SIMPLIFIED APPROACH TOWARDS OBTAINING FUNCTIONAL CRITERIA OF TOPSIDE FACILITIES FOR OFFSHORE JACKET PLATFORM

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Synopsis

It is almost impossible to provide a standard 'design procedure' for offshore jacket topside facilities design. The proposed postulate is that the weight of production and processing facilities do provide a reasonable measure of the production of oil and gas per day. Presentation of weight data collected from actual North Sea platforms however indicated little logic dependents on platform functional parameters. A further breakdown of these weights according to type or function offers some possible explanations. It is acknowledged that various other variables and parameters complicates issues relating to topside facilities. The subject is nevertheless of great importance.

Introduction to Operational Loading

The initial design requirements for any offshore platform is that it should be able to support an equipment and personnel workload above the wave zone, and simultaneously resist the effect of waves, currents, winds and temperatures expected at its fixed location during its intented working lifespan.

The development of a full inventory of platform weights commences with topside weight estimation very early in the conceptual design process. This topside weights vary significantly, depending on the platform location — the water depth, environmental conditions, foundation conditions, and the platform function — the peak throughput of oil or/and gas, the type of process facilities, the number and depth of wells, the number of personnel to be accommodated, type and standard of the accommodation.

Since significant load acting on an offshore platform is due to the deck and equipment weights, it is necessary to have a reliable estimate of these weights early in the design process. This allows preliminary design of the support structure to be made, and the module lifting and transportation requirement determined.

The topside design objectives are generally very complex. The superstructure have to fulfill the basic structural requirements of strength, serviceability and so on. Various other functional requirements must also be satisfied. The physical layout of the process plant and facilities, for example, must follow the process flow as far as possible to avoid unnecessary duplication of piping runs, areas of differing hazard potential, cleanliness and noise levels. There should also be sufficient access provided for large turbine exhausts, ventilation ducts, electrical and instrument trays. Additional considerations are escape routes and access for maintenance or replacement of large, heavy equipment.

Factors Affecting Operational Loads and Topside Platform Areas

Optimization

Optimization of platform facilities can be defined as limiting the amount of equipment to that which actually required to safely meet operational demands.

This can have a significant effect on the platform area requirements, the topside facilities weight, and the total installed cost. Optimizing the number of oil and gas separator trains, the number of gas compression trains, and the selection of equipment and the maximum utilisation of all facilities for example can result in reducing topside platform area, weight and cost by 25% to 40% [5].

Careful phasing of facilities could also result in reducing the platform area and weight. A platform with a large drilling program for example can have the drilling equipment removed upon completion of drilling, leaving only that equipment needed for a workover operation. Space may then be available for the deferred equipment such as water injection or gas compression facilities. Effluent water, increasing in volume with time, may also have its facilities phased, using the space vacated by drilling facilities.

Operating Weight of Living Quarters

The operating weight ofthe living quarters consists of personnel effects and galley consumables. On large latforms, pallets of consumables may be delivered by workboat and must be assigned to the living quarters weight.

Operating Weight Effect of Environment

Environmental loads on offshore platform may induce significant distortion to the topside structure. This distortion, resulting in the differential vertical deflections to the reactions to be redistributed. Wind and wave loads will cause the module reactions to fluctuate. These effects is quite significant for both the module structures and the deck structure. The increase in module reactions may cause load overstressing, and the fluctuating reactions caused by the wave loading will shorten the fatigue life to the deck structure and the modules.

Reservoir Support Facilities

The weight effect of water injection or gas reinjection depends on the method of reservoir pressure maintenance. If seawater is used for injection water source instead of source well water from an aquifer, additional facilities are required for dearation, filtration, and chemical treatment.

If gas is being reinjected into a reservoir, the type of compressor (reciprocating or centrifugal) and the type of compressor driver will make a large impact upon the platform area and supporting utility requirements.

