OFFSHORE OIL PRODUCTION PLATFORM FOR INDIAN SHELF

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ABSTRACT

Oil has recently been struck in Bombay High field in the Arabian Sea. Considering the huge gap between our requirements and likely indigenous onshore production, an intensified effort for the exploration in other offshore areas is anticipated. The commercial production from successful finds would require the fabrication and erection of several fixed production platforms. These require huge investment and it is necessary to consider pros and cons of different types before selecting any particular type, but so far no such study has been done. Aim of this paper is to present in brief the different types of platforms available, their requirements and the strategy for development considering various alternatives. Use of concrete platform has been preferred to the steel one and the reasons for the same have been given.

INTRODUCTION

Oil has recently been struck in five wells of Bombay High field in the Cambay basin, approximately 180 kilometers west of Bombay. Tests are in progress to estimate the production potential of this field. Once the commercial viability of the field is confirmed, several fixed platforms have to be fabricated and installed for regular production of crude. There are different types of oil production platforms in use and a careful study of various alternatives is needed before finally selecting one suitable for Indian conditions. This assumes importance because bulk of our future oil requirements are expected to be met from offshore resources and huge investments, of the order of Rupees 340 crores with a foreign exchange component of Rupees 270 crores over the next ten year period (NCST, 1973), are to be made for infrastructural and technological development in this area.

NUMBER OF PLATFORMS

Results of the production tests decide the number of platforms and, the size and storage capacity of each platform. As per preliminary indications, Bombay High complex is thought capable of eventually producing 10 million tonnes of oil per annum for 15 to 20 years with a production of
around a million tonnes for the next year. Assuming one platform for every 12,500 tonnes per day of production capacity, at least 22 platforms would be required in Bombay High. However, for the presently envisaged production of one million tonnes of oil per year, two fixed platforms would do.

**TYPES OF PRODUCTION PLATFORMS**

Depending on the material used, offshore oil production platforms can be divided into:

(a) **Steel - tubular jacket type**
(b) **Concrete Gravity Type** – reinforced or prestressed, box or column type
(c) **Hybrid Unit** – having a concrete base with steel tubular superstructure

Presently, steel jacket type platforms dominate. These were first used in the Gulf of Mexico in 40’s and the present day structure is developed by enlargement from earlier ones erected over the years in various parts of the world. Concrete and hybrid types are recent developments.

Steel jacket type platform is essentially a very large sized tubular three dimensional frame. Idea about its huge size can be obtained from the fact that each tubular member can be anything up to one metre and above in diameter with pipe thickness in range of 10 to 12 centimetres. The complete unit may weigh as much as ten to twenty thousand tonnes. Fabrication is normally done onshore and the prefabricated framed jacket is floated or barged to a given location in a horizontal position. It is then tipped over to the vertical position at the site and the piles are driven through the hollow tubular legs with the help of pile driving hammer for pinning the structure to the seabed. Additional pile segments are added till it reaches the design penetration (may be up to 70-80 metres) and these are joined together by field welding. Piles are joined to the jacket by welding them at its top. A steel platform is then put on the frame and weld jointed.

Concrete was used for the oil platform for the first time at the Ekofisk field in the Norwegian sector of the North Sea. This consists of a massive concrete gravity structure which includes a storage tank. It is normally in range of quarter of a million tonne and thus heavy enough to remain stable when simply sunk on to the seabed. These platforms range between two basic extremes - the box and the tower. Box types have a large caisson form of base with vertical walls and a considerable base area. Tower type have a far more slender base. These are constructed vertically in a dry dock and moved progressively into deeper waters as the construction proceeds. The successful towing and placing of the Ekofisk tank has boosted demand for the concrete gravity type platforms, especially for deeper waters beyond the limits of piled structures. It is estimated that at least 80 platforms of gravity type would be in use in the North Sea by 1980 (Wilson, 1974).

