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LABORATORY SIMULATION /COMPENSATION DEVICE OF THE FLOATING CRANES PITCHING MOVEMENT

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Abstract*: In recent years, floating cranes have been successfully used in offshore oil and gas operations. On the sea floor, there are installed specific mechanisms to vessels operating on the surface in a dynamic position, which are intended to counteract the action of the waves when the loads are handled by the cranes. In this paper, the authors present a test device developed at INOE 2000-IHP for the experimental study, on a small scale of the disturbing pitching movement. A test stand for two hydraulic servo-cylinders is also described and the results of the laboratory tests are presented.*

Keywords: *Marine operations, waves compensator, hydraulic mechanism for counteracting the waves acting, mathematical modeling, numerical simulations*

1. Introduction

Floating cranes are installations used in ports and waterways at loading, unloading and reloading of heavy goods and parts, at the construction and rescue of failed vessels, at the installation of seaports and at the execution of various hydrotechnical works. They are also used in various handling operations of general merchandise with hook, respectively of ores, coals or other bulk products, with the grab or for transhipment of heavy loads. In recent years, these cranes have also been used in offshore oil and gas operations. They are provided with specific mechanisms to counteract the action of the waves on the handled loads. The vessels and floating platforms on which cranes are mounted are subjected to a specific roll and pitch movements, which can affect the handling of loads, in some cases even arriving at unwanted accidents, Fig. 1,[1].The disturbing pitch movement occurs around the transverse axis of a mobile system. In navigation, pitch is the longitudinal balancing motion of a vessel in march or stationary. It is due both to waving motion of the water, i.e. waves and wind, and consists of submersion in the water and the alternate lifting of the bow and stern. For experimental, small-scale study, of this phenomenon, in order to find of technical solutions for compensating the waves disturbance movement, applicable to the floating cranes, was carried out at INOE 2000-IHP Bucharest, the test device, shown in Fig. 2 ÷ Fig. 5, [2]

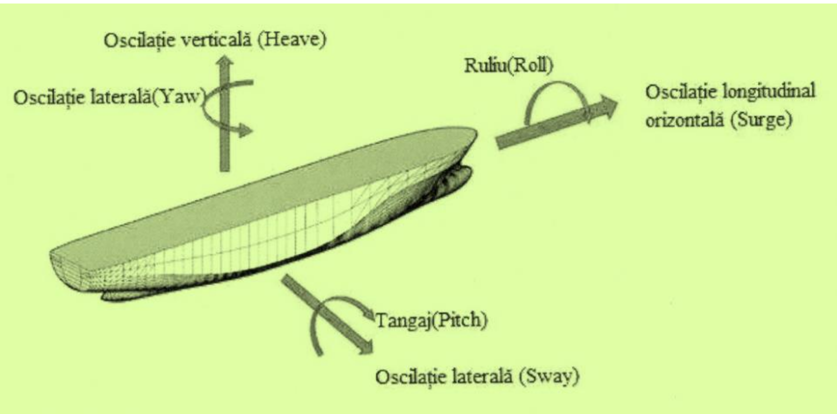

Fig. 1. The oscillatory movements of a vessel,[1]

Fig. 2. Device assembly,[2] **Fig. 3.** Detail grip for servocylinders,[2]

Fig. 4. Double mobile slide detail ,[2] **Fig. 5.** Driveway slides detail, [2]

2. Description of the test device

The device consists of two identical servo-cylinders, captured in a vertical position on a metal support made of a square calibrated metallic pipe (Fig.2). The body of the lower cylinder (Øpiston = 63,5mm, Ørod = 32mm, stroke = 300 mm) is attached to the metal support stand and its rod of a mobile double slide provided with four rollers; the body of the upper cylinder is attached to the same mobile double slide, and its rod of a mobile simple slide provided with two rollers. With this gripping system (Fig. 3), only the rod is movable at the lower cylinder, and both the body and the rod are movable to the upper cylinder. The two servo-cylinders also each includes a proportional hydraulic directional valve Dn 10 and a linear displacement transducer. The two movable slides have the displacement possibility on a driveway (Fig.4 and Fig.5).
The lower servocylinder simulate the disturbance movement caused by the waves in the vertical direction, and the upper servocylinder simulate the hydraulic compensation system of this disturbance, wiyh practical applicability at the floating cranes [2].

