Surface Facilities for Oil and Gas Handling

Prof. Abdus Samad

Department of Ocean Engineering

IIT Madras

Introduction To Oil And Gas-01

Good morning. I will be teaching surface facilities for oil and gas. This is a 12-week course, and each class will be around two and a half to 3 hours. The course covers surface production operation, separator, emulsion, heater-treater, water treatment, gas separation, and equipment- and fluid flow-related aspects. Whoever registers for the course will be doing the assignment, and there will be a final exam that will. The final exam will most probably be a proctored exam; some exam centers will be there within India and outside India. The student can register, appear for exams, and get certification.

Those not willing to get a certificate to watch YouTube videos will probably be available freely. For this course, I will follow the book Surface Production Operations, K Arnold and Stuart, and Maurice and Stuart's book. I think this book is the most widespread book for surface production operations. So, students willing to attend this course or eager to learn this course can follow the books.

If any other course material is required, I will give it to you or tell you during that lecture. I will say the book's name or content where you can find relevant course material. So, fossil fuel, so fossil fuel, why is the fossil fuel world coming? Fossil fuel means animals or trees or plants or phytoplankton, zooplankton, everything got deposited, and because of temperature and pressure, it got converted into fuel. So, that can be coal or hydrocarbon, such as petroleum coal and hydrocarbon. So, petroleum, whatever petrol you are filling in your car or bike. So, it is coming from petroleum.

So, directly from the earth's surface, whatever fluid you are getting is called petroleum, and you are not filling that same fuel in your car or bike. Before loading into a vehicle, you will have several processes to drill the earth's surface. Then what you have, you have to separate because whenever you hit, you get oil, water, sand, you get some other things such as H2S hydrogen sulfide these are you are getting. Still, you do not get money from that. You have to remove it. Otherwise, there will be some issues when you are transporting or you are using the fuel. Then, you have to separate this one into surface production systems. So, that is my course content. I will explain this separation process later and how to do it.

When you separate, you get water, sand, oil, gas, and gas will also be there, so gas. So, you separate everything, and oil will go to refineries, so one refinery, for example, Jamnagar refinery, is there, and the Reliance refinery is there. Many companies have set up refineries in India and abroad.

So, you get diesel, petrol, naphtha, kerosene, and many other components from that refinery. So, then the process is that fossil fuel you are getting from the earth's surface and maybe coal or petroleum. So, coal, I am not discussing. So, we are talking about petroleum because this course is relevant to separators. So, the separator is coming petroleum to separator actually, and petroleum contains different components such as oil, water, gas, and sand when you separate after separation you transport it to your refinery in the refinery you do fractional distillation and you separate diesel, petrol, kerosene, and many other components.

So, the formation of petroleum, so the formation of petroleum how did it form large quantities, a large number of dead organisms, dead organisms deposited mostly zooplankton, zooplankton or algae buried underneath the sedimentary rock and subjected to both prolonged heat and pressure. So, because of this, these chemical changes happen and you get petroleum when you are extracting you have a whole process of drilling two refineries and you are using for your day-to-day life car, bus, truck, train wherever you are using fuel liquid fuel. So, you are getting that fuel from actually petroleum. These days there are alternative options are coming, for example, bio or biofuel. So, biofuel is not coming from your petroleum.

So, biofuel a small conversion you are making from plants that you are mixing with petroleum fluid and you are trying to make you are trying to reduce dependency on petroleum because petroleum in India if you see petroleum we are importing 82 percent petroleum from other countries. Because of this huge amount of imports you are giving lots of money to other countries. So, the government is trying to replace petroleum as much as possible using biofuel. So, that is also in the basic stage. So, still, our dependency will be there on petroleum.

So, you have to study it. A little bit of historical prospect around 4300 years ago some reports are there. So, 4300 years ago petroleum Sumerans used 2000 years ago Chinese use in some Arabian text also petroleum is referred ok. So, the first crude oil in India, the first

crude oil in Pennsylvania Pennsylvania USA 1869 they found. So, from there things moved on and if you see the Middle East and other countries also they got after 1950s the crude oil.

In India also in India, it came in 1889. Natural gas industry in India natural gas and 1960s The natural gas industry in India started 1960s India is importing 80 percent about 80 percent crude oil imported by India ok. This is a very important term 80 percent about you are importing. So, a huge amount of money you are giving to another country we are among the top consumers of petroleum oil and gas, but our production is very low. So, that is why we are giving huge money ok.

That is why the government is trying to replace petroleum fluid or oil and gas from other sources for example, renewable energy solar they are trying to put wind energy they are trying to get biodiesel are trying to get other types of energy systems like nuclear there may be small hydro or maybe geothermal energy are trying to put, but still all together still not sufficient to replace the petroleum. So, our dependency on petroleum will continue for the next several years. Petroleum extracts extraction exploration to customer. So, in petroleum when you are extracting, first you explore then drill a weld bowl once drilling is done you make a hole drilling means making a hole ok. When you are making a hole fluid will move up because of reservoir pressure you have fluid on the surface then use some separator system that separator system will separate all the fluid I already told then you send it to your refineries refinery will send it to the Indian oil say Indian gas you are getting at your home or you are getting war petroleum the petrol pumps are there nearby your hometown.

