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Fuzzy control of a swells canal system

Taieb Ben Romdhane [a,*], Raouf Ketata [a,b], Sofiene Hermi [a]

[a] Département de Génie Physique et Instrumentation, Institut National des Sciences Appliquées et de Technologie, Centre Urbain Nord, BP No. 676, 1080 Tunis Cedex, Tunisia
[b] Research Unit on Intelligent Control, Design and Optimization of Complex System (ICOS), University of Sfax, National School of Engineers of Sfax, Tunisia

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Abstract

This work forms a part of the research undertaken on the maritime developments behaviour submitted to the action of sea waves. To succeed in this objective, we have conceived and achieved a system of artificial wave generation in a swells channel (channel of 37.5 m of length, 1 m of width and 1 m of depth). Indeed, the simulation of swells on scale model has many advantages. We can mention the construction of dykes for the protection of ports, the didactic interest of conception and generation of new models of waves and the construction of boat shells. The installed canal has to achieve tests of developments stability in the domain of the maritime hydraulics. Every work or scale model is constituted of several layers of ripraps of shapes and well-determined relative density. Thus, the survey of stability consists in reproducing in similitude (scale 1/20) in the swells canal to observe their effects on the holding of riprap (accumulation of boulder) or the artificial blocks of the scale model. Otherwise, the modelling of the process of swell generation is described by complicated physical laws and requires important means of computation. To solve this problem, we have conceived a system based on fuzzy logic permitting to assure the generation of coherent command data with the statistical parameters characterizing the oceanic waves, and to guarantee its conformity to the model of Pierson Moskowich spectrum.

Keywords: Fuzzy logic; Pierson Moskowich spectrum; Swell generator; Average period; Average height

1. Introduction

Researches in the maritime hydraulics domain increased for example in France and Sweden. It is extend of the hydraulic effect prevision on shipping and the great port arrangement, until problems related to the conception of small harbours in particular pleasure ports [10,11,16]. Many specialists studied oceanic waves while using the concept of wave spectrum. After 1950, a lot of efforts and studies have been agreed for the development of spectrums models [3]. These models are applied to estimate the significant height and the average period of waves that are obtained by direct measures or by visual measures. However, it is difficult to describe perfectly the sea free surface by a computation and swells modelling theory. Thus, we intended to use the heuristic methods permitting us, on one hand, to simplify the conception process of digital control of swells generation mechanism, and on other hand, the regulation of the process in step with the adopted energy spectrum. In this context, the fuzzy logic appears therefore, among the most suitable methods to fulfil its expected results. In this setting, we are interested in the conception and implementation of a control law allowing to reproduce as faithfully possible, the Mediterranean wave. We subdivided this survey into two parts. The first is interested in the conception and the generation of digital control of random swells generator, while conforming to a Pierson Moskowich energy spectrum. The second is dedicated to the development of a control law permitting the regulation of generated swells in the canal, in order to satisfy initially the conformity with the parameters of the adopted energy spectrum. Those parts, account for other constraints: the respect insurance of the mechanical and electric limits of the generation system (frequencies limits, displacements, acceleration, torque, . . .).

2. System description

Generated swell is produced by a mobile organ (beating flap) within a canal filled of water. This flap is mechanically linked to

* Corresponding author. Tel.: +216 20 200 575/71 703 829, fax: +216 70 749 091/71 704 329.
E-mail address: BENROMDHANE.T@planet.tn (T. Ben Romdhane).