3. Description of the testing stand

The two hydraulic servo-cylinders were connected to a testing stand, Fig.6, with two pressure outlets, from the IHP laboratory. The stand has the following technical features [1]:
-pressure: max.40 bar (setting pressure safety valve stand);
-operating flows: max.30 l / min (for each pressure branch, adjustable flows rate from the adjustable pump of the stand); Laboratory tests useful power: 5 kW;
- maximum power installed on stand: 15 Kw;
-voltage supply drive motor variable flow volumetric pump: 380 VDC;
-voltage supply proportional electromagnets: 24 VDC;
-power control proportional hydraulic directional valves: 4 ... 20 mA;
-working domain displacement transducers: -10V ... + 10V

Fig. 6. Splitting the joint P of the stand in two cylinders power supplies,[2]

4. Results of laboratory tests

Laboratory tests were performed under the following conditions, [1]:
a) The testing device was placed in the servo-hydraulic and proportional equipments testing laboratory of IHP Bucharest, which contains a specialized stand;
b) The verticality of the test device has been checked and corrected by handling the four riding bolts mounted on the device frame;
c) The easy and unobstructed movement, on the drive-way of the two movable slides of the hydraulic cylinders was checked and found;
d) The two proportional hydraulic directional valves and the two hydraulic cylinders have been hydraulically connected;
e) The stand pressure valve was set at 30 bar and the adjustable volumetric pump flow rate at 60 l / min.
f)Ventilation of the hydraulic circuits has been performed by alternate manual switching of the hydraulic directional valves, followed by loosening and clamping of the screwed connections;
g)Through the programmable machine, the stroke transducers and the proportional electromagnets of the hydraulic directional vanes have been connected electrically.
h) Sinusoidal, trianguar, rectangular excitation signals of the servo-cylinder (the lower servo-cylinder) for vertical waves motion simulation were generated.

g) For these signals were drawn the graphs that represent the dynamic behavior of the hydraulic system for compensation the disturbances generated by the waves, of the type of hydraulic servomechanism tracking (the upper servocylinder).

For exemplify the tests, it shown in Fig. 7 the dynamics of the tracking hydraulic servosystem, when a constant sinusoidal signal with a frequency of 20 mHz and an amplitude of 120 mm is applied at the input of the hydraulic servomechanism for generation the disturbing motion of the waves. The test was conducted for 115 s.
The linear displacement inductive transducers of hydraulic cylinders have been set such that they also provide informations on the real movement direction (the upper servocylinder moves in the opposite direction to the lower servocylinder).
The results of the measurements, chosen from a stability interval of the laser-controlled tracking hydraulic servomechanism, between seconds 34 ... 100, are shown in Tab 1, [2].

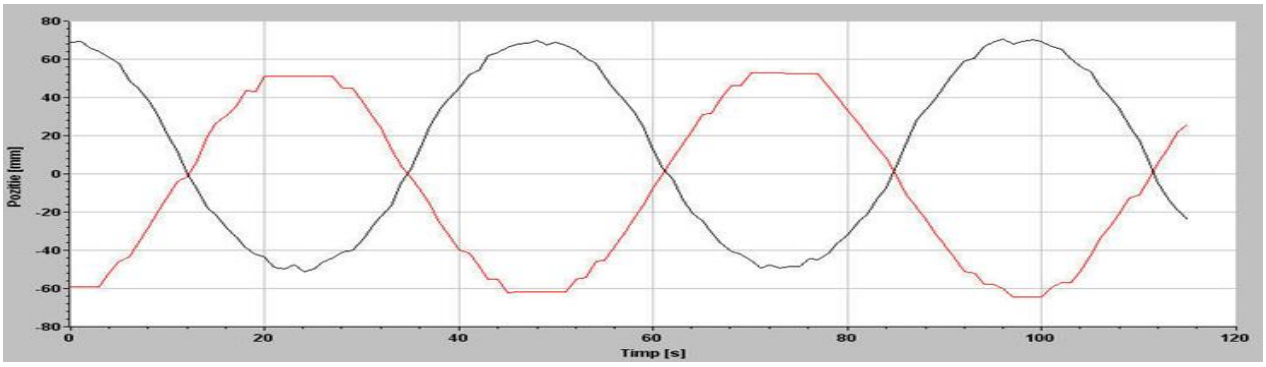

Fig. 7. The behavior of the tracking servomechanism (red) to the waves simulation servomechanism disturbance (black), which is excited with a frequence of 20 mHz sinusoidal signal, [2]

Table 1: The measurements's results represented by the graph in Fig.7, [2]