So, those are not coming directly from ONGC ok. ONGC is producing from they have drilling system production system they will be selling to some refinery. So, the refinery will be selling to your petrol pumps ok? So, in that way, things are working.

They should cut actually ok. So, composition by weight will be alkane 30 percent about naphthene it will be 49 percent around aromatics 15 percent around asphaltene it will be around 6 percent ok. So, this is an approximate ratio it can vary also this is just some idea. So, that you can get this much of about this much it will be in your mind ok. And carbon percentage if you see it will be around 83 to 85 percent huge amount of carbon will be there ok.

Hydrogen will be there 8 to 10 to 15 percent 10 to 15 percent nitrogen will be there 0.1 to 2 percent oxygen will be there 0.05 to 1.5 percent S sulfur this is your NME actually hydrogen sulfur or sulfur dioxide ok. This will create corrosive gas S S plus H 2 plus water which will create actually acid, acidic gas.

So, acidic gas means it will corrode everything it will be dangerous. So, if the sulfur content is higher, you have to first handle the sulfur then you can do other operations other all metallic parts will be corroded easily. So, sulfur will be like 0.05 to 6 percent which is a very high amount also possible. So, a small amount may they handled easily, but for high amounts, you have to treat them separately.

And crude oil gravity so, these are small simple statistics you should remember ok. Gravity will be 26 to 12 degrees API, API means American Petroleum Institute. So, there there are formulas we will discuss later. So, normally we do not specify gravity in terms of whatever you learn in your school books like kg per meter there you go something. So, here we specify in terms of API gravity.

So, later we will discuss the formula how to convert one unit to another unit. And whenever you are studying petroleum engineering any subject you should remember the field units what the people uses the units in field you have to remember. For example, they do not use m3/s they will be using barrel and barrel they will not say lightly 5 barrel per day they will say BBL or BOPD BWPD. So, those terms we will explain later what are the different terms ok. So, if you are from petroleum background or non petroleum background does not matter you should remember those field unit if you are going to work in a field and if someone is saying BOPD or BPD or BWPD.

So, you should not say I do not know these terms. So, you are engineer so, you should be familiar with the term GPM gallon per minute you have to familiar with your temperature Rankine temperature your Fahrenheit temperature normally centigrade they do not use they will be using Fahrenheit temperature there will be feet inch instead of meter. So, in India , normally, we are familiar with the SI unit, and I feel comfortable . I can tell one story: I was working in the UK, Scotland, with ne company called Zilly primitive. So, there what I data I got I got data in field unit and they asked me to do some calculation.

So, when I was doing calculation what I did I prepared one extra sheet whatever data I will get I will put there in extra sheet one extra sheet will be convergent table ok? If I get gallon it will create a meter cube per second then the third sheet will be my actual calculation volume flow rate this flow rate because I am very comfortable with SI unit ok. Then whenever I will be delivering that final result to the customer, the customer will not understand my centigrade kg meter cube. So, I will have another conversion table. So, using that conversion table actually I will give them data in the field unit.

So, I will get data in field unit I will do all calculations using my SI unit then I will give the in-field unit because whenever if I use only the field unit for calculation then I will I have to remember all these constants variables. So, many terms will be extra terms will be coming. So, you cannot remember ok, but SI unit Newton meter kg conversion is very easy and in India we are very much comfortable with that, but if you are going for field unit conversion then extra constant term you have to remember. So, to avoid that I prepared that sheet to get this gallon it will convert to meter cube per second. So, I will have that sheet prepared and the final sheet also will be there after the conversion pipe flow rate friction rate pump diameter flow rate I will give gpm I will give in feet I will give in Fahrenheit.

So, that way I make my life easier during my work in the field ok. Work in the field means I was working for one oil services company I was trying to design artificial lifting systems ok. So, I was getting data from different US-based companies, middle east based companies, and other companies. So, those company engineers they will be telling their terms in terms of barrel, feet, gallon and initially I was feeling difficulty because I was not familiar with those terms because in India again we are familiar with meter kg second, second anyway it is common. So, I had to familiarize myself with the new terms.

So, that I should not say 10 feet means then later I prepared my mind that 10 feet means divided by 3 approximately 3 meter then 10,000 feet means around 3 kilometers. That way I was trying to remember just I was trying to make my own thumb rule I can remember in kilometer meter, not in terms of feet. So, whenever I will get data in feet 10,000 feet 5,000 feet. So, quickly my mind will work divided by 3 and approximately this 10,000 divided by 3 is around 3 kilometers, but not exactly, but I will by thumb rule I can use about 3 kilometers means this is 0 ok. So, you also as a student can if you are familiar with the field unit and your mind is working on that this is fine.

