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**IMPACT OF AUXILIARY LINES ON VORTEX-INDUCED VIBRATION OF A DRILLING RISER SYSTEM**

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Vortex-Induced Vibration (VIV) has become one of the major problems that arises during a drilling operation, leading to riser failure. Engineers are concerned with the flow characteristics and control of a drilling riser to prolong the service life in order to optimize the operation for drilling. Auxiliary lines are typically integrated and attached to the outside of the main drilling riser. Apart from its technical functions, the auxiliary lines are expected to control the flow characteristics around the riser which eventually reduces the vibration of the riser system. However, its optimum geometrical size and gap between the auxiliary and the main riser are still scarcely studied. In this research, the effects of various incidence angles, diameter ratios (*d/D*) and gap ratios (*G/D*) were studied numerically using Computational Fluid Dynamics (CFD). Of particular interest is to study the flow characteristics around the main drilling riser with the auxiliaries acting as passive control rods for VIV suppression. Besides, the flow past a fixed and freely vibrating cylinder also are investigated. The riser system was modelled with six auxiliary lines with incidence angles (θ) of 0° to 50°, *d/D* of 0.10 to 0.60 and *G/D* of 0 to 2.00. The simulations were conducted in the laminar flow regime at Reynold Number of 200. As a result, it was found that the hydrodynamic forces were reduced as the *d/D* was increasing. This phenomenon was also observed for high *G/D*, which reduces the forces on the main drilling riser. The vortex shedding was significantly suppressed for auxiliaries with the range of *G/D* between 0.3 and 1.4. This shows that the hydrodynamic forces can be reduced by altering the interaction of

the vortices in the wake region using auxiliary lines. In addition, the simulation also concerns on Single Degree of Freedom (SDOF) of the freely vibrating riser. The results reveal that the freely vibrating riser experienced higher lift and drag forces compared to the fixed riser due to the synchronization (lock-in) of the shedding vibration and natural frequencies. Finally, this research could potentially be used in the designing stage of an optimum drilling riser system by considering significant governing factors.

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# IMPAK GARISAN BANTU TERHADAP GETARAN AKIBAT PUSARAN DARI SISTEM PENAIK PENGGERUDIAN

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Getaran akibat vortex (VIV) telah menjadi salah satu masalah utama yang timbul semasa operasi penggerudian, yang menyebabkan kegagalan semakin meningkat. Jurutera mengkaji ciri aliran dan kawalan riser penggerudian untuk memanjangkan hayat perkhidmatan untuk mencapai tahap optimum bagi persekitaran operasi untuk penggerudian. Garis bantu biasanya disatukan dan dilekatkan di bahagian luar riser penggerudian utama. Garis bantu diharapkan dapat mengawal ciri aliran di sekitar riser yang akhirnya dapat mengurangkan getaran sistem riser. Walau bagaimanapun, ukuran dan jurang geometri optimum antara garis bantu dan riser utama masih belum dapat dikaji. Dalam penyelidikan ini, kesan pelbagai sudut kejadian, nisbah diameter (*d/D*) dan nisbah jurang (*G/D*) dikaji secara berangka menggunakan Pengiraan Dinamik Bendalir (CFD). Yang menarik adalah untuk mengkaji ciri-ciri aliran di sekitar riser penggerudian utama dengan garis bantu berfungsi sebagai batang kawalan pasif untuk penekanan VIV. Selain itu, aliran melewati riser penggerudian tetap dan bergetar bebas juga diselidiki. Sistem riser dimodelkan dengan enam garis bantu dengan sudut kejadian 0° hingga 50°, *d/D* dari 0.10 hingga 0.60 dan *G/D* dari 0 hingga 2.00. Simulasi dilakukan dalam rejim aliran laminar dan Nombor Reynolds ialah 200. Hasilnya, didapati daya hidrodinamik berkurang apabila *d/D* meningkat. Fenomena ini juga diperhatikan untuk *G/D* tinggi, yang mengurangkan daya pada riser utama. Penumpahan pusaran secara signifikan ditekan untuk pembantu dengan julat *G/D*

antara 0.3 dan 1.4. Ini menunjukkan bahawa daya hidrodinamik dapat dikurangkan dengan mengubah interaksi pusaran di kawasan bangun dengan menggunakan garis bantu. Di samping itu, simulasi juga berkaitan dengan satu darjah kebebasan (SDOF) riser yang bergetar bebas. Hasil kajian menunjukkan bahawa riser yang bergetar bebas mengalami daya tarikan dan daya tarikan yang lebih tinggi berbanding dengan riser tetap kerana penyegerakan (mengunci) getaran penumpahan dan frekuensi semula jadi. Akhir sekali, kajian ini berpotensi digunakan dalam peringkat reka bentuk sistem riser penggerudian optimum dengan mengambil kira faktor pentadbir yang penting.