Gas-Oil Ration (GOR)

The method of gas disposal depends on the gas-oil ratio. A GOR greater than 200 to 300 may be economical to export by pipeline to sales. Other methods are high pressure gas reinjection or flare. If gas compresion equipment is required for sales or reinjection gas, the production equipment allocation and support utilities will have very large effect on the platform.

Estimation of The Operational Criteria

Most of the topside facilities are separate sub-assemblies or modules usually designed independently, sometimes to different codes or standards of practice, fabricated in isolation from one another, often in different countries and continents. Thus, very little firm data concerning the individual weight of the modules will be available at the start of the design.

In this paper, studies on the existing jacket platforms in the North Sea is done in order to draw some relationship concerning the topside weight and facilities. Another objective is to try to derive certain recommendations in terms of research toward designing better facilities in the future.

Topside Weight Estimation

Data related to seventeen different facilities, characterised in the following as A through Q, is given in Table 1. The weight given include drilling, production, and processing equipment, utility functions, modules

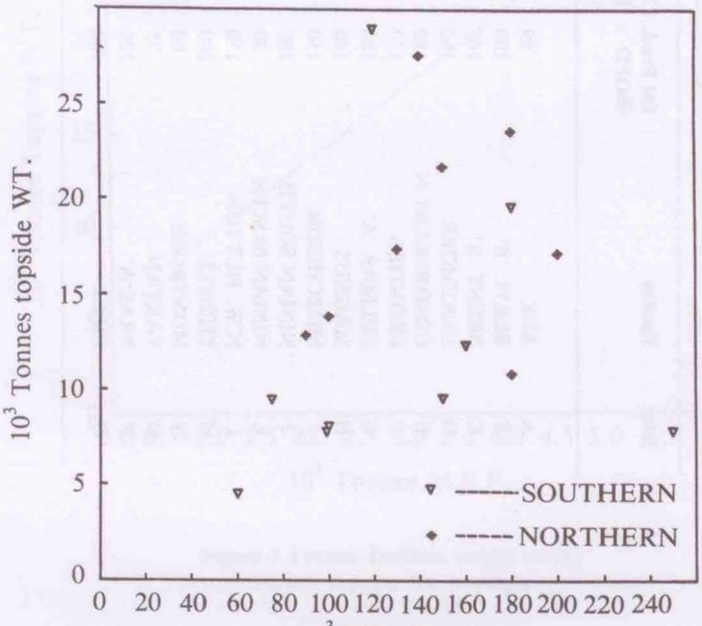

Figure 1. Weight of topside facilities as a function of oil production capacities

Table 1 Functional Information of the Topside Facilities

Item	Facility	Oil Prod. Cap. (BOPD × 10^3)	GOR (SCFD/BOPD)	Water INJ	Gas INJ	Topside Weight (T)	Water Depth (M)	No. of Conductors
A	AUK	99	101	YES	NO	7803	84	12
B	BERYL 'B'	100	1370	YES	NO	3100	120	21
C	BRENT 'A'	100	2000	YES	YES	13980	140	28
D	CLAYMORE	160	—	YES	NO	12400	110	36
E	COMMORANT N	180	500	YES	NO	10870	160	40
F	FRONTIES	150	—	YES	NO	9550	106	27
G	FULMAR 'A'	180	—	YES	YES	19570	82	36
H	MAGNUS	140	—	YES	NO	27600	187	27
I	MURCHISON	150	—	YES	YES	21685	156	30
J	NINIAN SOUTH	180	—	YES	NO	23600	140	42
K	NINIAN NORTH	90	—	YES	NO	12900	140	24
L	N.W. HUTTON	130	—	YES	NO	17420	144	40
M	THISTLE	200	—	YES	YES	17220	162	70
N	MONTROSE	60	—	YES	NO	4486	90	24
O	TARTAN	75	933	YES	NO	9000	142	33
P	BRAE'A'	120	—	YES	NO	29000	103	46
Q	PIPER	250	—	YES	NO	7920	122	36

