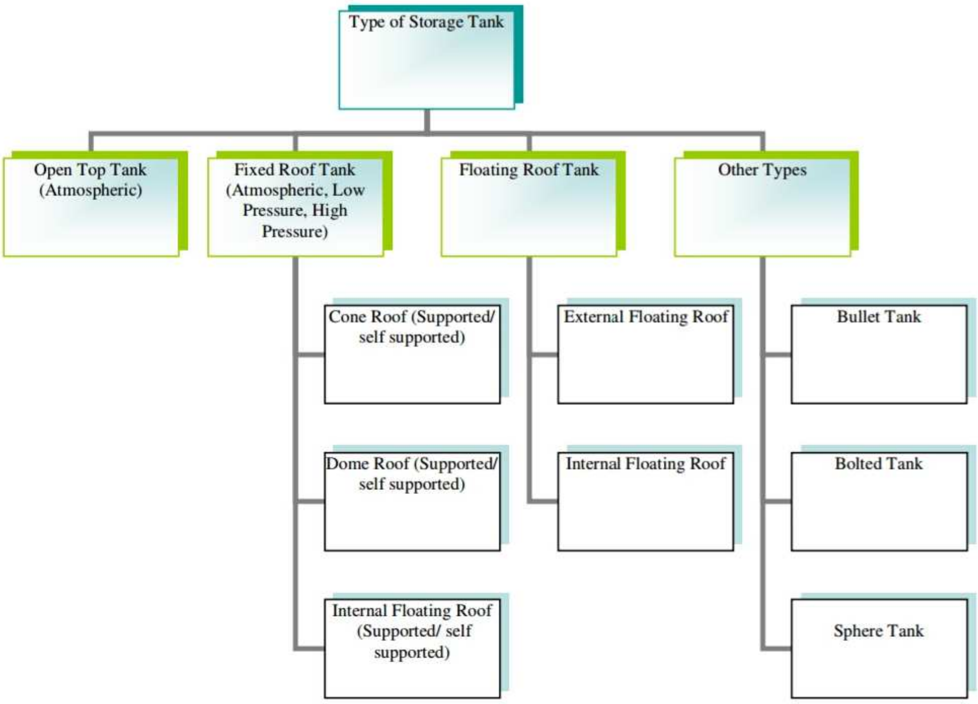

Figure 2.1: Types of Tank

2.2.2 Floating Roof Tanks

Floating roof tanks is which the roof floats directly on top of the product.

There are 2 types of floating roof:

Internal floating roof is where the roof floats on the product in a fixed roof tank.

External Floating roof is where the roof floats on the product in an open tank and the roof is open to atmosphere.

Types of external floating roof consist of:

Single Deck Pontoon type (Figure 2.2)
Double deck (Figure 2.3)

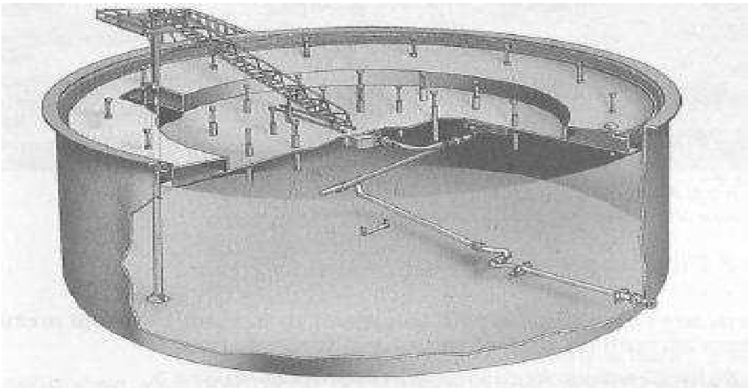

Figure 2.2: Single Deck

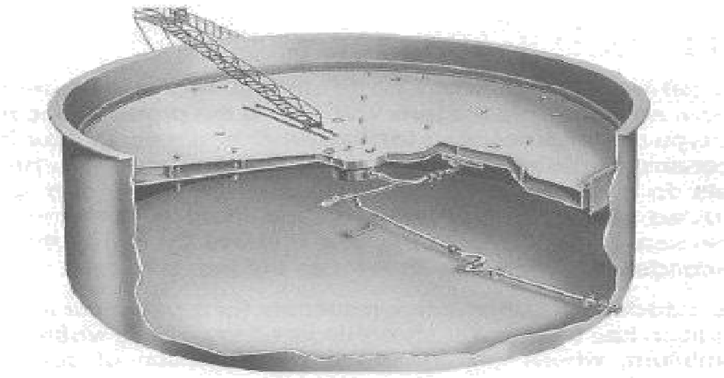

Figure 2.3: Double Deck Type Floating Roof

Floating roof tank was developed shortly after World War I by Chicago Bridge & Iron Company (CB & I). Evaporation of the product in fixed roof caused a great loss of money; this led to research to develop a roof that can float directly on the surface of product, reducing the evaporation losses.

The floating roof is a circular steel structure provided with a built-in buoyancy which allowing it to sit/ float on top of the liquid product in a close or open top tank.

The overall diameter of the roof is normally 400 mm smaller than the inside diameter of the tank, which has about 200 mm gap on each side between the roof and the inside tank wall. This is due to the limitation on the accuracy of dimension during construction for the large diameter tank. The gaps allow the floating roof to rise and fall without binding on the tank wall.

To protect the product inside the tank from evaporation to the atmosphere and contamination from the rain water through the gaps between the outer rim of the floating roof and the tank wall, the gaps will be closed or sealed up by mean of flexible sealing system.

Due to environmental issue, selection of the roof seal is one of the major concerns in the floating roof tank design.

In single deck roof which shown in Figure 1.6, is also called pontoon roof, the buoyancy is derived in the pontoon, an annular circular pontoon radially divided into liquid tight compartments.