Hybrid unit is a combination of two earlier types. This has a concrete box type gravity base for stability and better load distribution with lighter steel superstructure at the top for reduction in self weight and wave
action. This seems a promising approach but the variety of solutions proposed is bewildering. More than 600 alternative configurations have been proposed, including various kinds of production systems, flaring, reinjection techniques and maintenance considerations (Wilson, 1974). It is extremely difficult to select the correct one for a given site and local problems have to be considered in arriving at an appropriate decision.

**DESIGN CONSIDERATIONS**

Offshore oil production platform is an essentially very large three dimensional redundant structure in a severe oceanic environment. For safety of personnel and equipment, the height is so fixed that the lowest part of the deck is much above the water even under the worst oceanographic and metrological conditions. The platform is subjected to vertical dead and live loads, wind loads, seismic loads, wave loads and currents. In addition, impact forces due to operation of rigs, landing and taking off of helicopters, and a likely collision with a foreign object have also to be provided for. Moreover, it has to remain fairly static under constantly vibrating action of wind, current, wave action or its own power plant, to prevent the drill pipe from excessive bending.

The vertical loads from the self weight of the unit, the drilling rig, mud pumps, generators, fuel tanks, accommodation for crew, helipad etc. are carried through the deck structure to the supports and eventually to the seabed.

The wind loads on the drilling derrick and the exposed part of the platform mainly affects the stability of the unit. The wind velocity selected for design is usually that which will occur on the average only once in 100 years. As the wind records for most locations of interest for such a long period are lacking, statistical methods are employed to estimate the wind velocity corresponding to specified recurrence interval.

However, the most severe loading conditions are almost always caused by the wind generated water waves. These loads are enormous and difficult to determine due to their random nature and can only be described by probabilistic methods. The major source of uncertainty is the assessment of the dimensions of the extreme waves for particular areas of operation, and the estimation of wave forces from these. It is common practice in designs to ignore the complexities of a confused sea and assume trains of smooth regular design waves of fixed dimensions striking the structure at regular intervals. The selection of design wave (expected to occur once in 100 years) is based on statistical parameters and wave data presented in terms of significant wave height and this is used for the formulation of loading criterion.

The additional forces induced by the tidal, wind driven or other currents are also to be considered because the vector combination of relatively small currents with wave particle velocity can result in a large increase in wave force due to the nature of vector addition. The critical condition will exist for crest position at mean surface when the steady current is in the same direction as the wave propagation.
All these loads suitably combined with seismic loads (if the structure is in earthquake zone), impact and hydrostatic forces help to define the total loading profile. Design is usually done for two main conditions (Muscarella, 1971): (a) Maximum storm condition while the platform is under maximum load (but not operating, as at the approach of a storm, operations are interrupted). (b) Maximum operating load with maximum operating wave. Actual analysis and design is a normal structural engineering work and is done with the help of electronic computers. Besides the above mentioned routine calculations, the special problems due to metal fatigue and metal corrosion, vibrations, biological growth and peculiar local topography of the area may also have to be studied before finalising the design.

Here, it is pertinent to point out that there is an appalling lack of reliable data regarding wind speeds, their directions and frequencies; wave heights, wave periods, wave directions and their frequencies; directions and speeds of currents; air-sea interaction coefficients; geotechnical and geographical features of the Indian Continental Shelves. Many accidents, often involving loss of the platform and of human lives and in any case, considerable expenditures for repairs of heavy damages have occurred because of an incomplete knowledge or optimistic interpretation of oceanographic, meteorological and soil characteristics data. This major gap in our knowledge has to be bridged before contemplating any large scale exploitation of offshore mineral resources.

Choosing Platform for Indian Continental Shelves

Practically, no indigenous know how exists regarding fabrication and installation of any type of offshore structure. The software problems like planning, analysis and design of these structures including computer simulation of their environmental conditions are not much difficult and well within the capacity of many establishments in India. It is the hardware which is likely to pose problems.

National Committee on Science and Technology has recommended the use of steel platforms for Bombay High. It is necessary to evaluate this decision critically because the country is committing itself for using steel platforms for other areas too since huge investments made in basic exclusive infrastructural facilities are difficult to duplicate or alter at a later stage.