and minor structural steel as well as miscellaneous items necessary to maintain and safeguard the platforms. Since the weight of the living quarters varies with the number of personnel to be accommodated, it is excluded from the topside weight. The module support frame weight is also excluded because this is necessary to allow comparison of the topside weight only. Note that all the seventeen facilities have the same function that is, drilling, production and accomodation. This table also includes the oil production capacity, the gas and oil ratio, the number of conductors and the depth of water. Qualitative information about other possible platform functions are given (yes/no). Such functions being the water and gas injection.

It is worth noting that if oil production capacity alone is considered in relation to the topside weight; the weight necessary to produce one barrel of oil varies between 0.061 to 0.241 tonnes. Although it is clear that oil production capacity alone does not define the extent of platform facilities, the relationship between weight and oil production capacity is further analysed in Figure 1.

In this figure, two characteristic plots have been used to distinguished between the Northern North Sea platforms and the southern North Sea Platforms. This is necessary, since the design criteria used may not be similar. The Northern North Sea platforms may have to be designed more generously in order to overcome the severe weather conditions as compared to the southern North Sea weather conditions. Two lines may be drawn, the lower to bound the southern platforms and the upper line for the northern platforms.

The most significant deviation for the southern North Sea platform is Piper, which seems to be the lightest and Brae B, by concept of weight against barrel of oil per day, is the heaviest of all. This is best explained by the fact that this platform consists of twin facilities including two drilling modules, two wellheads, and two separator and compression modules. For the northern North Sea, platform Claymore seems to be the lightest.

Within available information the weight data against production capacity plat shows a few cases apparently out of normal bounds. There may be special cases or they may indicate unnecessarily heavy and costly installation.

In order to understand the topside facilities in more detail, several functions of the topside facilities are given in Table 2 in terms of percentage of these function weights over the total weight of the topside facilities.

The most immediate comment about this table is the limited different between the corresponding figures. Some of the percentage deviations may be accounted for by the nature of the facility. Other conclusions are difficult to draw.

Figure 2 shows the relationship between the module support frame weight and the topside facilities weight and Figure 3 gives the relationship between the number of men to be quartered and the accomodation weight.

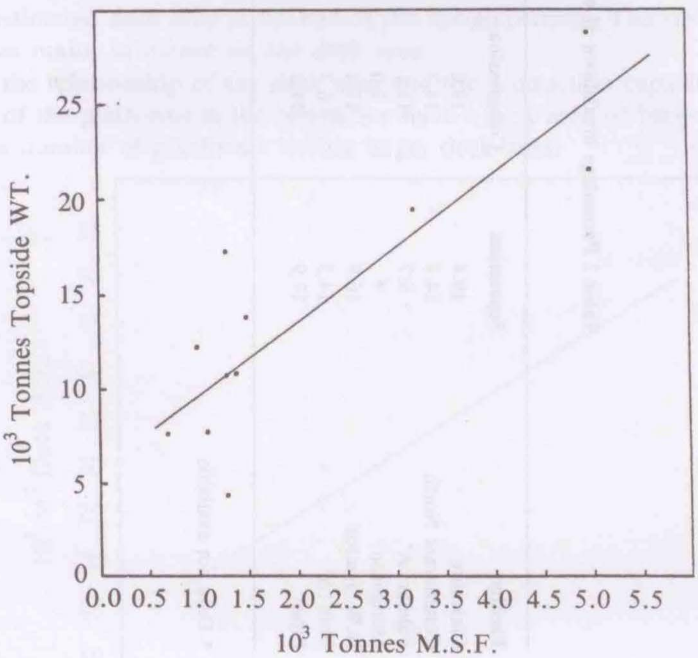

Figure 2 Topside facilities weight versus module support frame weight

Table 2 Percentage breakdown of weights of topside facilities

Facility	Separation	Compression	Utilities	Wellhead	Water Inj.	Generation
Claymore	19.4	19.0	*	12.1	*	20.0
Commorant North	14.7	14.7	10.9	12.9	11.6	10.3
Fulmar 'A'	9.7	11.1	9.3	9.7	11.0	8.9
Murchison	*	7.0	12.6	13.7	*	10.5
N.W. Hutton	16.9	17.4	13.9	*	*	17.2
Brae 'A'	14.5	6.3	6.2	11.0	17.4	10.5
Piper	17.9	14.2	*	12.3	*	14.9