The center deck which is formed by membrane of thin steel plates are lap welded together and connected to the inner rim of the pontoons.

Double deck roof consists of upper and lower steel membranes separated by a series of circumferential bulkhead which is subdivided by radial bulkhead. The outer ring of the compartments is the main liquid tight buoyancy for the roof.

Double deck roof is much heavier than single deck one, hence it is more rigid. The air gap between the upper and bottom plates of the deck has insulation effect which helps against the solar heat reaching the product during the hot climate and preventing heat loss of the product during cold climate.

As the roof floats directly on the product, there is no vapour space and thus eliminating any possibility of flammable atmosphere. It reduces evaporation losses and hence reduction in air pollution. Vapour emission is only possible from the rim seal area and this would mainly depend on the type of seal selected and used.

Despite of the advantages of the floating roof, to design and construct a floating roof tank will be much more complicated and costly than the fixed ones. In term of tank stability and design integrity, floating roof tank is never better than the fixed roof tank as there are still many unknown parameters and factors in designing the floating roof.

2.2.3 Process Description and Requirements

Capacity determination is the one of the first steps in designing the tank. Only after the capacity is known, the tank can be sized up.

The maximum or total capacity is the sum of the inactive capacity (minimum operating volume remaining volume in tank), actual or networking capacity and the overfill protecting capacity.

The net working capacity is the volume of available product under normal operating conditions, which is between the low liquid level (LLL) and the high liquid level (HLL).

The storage tank capacity is sized in accordance with --------barrel tanker and 3 days of unavailability of the offloading system at production rate -------barrels per day.

2.2.4 Material Selection and Corrosion Assessment

Material selection study was carried out by the material specialist to review the conceptual design basic of the plant and assess expected longevity of materials for various piping and equipment, he/she then proposes materials suitable for the required design life of 30 years. The approach of this material selection is to evaluate the internal corrosivity of the fluids with respect to utilization of carbon steel.

Carbon Steel is considered as first choice, due to its lower cost, ready availability and well understood requirements to fabrication and testing. Material selection for the hydrocarbon system is based on detail evaluation of fluid properties, particularly using the carbon dioxide models.

Carbon dioxide dissolves in water and dissociates to form weak carbonic acid which causes corrosion on carbon steels. Higher partial pressures of CO_2 imply more dissolved CO_2 and hence higher corrosion rate. Higher temperatures and pressure increase the corrosion rate, but in certain conditions, about 70 to 80°C, a protective carbonate scale can form on the steel surface that reduces the corrosion rate, compared to lower temperatures where the scale does not form.

Corrosion resistant alloys (CRA) are used to avoid corrosion at high CO_2 contents, and in less corrosive condition and where required lifetime is limited, but it would be more economical to use carbon steel with a corrosion allowance and/or chemical inhibitor treatment. The presence of CO_2 infers that carbon steel will have finite life due to the wall thinning, a corrosion allowance is practical to accommodate up to 6mm.
Other concerns for the material selection are:

- Material at minimum temperature
    - At low temperatures, ferritic steels (unalloyed and low alloy steels, and ferrictic-austenitic duplex stainless steels), lose their ductility spontaneously as the materials are cooled, allowing any cracks and crack-like defects, that are harmless at normal operating temperatures, to propagate under load.
    - To have greater resistance to low temperature embrittlement, materials and welds are to be heat treated where applicable eg. normalised and post weld

heat treated low alloy and carbon steel). For an even lower service temperature, fine grained materials are required, high nickel steels, or austenitic materials have to be used.

- The seasonal changes in ambient temperatures require that low temperature properties of materials must be selected.
-

- Mercury

  - Stabilised condensate from Turkmenistan was measured to contain Hg 4μg/kg. [13]
  - Mercury (Hg) is a trace component of all fossil fuels. It is therefore present in liquid hydrocarbon and natural gas deposits, and may transfer into air, water and soil.
  - Materials unsuitable for hydrocarbon streams in presence of mercury due to liquid metal embrittlement, which will result in crack are:

    Aluminium and Aluminium Alloys

    Titanium and Titanium Alloys

    Copper and Copper Alloys

    Zinc and Zinc Alloys

  Recommended materials are:

    Carbon steels and low allow steels

    Stainless steels (Austenitic stainless steel, Duplex stainless steel)

    Nickel Alloys (Inconel 625, 825 and Monel)

2.2.5 Carbon Dioxide Corrosion Modeling

In the material selection study report, the design corrosion rate for carbon steel was calculated using the NORSOK "CO2 Corrosion Rate Calculation Model" - M-506" [14]. This model is a development of the original work by De, Waard, Williams and Lotz , and includes some effects due to the wall fluid shear stress.

The calculated results for the corrosion rate sensitivity for 50% summer and 50% winter condition is summarized in Table 2.1.

		mm/ year
Corrosion rate Case Sensitive (Summer)	Without Inhibitor	0.0033
	With Inhibitor	0.00033
Corrosion Allowance for 30yrs Design Life (50% Summer condition)	Without Inhibitor	0.0495
	With Inhibitor	0.00495
Corrosion rate Case Sensitive (Winter)	Without Inhibitor	0.0033
	With Inhibitor	0.00033
Corrosion Allowance for 30yrs Design Life (50% Winter condition)	Without Inhibitor	0.0495
	With Inhibitor	0.00495

Table 2.1: Corrosion Rate Sensitively Result for 50% Summer and 50% Winter Condition

The design life of 30 years is required and a typical 3 and 6mm corrosion allowance is used as the basic for the selection of carbon steel. For 30 years service, the maximum time-averaged corrosion rates that can be accommodated by a 3mm and 6mm corrosion allowance are 0.1 mm/years and 0.2 mm/year respectively. Therefore, based on the calculated result, low temperature carbon steel (LTCS) + 3 mm corrosion allowances + internal lining is recommended.

