723. Ultrasonic cavitations research in flowing liquids with low depth of duct

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(Received 1 September 2011; accepted 14 February 2012)

Abstract. A few methods and devices are known that can be used to clean heavily contaminated items (repaired car parts, watch mechanisms, clothing cleaning without washer, etc.). Basically cleaning effect appears in a small volume of liquid which was affected by ultrasonic cavitation. Surely to create cavitations a reason able amount of energy is needed.

In this research we discuss possibility of creating ultrasonic cavitations in flowing liquids with approximate depth of duct of 0.1÷1 mm.

We introduce an ultrasonic device that performs an ultrasonic cavitation. A huge number of modeling analysis was made for this device. A method was developed which allows us to evaluate the power of cavitation in thin layer of liquid. The dependence between depth of liquid and cavitation was explored. The boundaries of application, for research results were defined.

Keywords: ultrasonic, piezoelectric, mechanics, cavitation.

Introduction

A few methods and devices are known that can be used to clean heavily contaminated items (repaired car parts, watch mechanisms, clothing cleaning without washer etc.). Basically cleaning effect appears in a small volume of liquid which was affected by ultrasonic cavitations. Surely to create cavitations a reason able amount of energy is needed.

Sometimes there is no need to create cavitation in volume. For flat surface cleaning it is enough to create cavitation in a thin layer of liquid placed on that surface. In scientific literature there are lots of articles about how to create cavitation in liquid volume (see e.g. [1, 2]). However we were unable to find any articles on how to create cavitation in a thin liquid layer.

Experimental ultrasonic device. Modeling of ultrasonic system

In this research we discuss possibility of creating ultrasonic cavitations in flowing liquids with approximate depth of duct of 0.1÷1 mm.

To achieve such a goal an experimental ultrasonic device was developed and created. As shown on Fig. 1, it consists of bidirectional ultrasonic piezoelectric vibrator (1), and has a long plates attached on each side (2). Fig. 1 also shows the parts of a bidirectional vibrator – piezoelectric rings (3), which are assembled on a pin (4), and strongly compressed between two fluctuation concentrators (5). Such a system was tested on a solar panel for it surface cleaning.

The idea is to create ultrasonic transverse vibrations in long plates. The plates are repetitively (every 134 mm.) situated in neutral zone of solar panel so it is prevent of any shadows falling on active regions of solar panel. The vibration is created by bidirectional vibrator attached by the ends on both plates (which are made of D16T). Other ends of both plates are connected with passive supporting rod.

So the vibrator is generating longitudinal vibrations which are forces long plates to create an intensive transverse vibration.

Fig. 2 shows the modeling of natural fluctuations of bidirectional vibrator (a) and assembled ultrasonic system (b).

Thin layer of liquid flowing down by the surface is affected by ultrasonic waves radiated from earlier mentioned long plates (2), thus cavitation appears in it.

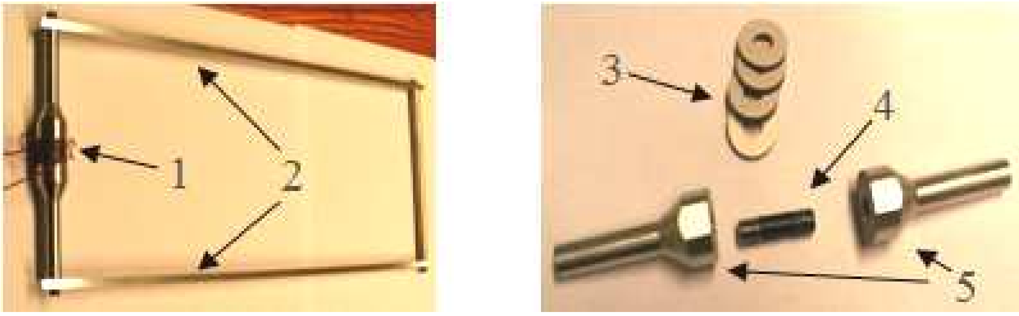
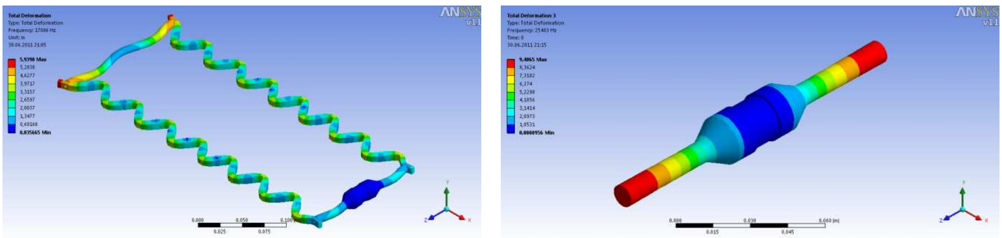