* Data not available

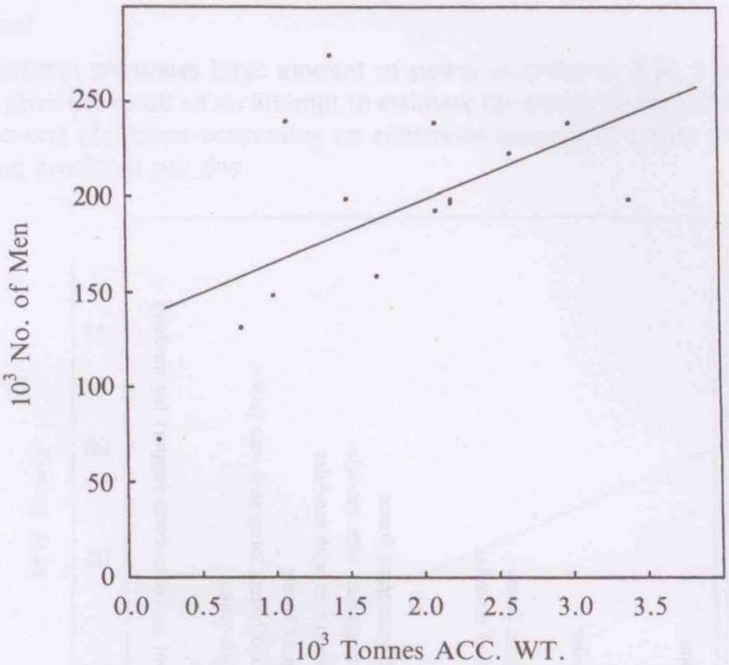

Figure 3. Number of men versus accommodation weight

Deck Area

Another important requirement concerning the topside facilities and the deck structure is the required area needed for the platform. This is necessary, not only to initiate the design of the configuration of the jacket but also to analyse the concentration of the forces from the modules onto the module support frames and subsequently onto the jacket itself.

Table 3 shows the various platforms taking into account the production capacity and the deck area. Even though this analysis includes platforms that produce both oil and gas and there is a certain risk of overestimating the required area nevertheless it is reasonable to consider it as a safely factor rather than to have an underestimated deck area at the end of the design process. The type of deck structure are also given since this has major influence on the deck area.

Figure 4 shows the relationship of the deck area and the production capacity. From this figure, it can be seen that most of the platforms in the North Sea have a deck area of between 1500m and 3500m even though there are a number of platforms having larger deck area.