2.3 Aim of the project

To give a suitable solution in order to retrict the sludge formation. In order to do so 3 impellers are used to provide the minimum turbulence inside the tanks to restrict contamination of sludge.

2.4 Objectives

1) To introduce impellers inside the tank at suitable position for proper mixing in the tank.
2) To create impellers turbulence pattern using ansys fluent CFD.
3) Comparing of ansys results with minimum velocity of turbulence to restrict formation of sludge.

2.5 Scope

After successfull analysis of the design and by simulation the crude oil sludge formation can be restricted . One meter height of crude oil sludge in tank consist of about 5000m^3 of oil which is very great loss. Hence by implementation of impellers in crude oil storage tanks such loss can be prevented.

Chapter 3

3. Methodology

3.1 General

Modeling software used to model tank was solid works 2015. To analyze the turbulence pattern ansys fluent cfd was used.

3.2 Use of solid works

SolidWorks is a solid modelling computer-aided design (CAD) and computer-aided engineering (CAE) computer program that runs on Microsoft Windows. SolidWorks is published by Dassault Systems.

According to the publisher, over two million engineers and designers at more than 165,000 companies were using SolidWorks as of 2013. Also according to the company, fiscal year 2011–12 revenue for SolidWorks totalled $483 million.

SolidWorks is a solid modeler, and utilizes a parametric feature-based approach to create models and assemblies. The software is written on Parasolid-kernel.

Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allows them to capture design intent.

Building a model in SolidWorks usually starts with a 2D sketch (although 3D sketches are available for power users). The sketch consists of geometry such as points, lines, arcs, conics (except the hyperbola), and splines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicular, and concentricity. The parametric nature of SolidWorks means that the dimensions and relations drive the geometry, not the other way around. The dimensions in the sketch can be controlled independently, or by relationships to other parameters inside or outside of the sketch.

In an assembly, the analogy to sketch relations are mates. Just as sketch relations define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, define equivalent relations with respect to the individual parts or components, allowing the easy construction of assemblies. SolidWorks also includes additional advanced mating features such as gear and cam follower mates, which allow * ultiphy gear assemblies to accurately reproduce the rotational movement of an actual gear train.

Finally, drawings can be created either from parts or assemblies. Views are automatically generated from the solid model, and notes, dimensions and tolerances can then be easily added to the drawing as needed. The drawing module includes most paper sizes and standards