There are some fundamental difficulties in using steel platforms in India. These require large quantities of high grade structural steel conforming to foreign specifications in the form of large diameter pipes, which cannot be produced in steel rolling mills and scarce foreign exchange will be required for importing these. There are very few countries making high grade structural steel and due to present boom in offshore activity, market position is very tight. Thus, even if it is possible to arrange for foreign exchange, supply cannot be guaranteed. Experience in the North Sea shows that the installation work can be delayed, even with best possible advanced planning, due
to shortages of various kinds. Dependence on another country for our requirements in this critical sphere is risky and attempts must be directed towards maximum use of locally available material.

Steel platforms require prolonged installation work at the offshore site in difficult oceanic environment and need expensive equipment like large capacity cranes, derrick barges, pile driving hammers etc. Heavy construction equipment used for installation work is not available in the country and due to widespread demand, is difficult to buy these abroad at a reasonable price. Alternative proposal of hiring these, made by NCST, will be very costly. Moreover, there are not many skilled persons capable of operating these.

Steel platforms demand very exacting standards in fabrication and this results in very high fabrication costs. The design of these involve some peculiar factors like fatigue, corrosion and corrosion fatigue. The welding of additions or extensions in large diameter and thick material is time-consuming and each weld requires stress relieving and full non-destructive test examination. The complete underwater welding is done at the site, the technology for which is not available locally. "Underwater burning or welding tasks and use of torches is not entirely safe and mishaps can occur, due to presence of gas, fuel oil, paint and other petroleum products and electrical shocks, with disastrous results for divers and other men working in the area. Even a simple task becomes a harder one for the diver because of restrictions of diving equipment, confined spaces, limited visibility, uncontrolled movement and the resistance of water. In addition, there is danger of marine animals that bite or inflict wounds, sting or induce dermatitis, shock etc."

(Myers, 1969).

Most of these problems are absent in concrete platforms because of minimal site and underwater operations. Firms like British Petroleum, which continue using steel platforms, do so largely because they have already made large investments in the floatation units, pile drivers and other ancillary equipment and facilities needed for such platforms and do not want to waste these. India, on the other hand, has to start from the scratch and need not fall in this trap of making huge investments in equipment and facilities which may not be required later or have to be duplicated. Here, it is pertinent to note that the steel piled units can only be used up to limited water depths and beyond these, as oil is discovered in deeper waters, concrete/hybrid platforms have to be used in any case. If the technology of their construction for shallow waters of Bombay High is mastered, it will be relatively easy to extend it to deeper waters rather than starting over it later from scratch.

Concrete platforms are heavy enough to remain stable when simply sunk on to the seabed, are constructed in sheltered waters and require no costly and risky prolonged operations at site. Due to their vertical position during construction, there is no need for unending at the location, as is the case
with steel platforms. Thus, the need for many of the expensive modules and the exorbitant cost of derrick barges and other equipment required for working in oceanic environment is obviated.

They are sunk in situ in one simple and controllable operation. These can be ballasted with reversible techniques and the vessel can be refloated for survey or movement to another site, in comparable depth of water for reuse. Their heavy weight and size can be used with advantage to flatten the uneven seabed conditions and by sheer size and scale, it can resist the impact of wave forces. Many problems could be avoided if the structure did not have to go through the wave zone, in order to avoid the severe wave forces, and in this respect concrete platforms lend themselves perfectly to be fully submerged. It is a distinct possibility that all items of plant and equipment will be placed at seabed level in near future, keeping only vital communication needs at the top. This can only be possible with the concrete platforms.

Concrete platforms are safer than steel ones in case of enemy attack during war because they can resist better due to their bulk. This is a very important factor because Bombay High is an extremely vulnerable zone from defence viewpoint. Considering the future possibility of using underwater platforms (to make them still safer), concrete has a decisive edge over steel. Research in this direction is going on throughout the world and it is a challenge as well as an opportunity for India to start with other countries in this race and not always lag behind developments abroad.

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