Time [s]	Waves profile [mm]	Displacement tracking system [mm]
34	-469,415,283,203,125	452,848,111,572,268
35	253,923,339,843,749	-199,534,489,257,812
36	140,272,521,972,656	-877,726,174,682,616
37	242,372,192,382,813	-155,293,231,738,281
38	332,293,273,925,781	-254,061,776,794,433
39	396,992,919,921,875	-326,088,010,791,015
40	4,482,587,890,625	-398,109,021,191,406
41	518,364,013,671,875	-413,960,533,581,543
42	543,018,981,933,594	-484,256,107,128,906
43	618,493,530,273,437	-552,978,695,056,152

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Table 1: (continuation) The measurements's results represented by the graph in Fig.7, [2]

Time [s]	Waves profile [mm]	Displacement tracking system [mm]
44	635,161,376,953,125	-552,722,003,125
45	660,579,895,019,531	-62,022,502,322,998
46	678,940,734,863,281	-620,099,646,411,133
47	684,958,129,882,813	-619,887,717,651,367
48	697,086,669,921,875	-619,688,359,155,273
49	673,615,844,726,563	-619,464,616,870,117
50	689,706,970,214,844	-619,130,968,859,863
51	672,895,385,742,187	-618,801,451,379,394
52	646,726,623,535,156	-54,994,234,576,416
53	6,031,865,234,375	-540,645,311,486,816
54	577,966,491,699,219	-459,289,019,995,117
55	508,699,951,171,875	-4,526,859,109,375
56	441,773,620,605,469	-380,583,036,169,433
57	385,130,432,128,906	-310,622,676,660,156
58	325,839,660,644,531	-229,465,680,603,027
59	234,061,157,226,562	-157,224,690,588,379
60	126,471,130,371,094	-778,735,032,958,983
61	286,143,188,476,564	0.102380919189471
62	-261,438,598,632,813	780,153,814,208,987
63	-133,595,947,265,625	155,638,809,094,239
64	-210,845,275,878,906	232,299,255,773,926
65	-244,370,544,433,594	309,712,615,002,442
66	-309,001,831,054,688	317,416,883,361,816
67	-365,885,437,011,719	394,404,219,958,496
68	-404,054,138,183,594	462,255,959,777,832
69	-423,079,833,984,375	462,811,279,553,223
70	-451,504,943,847,656	526,763,914,868,164
71	-491,977,966,308,594	526,677,257,824,707
72	-474,029,479,980,469	526,618,726,220,703
73	-492,960,266,113,281	526,540,088,500,977
74	-483,058,166,503,906	526,368,287,890,625
75	-486,298,095,703,125	525,936,411,047,363

Table 1: (continuation) The measurements's results represented by the graph in Fig.7, [2]

Time [s]	Waves profile [mm]	Displacement tracking system [mm]
76	-445,271,545,410,156	524,980,965,905,762
77	-448,676,940,917,969	52,478,274,251,709
78	-418,021,423,339,844	463,711,861,169,434
79	-360,566,101,074,219	399,172,280,725,098
80	-319,608,276,367,188	330,113,207,019,043
81	-251,882,690,429,688	269,566,062,133,789
82	-211,139,526,367,188	201,172,192,907,715
83	-138,700,012,207,031	148,051,362,207,031
84	-704,994,506,835,936	823,437,141,845,704
85	408,278,198,242,186	-105,097,755,859,373
86	158,526,306,152,344	-106,098,254,138,183
87	275,133,178,710,938	-173,294,070,031,738
88	335,576,904,296,875	-240,064,189,111,328
89	387,102,355,957,031	-304,788,834,106,445
90	461,951,599,121,094	-373,395,388,830,566
91	534,602,233,886,719	-441,952,219,543,457
92	589,571,594,238,281	-512,032,742,785,645
93	605,573,181,152,344	-520,894,642,041,016
94	66,569,921,875	-579,551,244,494,629
95	686,786,743,164,063	-579,245,469,677,734
96	704,970,397,949,219	-599,941,567,993,164
97	681,842,163,085,938	-646,685,564,892,578
98	691,039,001,464,844	-646,569,994,140,625
99	70,250,634,765,625	-64,625,687,265,625
100	691,003,173,828,125	-646,074,898,120,117
101	668,007,690,429,687	-594,501,744,348,144
102	653,177,001,953,125	-567,164,353,222,656
103	599,284,057,617,188	-567,004,408,178,711

5. Conclusions

1. The results of the experimental tests indicate that the hydraulic tracking servomechanism is fast and stable in operation.
2. These dynamic performances recommend that the servomechanism tested in the laboratory is a technical solution to compensate the disruptive effect of the floating cranes.

Acknowledgments

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