Fig. 1. The basic view of experimental device (400x145x15mm): 1 – bidirectional ultrasonic piezoelectric vibrator, 2 – long plates, 3 – piezoelectric rings, 4 – pin, 5 – concentrators



a) b)

Fig. 2. Modeling results: a – bidirectional vibrator; b – ultrasonic system, which is creating cavitation effect in a thin liquid layer

Ultrasonic cavitation is creating a cleaning effect and prevents pollution appearance after all water droplets dried on surface.

Experimental research

As it is mentioned earlier the promising application of such a system is to clean polluted solar panel surface, during and after polluted rain. The vibrating plates are situated in between active solar panel elements and radiating ultrasonic waves into its active part (Fig. 3). Any amount of liquid, one droplet or entire flow of droplets, placed on surface is affected by this radiation and starts to cavitate or is sprayed when strong pulse of ultrasonic wave appears. During this process any pollution on the surface is forced to disappear.

A number of tests were performed to confirm a possibility and efficiency of such solar panel cleaning. During these tests the cleaning quality was measured by solar panel created voltage and it is variation depending on surface clarity.

The surface pollution indicators: 1-cleand by hands, 2-polluted with dust, 3-dried dust, 4-pollution after rain, 5-after ultrasonic cleaning.

Fig. 4 and Fig. 5 are showing impedance-frequency characteristics of bidirectional ultrasonic vibrator and impedance-frequency characteristics of all system elements assembled together.

Because of plates length (l-400mm, material – D16T aluminum alloy, cross-section 8x4mm) we were unable to get a good connection between two plates on the 16-th mode of transverse vibration and as a result the second peak appeared which can be seen on Fig. 5. For this reason during tests we used a stepped mode on (19,5KHz, ±1KHz (150 V)) and with a step changing frequency of about 80Hz. Still with not perfectly working system we have good results and it is forcing us to continue our tests. Since cleaning surface was not too large the difference between these (voltage) results is not significant, but it is. The results are shown in Table 1 and Fig. 6.