Otherwise, if you think you want to convert and you do calculations and you deliver to your customer or your company bosses or your client in field unit is also fine. I think ONGC uses this SI unit I think both units are using, but US US-based companies will be using field units you should remember this ok. Regarding the chemistry of petroleum oil and gas when you are talking about carbon and hydrogen must be right. This way we say hydro carbon hydrogen and carbon are there that is why we say hydrocarbon or HC we see in short form many times ok. And whenever you are saying hydrocarbon that means, it may have C5 to C40 this much of carbon possible some hydrocarbon or some fluid oil or gas will have C5 very low amount of carbon.

In some cases very large number of long-chain hydrocarbons will be there. So, in C40 if this is wax zone ok, C5 is low light oil may be there and C5 like methane if you say carbon only 1. So, in that case your carbon actually 1 ok. So, normally it will be within this range. And petrol is your common fuel when you are driving by C_nH_{2n+2}.

So, this is the approximate formula for petrol. So, normally the petroleum fluid will be mixture of many chemicals not single chemical ok. This will have long-chain hydrocarbon and short-chain hydrocarbon. Short-chain hydrocarbon means small hydrocarbon molecular weight will be lower. So, there will be more volatile gas like methane C only 1 CH_4 only 1 carbon is there.

But if you go to wax long chain hydrocarbon many carbon carbon carbon carbon bonding will be there C C C C many bonding will be there ok. So, when the long chain is there. So, it cannot move easily you increase temperature the 1 chain another chain will be tangled up. So, because of this one volatile it will be reduced ok. So, that is wax zone will be all lubricating oil there will be long chain hydrocarbon.

A short-chain hydrocarbon petrol can be very short-chain hydrocarbon gas will be very further lower hydrocarbon molecular weight will be very low. So, if you small amount of heat. So, there will be trying to move away from your vessel or pot ok reservoir. The reservoir means where your oil or gas is there ok. So, whenever you are getting oil and gas that means 3 conditions are maintained one is source shock must be there one will be porosity.

Porosity must be there source shock means your hydrocarbon is there ok. You have oil gas ok maybe water also will be there hydrocarbon is there this must be your pockets, but if pockets are not connected you are already in production. So, porosity is there which means, the pockets will be connected and you make a hole connected pockets will be delivering fluid and you are becoming economical. And to prevent oil from escaping to the surface one rock is required called cap rock ok. So, otherwise cap rock is not there then all gas and oil will go away.

So, these 3 conditions must be maintained if you want to get one reservoir ok consumption ok. So, if you see just simple consumption patterns of different countries. So, first the developed country most developed country you can say USA. The USA is in most oil and gas although they have also a very huge amount of oil and gas, their consumption is very much I think all families will have one car like in Saudi Arabia and the USA they will have each family will have. Europe has done lots of public transport systems.

So, they also depend on the car, but they have like cycling road and they use the public transport system. I was in South Korea. So, South Korean people government will say that use more public transport ok although they can afford ok. But India is a mixed economy and developing. So, we cannot afford that much of all public transport or all car for everyone ok.

So, we have to depend on everything. And the next consumer is China ok? This depends on every year's data. So, normally this will be a common trend then Japan also use very high amount of oil and gas ok. In India you see KSA they are having a huge amount of oil, but they are using also every family will have very one or two cars minimum actually ok. And if you see production side production, Russia this is this day they are also producing and sending to India.

KSA is there a high amount of production, Iraq then Iran then China ok. So, KSA USA also there ok. This may or may not be in sequence, but these are top countries ok. You see Japan is using a very high amount, but Japan is not having any production actually ok. South Korea I do not know whether they are having production, but they are using a very high amount of ok.

China, USA they are having production, but they are consumer also. But in India case we are consuming more, we are not in top production list ok that is our problem. If we can reduce dependency on petroleum, then our economy no one can actually because huge amount of money we are giving to other countries. And normally because of strategic reason one country should will not buy all oil and gas from only one country. They say India will be buying from KSA, from Russia, from the USA from different countries.

So, that like if any political disturbance is there in one country. So, they can get other source of oil ok. So, although they will be having strategic oil, but strategic oil will be supplying maybe 2-3 months maximum. But for strategic reasons, one country will be importing oil and gas from different countries ok. Some from Iran, some from Russia, some from USA, some from Saudi Arabia that way they will make ok.

Second scenario I said like in India the Digby Assam, there they first time got oil and gas, but actual recovery started in 1960s and later ok. Bombay High started in 1974 1974 I think ok. Bombay high is there around 14 percent of India's oil it is supplying ok. Although India has several sources, several reservoir, but Bombay high is giving still more oil. So, initially they drilled vertical wellbore later they went for multilateral and horizontal wellbore also.

India imports about again 80 percent about 80 percent oil and gas from other country and our importing countries are basically Iraq, KSA, UAE, USA, Russia ok. This term just for example, you should remember because Iraq, KSA, UAE, USA, Russia ok, Russia newest tradition. Previously it was there, but now increased. Peak oil, peak oil is actually many scientists they are believing that already we have reached peak oil because in maximum production we have done. There are conservation more, but we are not getting everyday new reservoir or new production we are not getting.

So, people are thinking that peak oil we have reached and it is gradually it is declined ok already reached or maybe we are reaching soon that peak.