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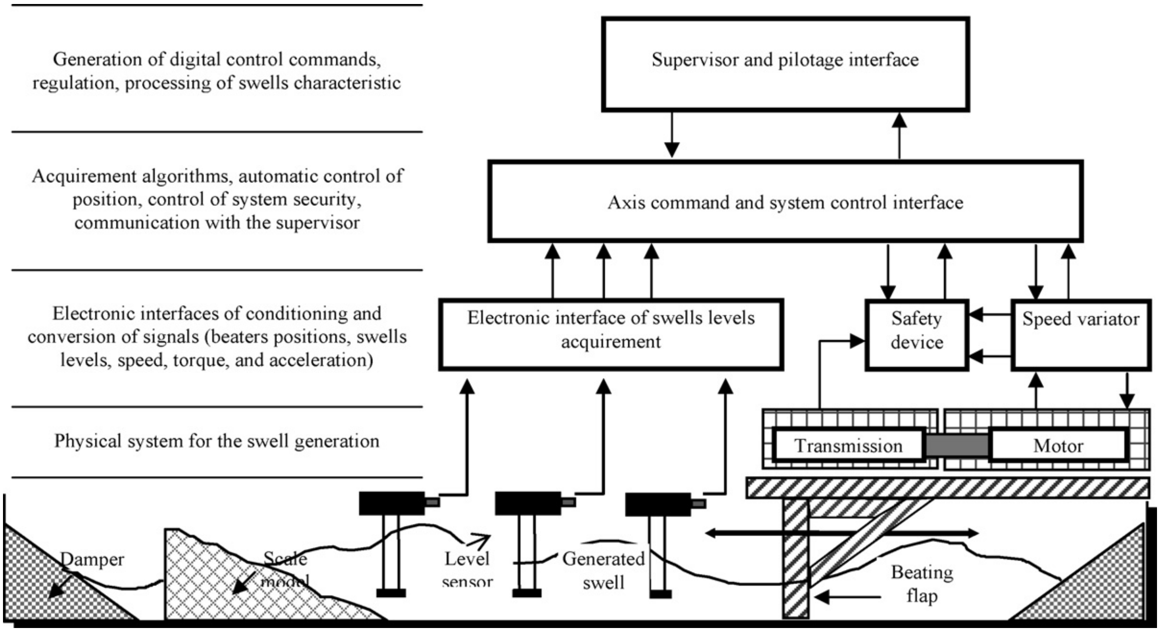

Fig. 1. Swells canal system.

the rotor of an electric motor that produces the sequences of movements, creating the desired swells. The motor is digitally controlled by a speed variator or servo motor, which is linked to an axis control board that pilot the swell generator system (Fig. 1).

This board allows the acquirement of positions and displacements of the beating flap. It also assures the automatic control of position and speed of the axis command system. In addition to these functions, it allows the control of security parameters in real time for instance: the sudden accelerations, the high currents and voltages, energy recuperation resistances temperatures owed to braking and sudden changes of displacement directions.

Other functions are assigned to this board, such as the conditioning and the acquirement of swells heights through levels sensors installed in the canal [13].

The axis control system is supervised with a microcomputer that is dedicated to the conception of digital control and the regulation of global system to assure the conformity with the adopted energy spectrum. Generated swell in the canal is illustrated in Fig. 2.

The conception and the manufacture of this transmission system result in characteristics given in Table 1.

Fig. 2. Generated swell in the canal.

Table 1
Swells generator's

Positioning maximal speed (m/s)	1.31
Maximal frequency of beating (Hz)	2.00
Maximal acceleration of piston (m/s^2)	9.48
Transmission system is high fidelity. Indeed, the difference between the input and the output of the movement is limited to 4 mn	
Maximal course of beater piston (cm)	52.00

Table 2
Characteristics motor's

Output power (kW)	15.00
Maximal torque (N cm)	7350.00
Maximal speed (r/min)	2000.00
Angular acceleration (rad/s^2)	2616.00
Rotor inertia ($\times 10^{-2}$ kg m^2)	2.75
Mechanical time constant (m s)	1.22
Thermic time constant (min)	47.00
Power rise factor (kW/s)	188.40

The choice of system motorization has been decided while referring to Table 2.

3. Swell generator digital control

The determination of digital control of the swell generator is based on the adoption of an energy spectrum judged by maritime hydraulics specialists and taking in consideration different electromechanical constraints of the system.

3.1. Swells generation

To maintain swells generation, we have adopted the Pierson Moskowich [1] energy spectrum reassuring an approximate representation to the Mediterranean waves, given by Eq. (1) and