P-35: Large Scale Ultrasonic Boat Cleaning System: in situ tests with 20 kHz Specific Ultrasonic Cleaning Tool

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Ultrasonic cleaning processes are widely used in both laboratories and industrial fields and evidences have been given that ultrasound have a good efficiency (Maisonhaute (2002)), especially at low frequencies (20 to 100 kHz), when high powers can be used.

The operation of boat cockle cleaning is hard and long, and in most of the processes, boats have to be to pull out of the water for a long period. Therefore, this project consist in the development of an automatic cleaning station for immersed parts of boats (cockle, ninepin, etc.) in a self-service mode, by combining ultrasound for washing with a specific water treatment. The cleaning is carried out by 2 tools made of 3 transducers operating simultaneously at low frequency, and moving along the surface by means of programmable logic controllers. The design includes a suction device to retrieve the dirt removed and the process is done directly in the water and should last less than 2 hours for a 15 m long boat. Conception of the different tools and the station has already been detailed (Mazue (2011)) in previous work and the present work will detail the results of an "in situ cleaning test session" in real conditions, i.e. directly on a dirt cockle of a boat located in "La Seyne sur Mer" at the Mediterranean Sea.

1. Materials

1.1. Cleaning Tool

Each cleaning device should include three ultrasonic horns and an aspiration collecting the waste and directing it toward a water treatment plant. This is carried out by a suction device. Mechanical tools allow us to keep the horn-surface distance constant despite the movements. Transducers (Martin Walters) are running at 20 kHz and are driven by a 1000 W power supply unit. Cooling is ensured by compressed air, avoiding them to reach overheating (Curie temperature) because they are able to operate continuously up to 2 hours. The transducers are linked to especially designed wave guides with a 45 mm circular active zone. A grip area completes the protection and restricted the waste dissemination.

Figure 1 : Cleaning Tool

1.2. Moving tool device

As the final prototype of logical controller was not ready to date, a temporary set-up was design and built in order to enable "in situ tests" to be performed in real conditions on a boat immersed into the sea. In fact, even if feasibility tests have shown conclusive results, large scale experiments are always important to collect data on operating conditions (good sealing, no overheat, good position on the cockle,..).

The set-up should be able to support the Cleaning Tool attached by the available grip area and allow us to put it into the water and move it nearby the cockle with the expected angle. If not, the ultrasonic devices will not be close enough to the surface to have the full efficiency. The design of such a device was really complicated, and it appears rapidly that all functions of the final prototypes will be too difficult to obtain. So, only one freedom-degree (horizontal motion) will be authorized by adding some wheels to the device.

1.3. Observation device

A waterproof video recorder was needed to observe continuously our cleaning test session (figure 2: mini ROV supply by Subseatech company). This equipment consists in a little submarine including a video recorder and

able to move in all the direction in water. It can be driven by a computer at 50 meter length distance, outside of the water. This device allows us to see in live show the Cleaning Tool inside the water and to record the different tests.

Figure 2: Observation device

Figure 3: Moving Tool Device

1.4. Test Boat

For this session, the boat must not be cleaned since a few months to have collected enough waste. A ten meter long boat has been lent for this occasion. It was last cleaned six months before and so was representative of the target customers (6 months to one year since last cleaning). A slight layer of natural green fooling was covering all the immersed part of the boat.

2. Results

2.1. Cleaning Tool position

Figure 4: Underwater cleaning test results

Before beginning cleaning tests, various operating parameters have been checked. The position of the cleaning tool vs. the boat cockle was verified, in term of angle of inclination so that the vibrating faces could be consider as parallel to the substrate. But the distances from horn to cockle, maintain into 5 mm was verified as well. All this parameters have to be kept constant during the tool displacement. Moving speed during experiments has been measured up to 4 to 6 centimeter per second, i.e 2 to 3 times faster than normal process speed expected because of manual displacement. Finally, it has been verified that the transducers were well protected from water. Since the inner chambers are pressurized by the air cooling, no sealing problem have been coming into sight.

2.2. Cleaning test results

On picture 4, the efficiency of the Cleaning Tool is clearly put in evidence. The fooling layer is removed in the Cleaning tool pathway. In real conditions, the Cleaning Tool is fully functional and provides an efficient cleaning under the sea level. The design was considered as validated, and interesting operating parameters have been collecting in order to prepare the implementation of logical controllers.

References

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