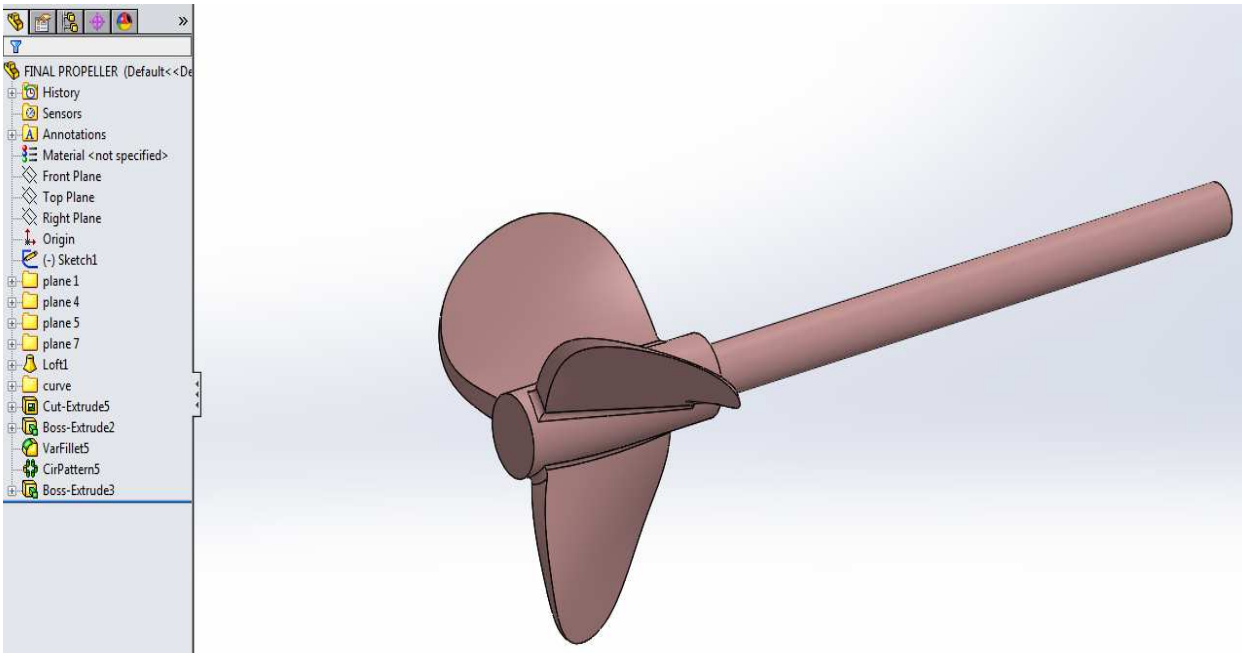

Figure 3.1: Model of impeller

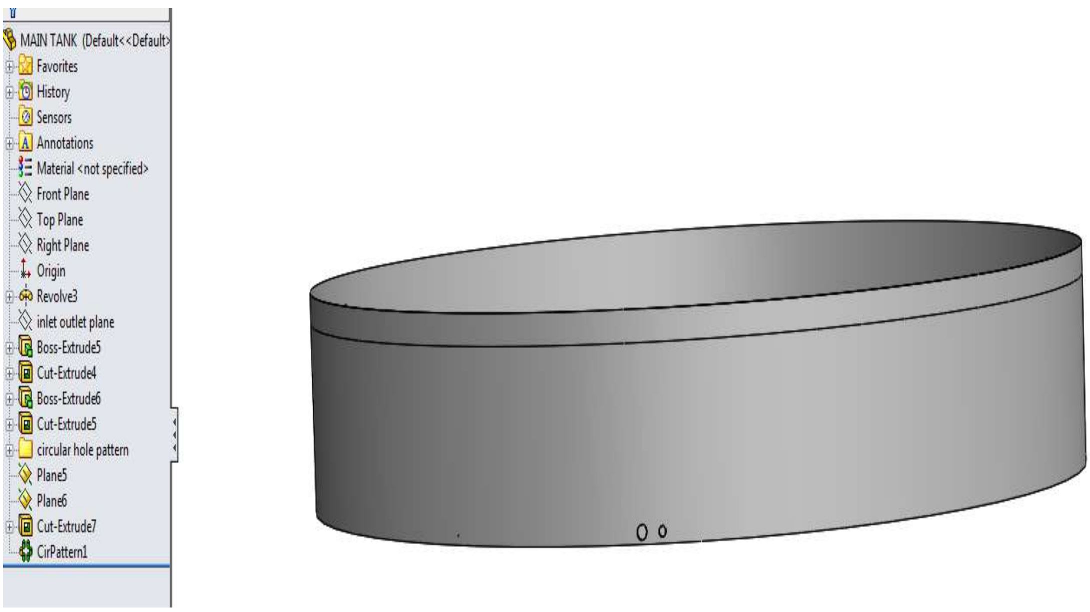

Figure 3.2: Model of tank

3.2.1 File format

SolidWorks files (previous to version 2015) use the Microsoft Structured Storage file format. This means that there are various files embedded within each SLDDRW (drawing files), SLDPRT (part files), SLDASM (assembly files) file, including preview bitmaps and metadata sub-files. Various third-party tools (see COM Structured Storage) can be used to extract these sub-files, although the sub files in many cases use proprietary binary file formats. STP file format is used for fine meshing in the ansys fluent cfd.

3.3 Use of ansys fluent cfd

ANSYS Fluent is the most-powerful computational fluid dynamics (CFD) software tool available, empowering you to go further and faster as you optimize your product's performance. Fluent includes well-validated physical modeling capabilities to deliver fast, accurate results across the widest range of CFD and * ultiphysics applications.

Computational fluid dynamics (CFD) is a branch of fluid mechanics that uses numerical analysis and data structures to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions. With high-speed supercomputers, better solutions can be achieved. Ongoing research yields software that improves the accuracy and speed of complex simulation scenarios such as transonic or turbulent flows.

3.3.1 DOMAIN of the analysis :

80m diameter with 14m high tank fitted with three propellers tilted at 30 deg with horizontal plane. i.e $\beta = 30$.

Steady state numerical analysis for three different heights are shown from the base :

i, 3m   ii, 6m

iii, 9m .

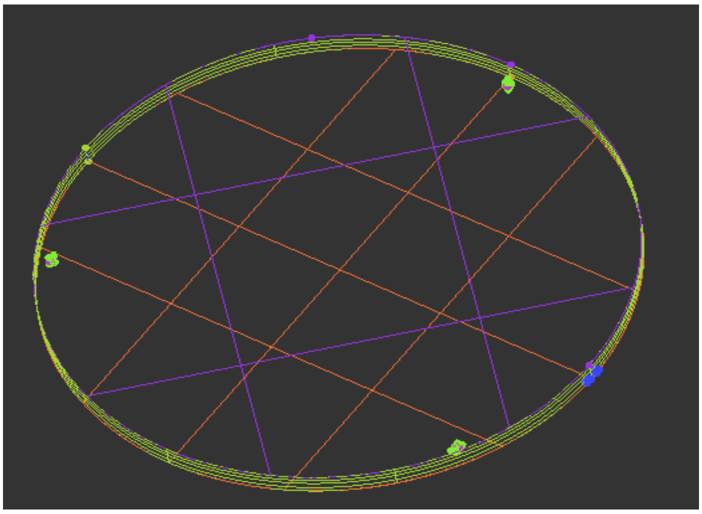

Figure 3.3: Tank domain

3.3.2 Methodology of analysis :

The geometry has been checked for any repair of gaps between the surfaces. Cleaned up geometry is imported into the meshing tool – ICEM CFD, where the unstructured meshing was implemented

Mesh is exported to fluent for solving the Mass, momentum equations using Moving Frame Reference model for propellers . Finally the generated data files are imported in CFD-POST for post processing

3.3.3 Meshing of tank :

Meshing is carried out in ICEM CFD

Unstructured mesh is considered for the given problem

Mesh was finalized with the quality of 0.4

500,000 elements where used for 3m height tank

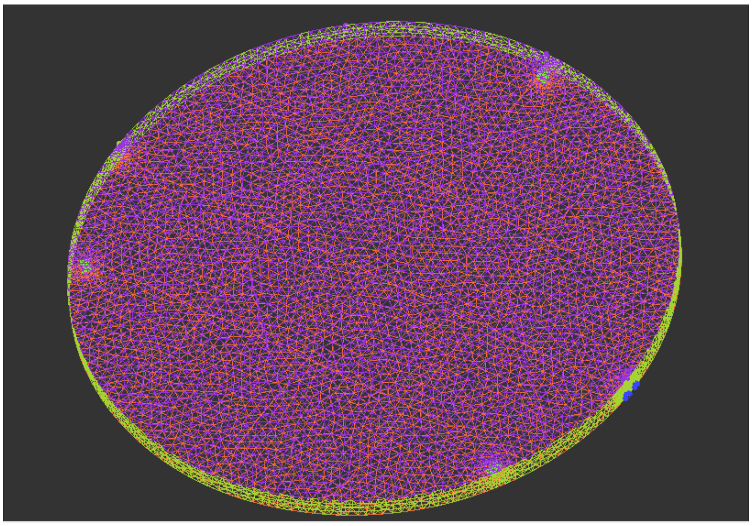

Figure 3.4: Tank meshing

3.3.4 Propeller meshing :

Propellers are enclosed inside an enclosure to capture the flow pattern near the propeller

Refined mesh sizes are used near the propellers in order to make sure the physics is captured correctly.

