

## **Parametric Motion Responses for Deep Draft Production Units**

*Erik Pettersen, and Ulla E. Machado-Damhaug*

Moss Maritime a.s.

Lysaker, Norway

### **ABSTRACT**

Deep draft floating production units are supposed to have motion characteristics that can accommodate dry tree wellheads. The motion response characteristics are normally determined by means of linear hydrodynamic calculations. The paper shows that there are nonlinear phenomena that may influence the final motion characteristics, like the parametric resonance. We explain the theoretical background of this, and discuss different measures that can reduce the adverse effects of it for different types of deep draft floaters.

**KEY WORDS:** Parametric motion; Octabuoy; SPAR; pitch; Mathieu's differential equation.

### **INTRODUCTION**

Oil production from floating offshore structures is either based on dry tree risers or flexible risers from sub sea wellheads. Up to now, dry tree solutions are normally accommodated by TLP platforms or SPAR buoys. Ordinary semisubmersibles and FPSOs are normally accommodating flexible risers. The reason for this is the fact that dry tree risers require the motions of the production unit to be relatively moderate; within the stroke lengths of available heave compensators.

The "dry tree floaters" have some inherent drawbacks. The TLPs will have very expensive and complicated tether system for large water depths. SPAR buoys have almost no form stability and need to trade large wind heeling angles with reduced topside weight. Therefore it can be interesting to develop deep draft semisubmersible units as dry tree production units, especially for large water depths.

So-called deep draft semisubmersible column stabilized units have the potential to accommodate dry tree risers due to reduced wave excitation at deeper drafts. Even if such units have been projected for some years now, very few, if any, have been constructed or put into operation. There is consequently no full scale experience with how such units will behave in real wave conditions.

When extrapolating the knowledge from known technology beyond the

frontiers of full scale experience, there is always the danger of overlooking something. Even if today's computer tools are very advanced, most of them are still based on several simplifications such as the assumption of linearity between waves and responses, linear damping, etc. An example from the past where the analysis tools were not able to predict the correct behavior is the "ringing" phenomena of TLPs.

When it comes to deep draft floaters, these units have the potential for very favorable motions. First of all the fact that deep draft (say above 40 m draft) will, very much, reduce the wave excitation forces and moment. In addition to this, it is possible by proper scaling of the relative proportions of the underwater elements (pontoons and columns) to reduce the wave excitation pitch (and roll) moments to almost zero, at least for the most important frequencies.

The question is now if this theoretical ideal picture can be negatively influenced by non-linear response characteristics. In the following we shall discuss the so-called parametric coupling between heave and pitch/roll, also called the Mathieu motions.

### **PARAMETRIC RESONANCE**

Parametric resonance has been known from a long time and is often known as Mathieu instability. It was originally shown theoretically that this effect could happen, but in the start it was just considered to be of scientific interest. It has later been shown, however, that this phenomenon is in fact very important for floating structures and there have probably been several serious capsizing incidents that can be credited to parametric resonance.

The question of reduced stability of ships in waves caused by parametric roll has been addressed by several papers. One of the last is by Boroday and Rakhmanin (2000).

Excessive parametric roll motions have often been experienced in head or following waves where the roll excitation has supposedly been very small. It is therefore assumed that parametric roll/pitch motions can also be a problem for deep draft semisubmersible units even if the roll/pitch excitation moments in this case are very small.