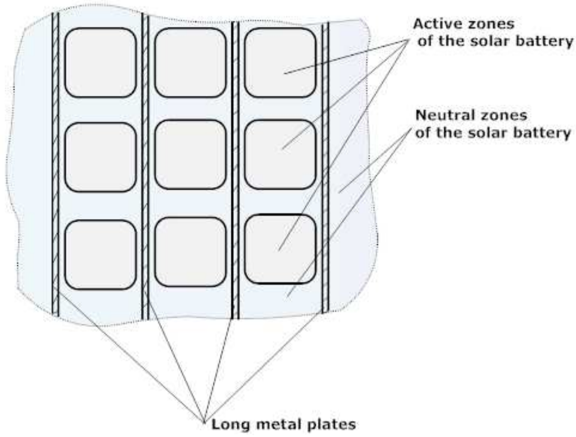


Fig. 3. The schematics of long plates positioning on solar panel surface

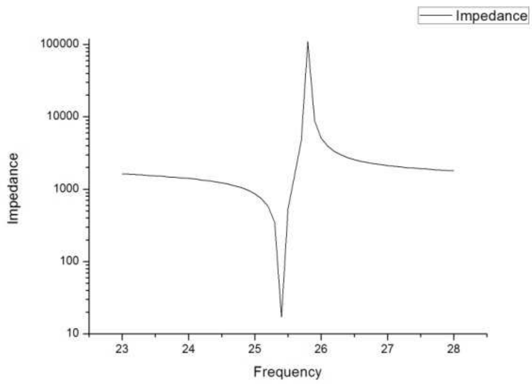


Fig. 4. Impedance-frequency characteristics of bidirectional ultrasonic vibrator

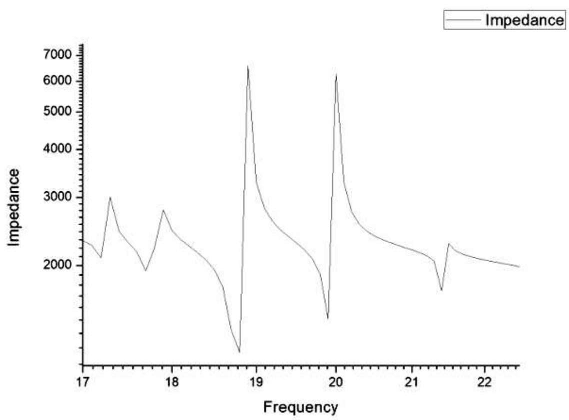


Fig. 5. Impedance-frequency characteristics of ultrasonic system

Table 1. Voltage dependence on surface clarity

	Hand cleaning	Poluted	Dried dust	After rain	After ultrasonic clening
Voltage	4,89 V	4,39 V	4,42 V	4,86 V	4,94 V

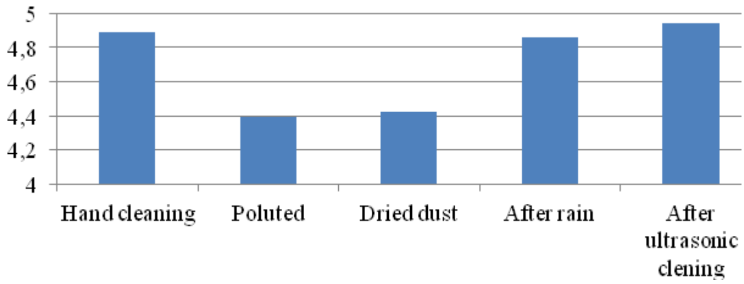
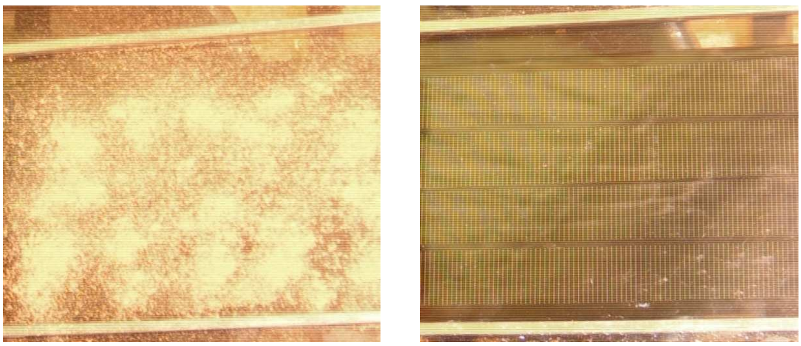


Fig. 6. Voltage dependence on surface clarity

For visual comparison we present a Fig. 7 with (a) artificially polluted solar panel surface with a production of (4.39V) and (b) after ultrasonic cleaning during the rain with cavitation created in flowing liquid and the respectively better voltage output of (4.9V).



a) b)

Fig. 7. General view of some part of solar panel: a – artificially polluted panel; b – same panel after ultrasonic cleaning

Conclusions

The new method of ultrasonic cleaning for flat surfaces is presented and a simple device is created to for polluted surface cleaning.

The optimal modes of vibration are defined for bidirectional vibrator and all system.

The preliminary working conditions of such system are defined and it is cleaning efficiency approved.

Acknowledgements

This research was supported by the Lithuanian Science Council, Scientific Group Project No. MIP-11089.

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