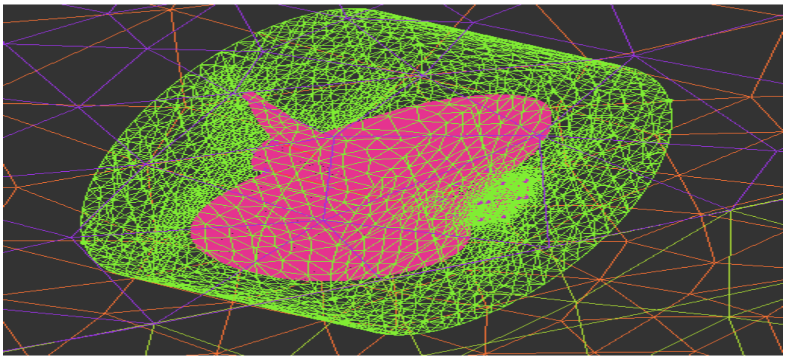

Figure 3.5: Cylindrical enclosure of impeller

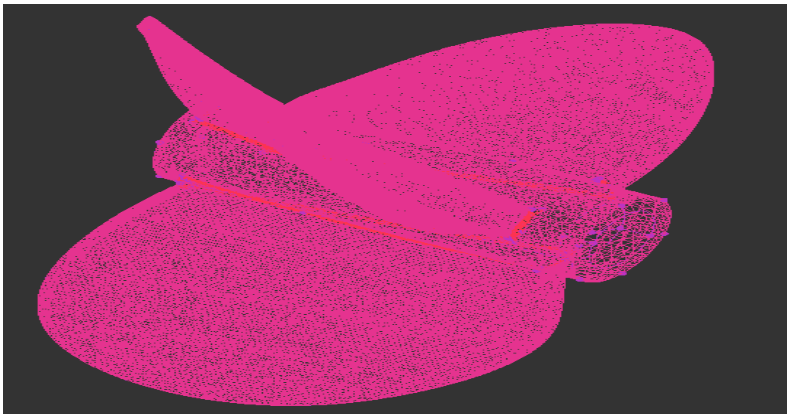

Figure 3.6 : Impeller mesh

Chapter 4

4. Case study

4.1 General

This chapter involves the design procedure of tank and impeller. Design steps involved in this chapter is been taken form MV joshi's book for processs equipment design and API-650.

4.2 Design of tank

1. Stresses in tank shell (mv joshi's process equipment design)

   A) Hoop stress -

   P= density g = 0.93

   hoop stress= =319.32N/

   B) Longitudinal stress-

   == 159.662

2. Bottom plate thickness (mv joshi's process equipment design)

Mild steel material for bottom plate

t= + c f = max permissible stress
j= joint efficiency by radiograph
c= corrosion allowance

t = + 3=16mm

3. Variation of shell thickness (by i foot method) (mv joshi's process equipment design, api-650)

t= + c.a sd = max allowable stress = 370mpa
ca= corrosion allowance = 3mm

considering two plate thickness

A) For height upto 10m from bottom

t 1 = + 3 = 12.55mm

B) For height upto 6m above

t 2 = + 3 = 8.68 mm

4. Diameter of inlet and outlet nozzles (assumptions)

q = 3546 (assumed)

q = av

3546 = (velocity assumed 2 m/s)

d = 36 inch

outlet assumed discharge = 2466.2

2466.2 =

d = 26 inch

5) Reprocessing line (assumption) (velocity assumed 1.5m/s)

(flow rate assumed 131.33)

131.33 =

d = 0.154m = 6 inch

6) Dike wall

velocity of crude oil = 60000

60000 = area 1.5

area = 40000

dimensions of dike wall = 400 100 m

7) Nozzle reinforcement (API -650)

inlet nozzle 36 inch (note- area cut from the cylindrical shell = area of the reinforced material)

length of side reinforcing plate = 1847.85 mm

width of reinforcing plate = 92.75 mm

outlet nozzle of 26 inch

length as side reinforcing plate = 1340 mm

width of reinforcing plate = 1625mm

8) Roof calculation (mv joshi's process equipment design)

area of pontoon = = 248.18

total area of roof = =5026

total weight of roof = 40.2087000 = 281.4 tonnes

total weight of crude oil displaced =

9) Design of supporting legs (mv joshi's process equipment design)

number of legs =200

area of legs = = 6.89

Volume of legs = 6.89 = 1.378

Weight of leg = 1.378= 9.646kg

Weight of 200 legs = 1.929 tones

4.3 Design of impellers

from the references, the initial design parameters of the impellers are decided

1. number of blades (z) - 3
2. diameter of impellers (di)- 1.3m
3. pitch ratio (p/di) -1.2
4. propeller rate of motion (rpm) – 450rpm
5. rake angle - 15
6. boss (hub) diameter ratio – 0.19di

1) Pitch of the impellers (p)

since pitch = (pitch ratio)di

=1.21.3= 1.56m

2) Hub diameter of impeller (di)

to determine the hub (boss) diameter of the impeller, the relation boss (hub) diameter 19

0.19 =

di = 0.191.3= 0.24m

di = hub(boss) diameter

di = propeller diameter

3) Pitch angle ()

pitch angle=

pitch angle = =64.20

r = hub (boss radius)