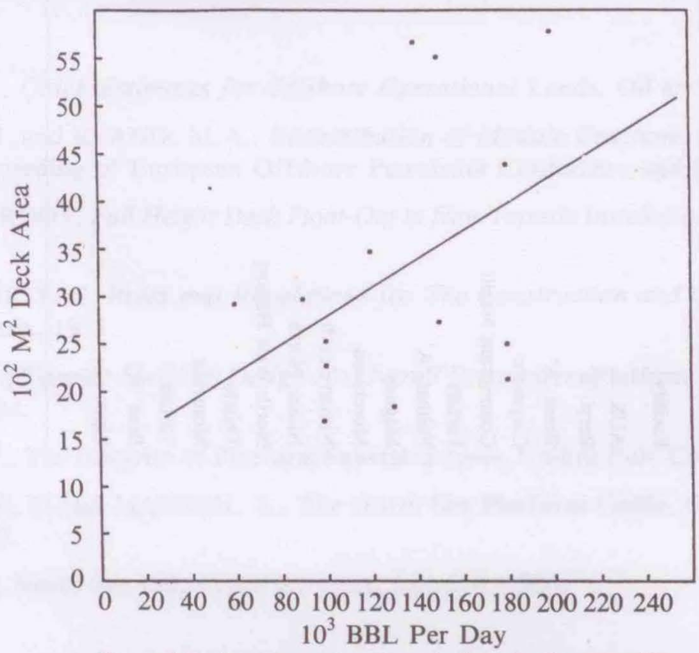

Figure 4 Deck area as a function of oil production capacities

Table 3 Information on deck area and type of construction

Facility	Area (m^2)	Type of construction
AUK	1720	Steel, truss deck
Beryl 'B'	2560	Cellar
Brent 'A'	2300	Steel, plate and girder
Claymore	*	Steel
Commorant North	2158	Steel, module support frame
Forties	2764	Steel, integral part of modules
Fulmar 'A'	2530	Steel
Magnus	5700	*
Murchison	5544	Steel, tubular module support frame
Ninian South	4420	Steel, truss deck integerated with modules
Ninian North	3000	Steel, truss deck integrated with modules
North West Hutton	1872	Steel, module support frame
Thistle	5810	Steel, box-grider skid-beams integrated into jacket
Montrose	2950	Two steel decks with tanks
Tartan	*	Steel
Brae 'A'	3500	Skid, acts as part of jacket to form support for modules
Piper	*	Steel

* Data not available

Power Consumed

An offshore platform consumes large amount of power in order to drill, produce and process the oil and gas. Figure 5 gives the result of an attempt to estimate the power consumed by steel jacket platforms. Again there are several platforms consuming an enormous amount of power compare to the number of barrels of oil being produced per day.

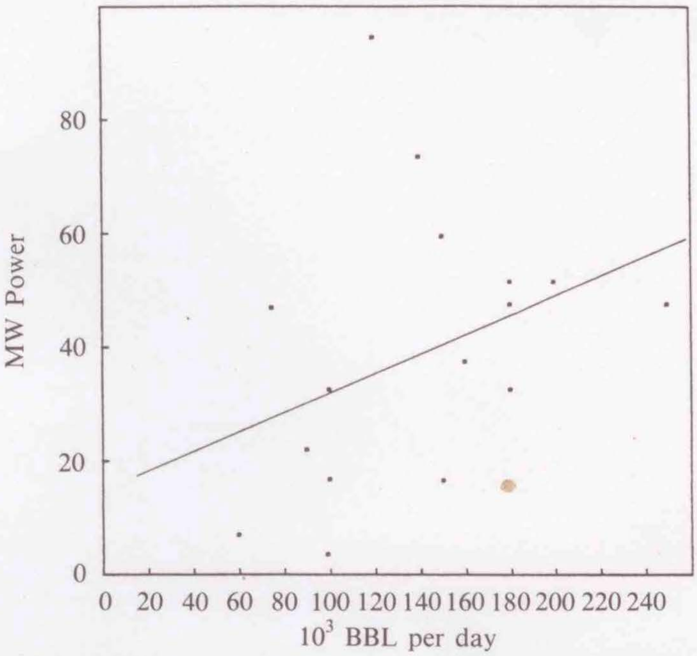

Figure 5 Power consumed as a function of oil production capacities

Conclusion

For no apparent reason related to the overall function, the weight of topside facilities of offshore platforms differ within wide limits. It seems that certain projects have produced heavier topsides and thereby more costly than necessary. A breakdown of total weights indicates a very consistent percentage distribution of weights for different functional parts of the facility.

As weight can be used as a measure of cost, such statistical weight information can be very useful in project decision making. Improved early weight estimates are possible based on a limited, but defined output.

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