4) Chord length (c)

chord length(c) = r-r = 0.65-0.12 =0.53m

r = hub (boss) radius
r = propeller radius

5) Maximum thickness of blade (to)

selecting standard naca 66 aero foil blade profile with thickness of blade 15% of chord length

the maximum blade thickness = 0.15c =0.150.3= 0.08m

the maximum blade thickness be at the root of the blade

6) Blade thickness ratio

Blade thickness = ==0.06

The thickness of the blade section could be found for the radii, using the blade thickness

to = 0.06r

Hence, to estimate the thickness along the radius of the propeller (at mid plane)

to =0.06r (r %)

to = thickness at 60% of blade section

to= (60% of r)0.06 =0.60.650.06=0.23 for safer design (t0.6= 0.04)

where to = maximum blade thickness

di = propeller diameter

Chapter 5

5. Conclusion

5.1 General

This chapter consists of the ansys results in all cases as well as average velocity of crude oil which is compared with the minimum velocity of crude oil required to restrict sludge formation.

5.2 Propeller velocity vector :

The speed of propeller is 450 rpm. The below diagram shows velocity vector around the propeller as velocity vector 2 and 3.

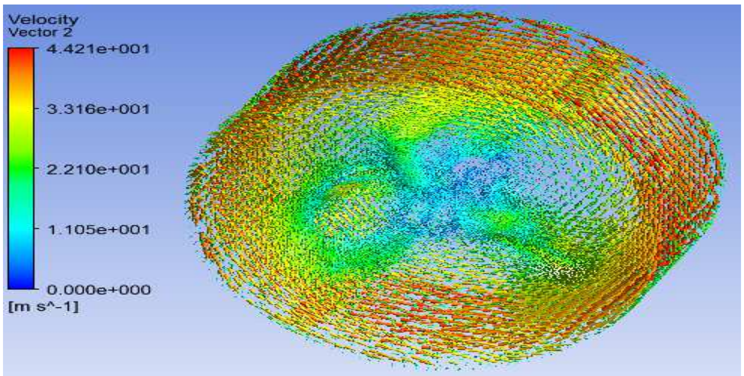

Figure 5.1: Velocity vector of impeller, view 1

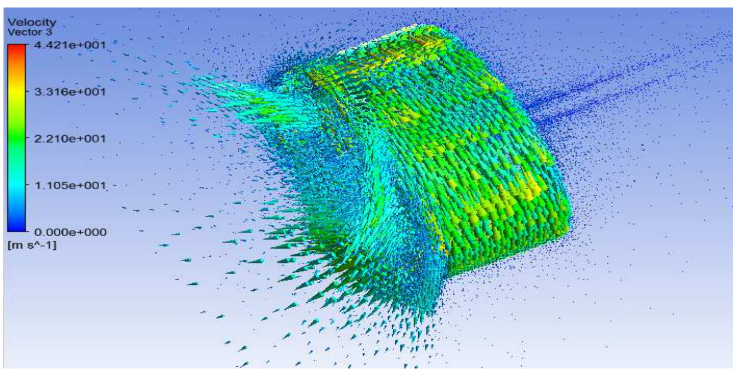

Figure 5.2: Velocity vector of impeller, view 2

5.3 Streamlines in the tank :

Turbulence is creating good mixing in all the part of the tank; except at the center.

Its due to the cumulative effect of the three propellers driven at an angle which rotates the liquid inside the tank.

The figure shows the velocity streamlines in the tank from top and the side. We can see even though the propellers are placed at z=1.3m, mixing happens at all parts of the tank. Velocity inside the tank is very low as compared to the velocity of the propellers.

5.3.1 Case I, H = 3m :

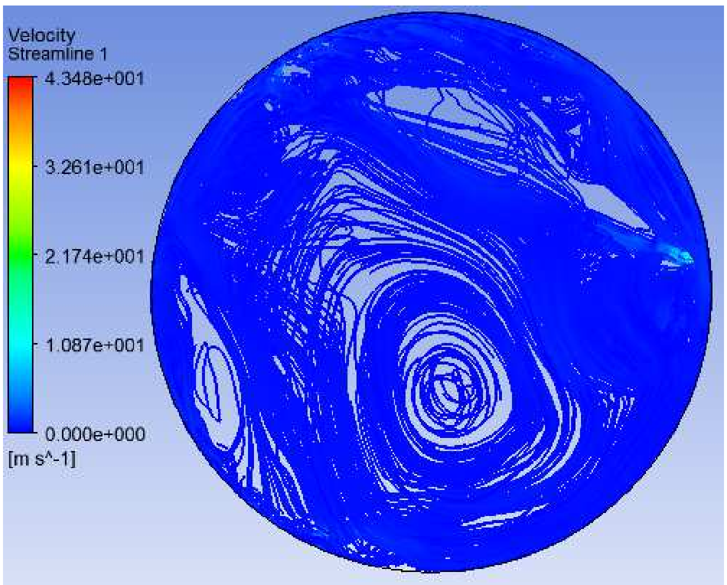

Figure 5.3: Streamline flow of crude oil at height of 3m

5.3.1.a Velocity vectors in tank :

Velocity vectors gives the clear picture of the swirl at the center

The volumetric average velocity in the tank is 0.9 m/s at height of 3m from the base .

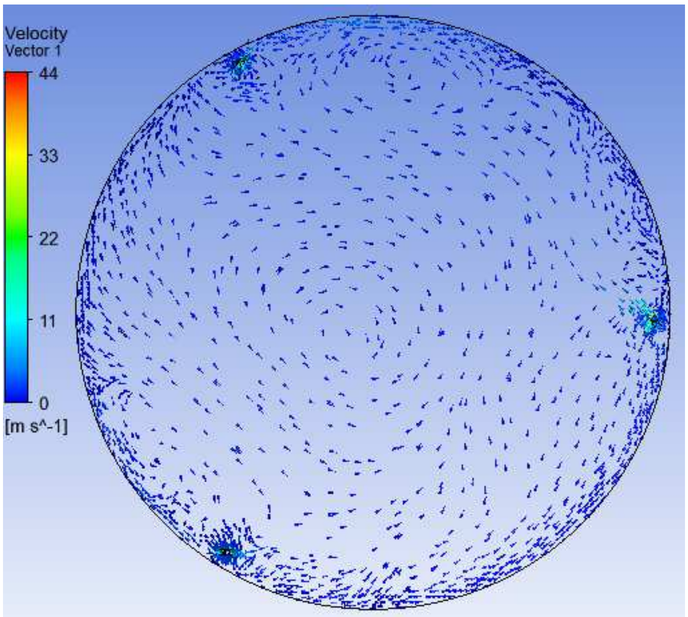

Figure 5.4: Velocity vector of crude oil at height of 3m

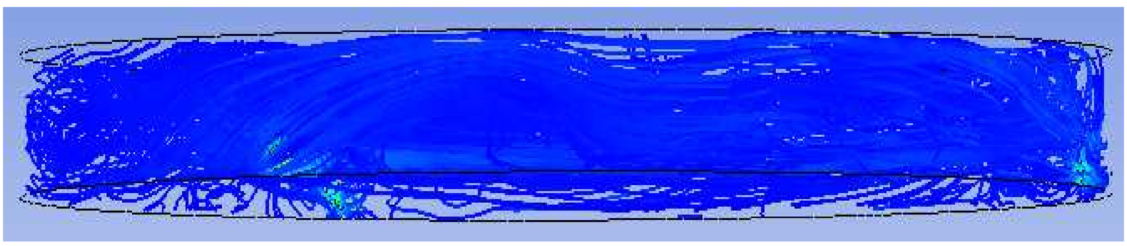

Figure 5.5 Vertical view of tank along with streamline flow

5.3.2 CASE II , H = 6m

Top view and the side view of velocity streamlines after 2000 iterations. For the sake of clarity only few streamlines are used.

Side view shows, turbulence is fully filled in the whole volume

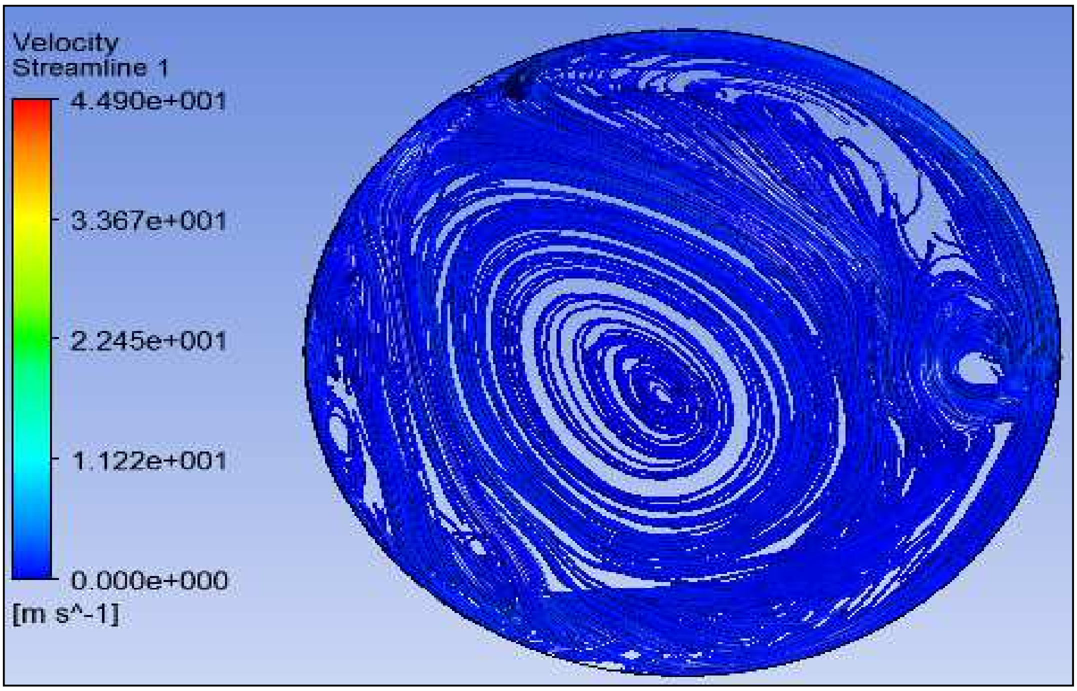

Figure 5.6: Streamline flow of crude oil at height of 6m

5.3.2.a Velocity vector :

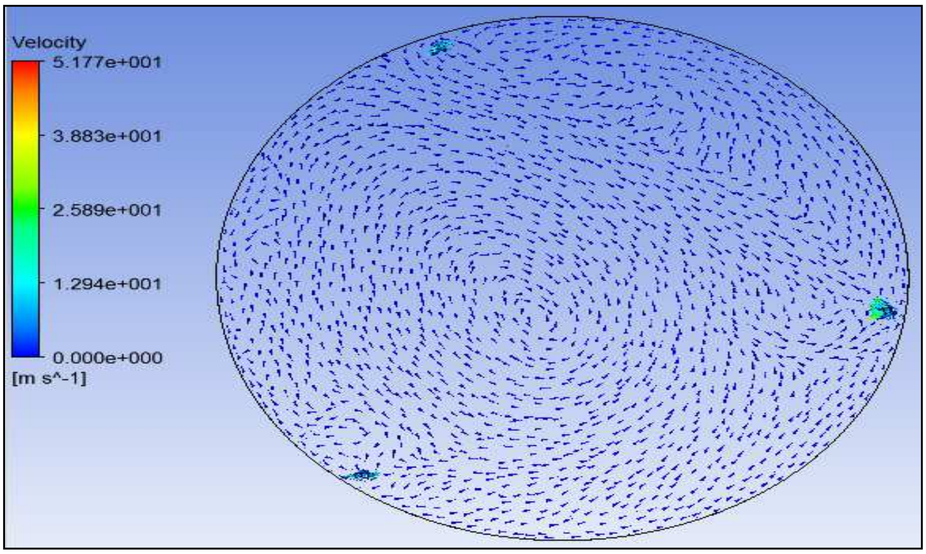

Figure 5.7:Velocity vector of crude oil at height of 6m

Volumetric average velocity is found to be 0.799678 m/s

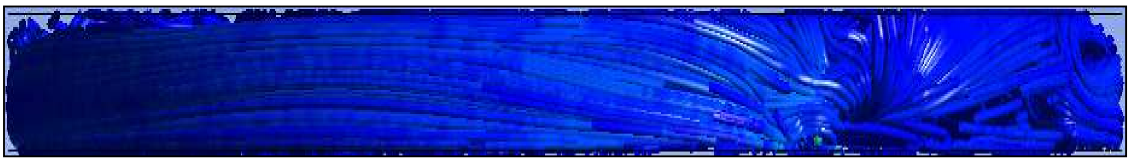

Figure 5.8: Streamline flow of crude oil in vertical view of tank

5.3.3 Case III H = 9m :

Volumetric average velocity in the tank is 0.685 m/s

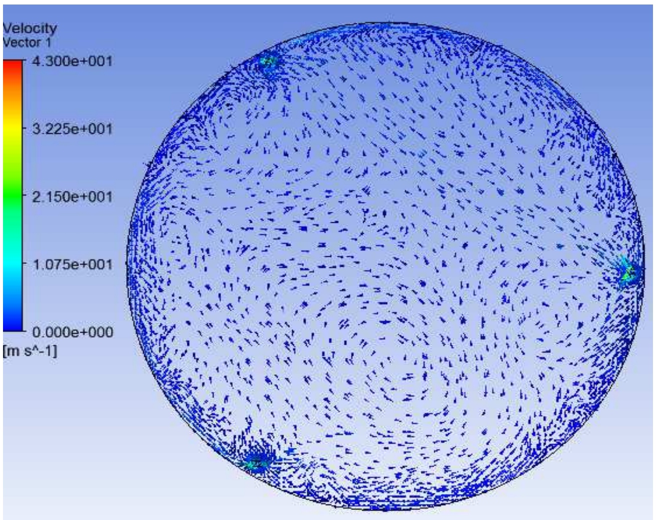

Figure 5.8: Velocity vector of crude oil at height of 9m

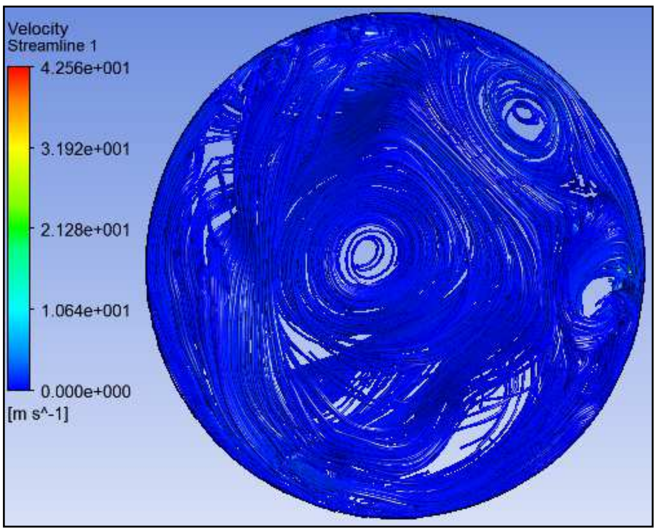

Figure 5.9: Streamline flow of crude oil at a height of 9m

figure 5.10: streamline flow of crude oil in vertical view of tank

5.4 Comparing of the results with standards

The energy required to prevent sludge formation in medium and heavy crudes is 0.6 to 0.8 hp/kbbl. It has been found that the critical velocity of typical crude oil required to maintain sheared sludge particles in suspension is approximately 0.6 to 1.2 m/s.

1) The average velocity of crude oil in case 1 was 0.9m/s by ansys simulation
2) The average velocity of crude oil in case 2 was 0.79m/s by ansys simulation
3) The average velocity of crude oil in case 3 was 0.68m/s by ansys simulation

All the velocities is in between the standard range in order to restrict the formation of sludge in floating roof type storage tank.

References

- Kailas L. Wasewar & J. Vijay Sarathi (2008) CFD Modelling and Simulation of Jet Mixed Tanks, Engineering Applications of Computational Fluid Mechanics, 2:2, 155-171.

- CFD simulation of homogenization in large-scale crude oil storage tanks Asghar Alizadeh Dakhel, Masoud Rahimi ,Department of Chemical Engineering, Faculty of Engineering, Razi University, Kermanshah, Iran.

- The effect of impellers layout on mixing time in a large-scalecrude oil storage tank Masoud Rahimi Department of Chemical Engineering, Faculty of Engineering, Razi University, Kermanshah, Iran.

- CFD study on mixing by coupled jet-impeller mixers in a large crude oil storage

  tank Masoud Rahimi *, Arsalan Parvareh Department of Chemical Engineering,

  Faculty of Engineering, Razi University, Kermanshah, Iran.

- Side entry tank mixers -characteristics and design criteria By Ahmed Mohamed Seliem Senior Process Engineer NPC.

- Mv joshi’s process equipment design

- API - 650