Available online at www.sciencedirect.com

ScienceDirect

Physics Procedia 70 (2015) 76 – 79

Physics Procedia

☒2015 International Congress on Ultrasonics, 2015 ICU Metz

Proposal of Pump Using Ultrasonic Transducer and Opposing Surface

H. Shinada[a], Y. Ishino[a], M. Hara[a], D. Yamaguchi[a], M. Takasaki[a], T. Mizuno[a]

[a]*Saitama University, 255 Shimo-okubo sakura-ku, saitama-city 338-8570, Japan*

Abstract

Conventional pumps include sliding parts and there is a limit of life time due to friction and wear. To solve this problem, a number of pumps using ultrasonic vibration have been proposed. In the present study, we found an occurrence of pump effect when an opposing block faces ultrasonically vibrating surface with small gap. According to the measurement results of gauge pressure, when circumference of the opposing block is tapered, fluid was discharged from the gap of two surfaces. On the other hand, when center of the block is tapered, fluid was sucked in the gap. This paper reports experimental results of the pump effect.

Peer-review under responsibility of the Scientific Committee of ICU 2015

Keywords: Ultrasonic pump, Opposing block, Taper, Squeeze film, Transducer

1. Introduction

Currently, a variety of pumps: for example, oblique flow pump, and piston pump are used in various applications, such as infrastructures, plants and medical equipments. However these pumps include sliding parts. Therefore, there is a limit of durable life due to friction and wear. To solve this problem, a number of pumps using ultrasonic vibration have been proposed. Yun et al. has shown that liquid is sucked into a pipe when the ultrasonic vibrating pipe end is faced at an flat surface with a small gap in liquid [1]. In addition, Hasegawa et al. proposed a miniature ultrasonic pump by using bending disk transducer instead of the piston vibration surface [2]. Suzuki et al. proposed pseudo-saw and trapezoid vibration [3]. Nakanishi et al. proposed a novel pumping method using ultrasound

Peer-review under responsibility of the Scientific Committee of ICU 2015
doi:10.1016/j.phpro.2015.08.046

induced pressure differences and cavitation [4]. Increasing the power of the ultrasound, the steady cavitation clouds start forming around the pipe inlet, which can suppress the negative pressure in the vibrating cycle as well as it cause a continuous pumping of water. Also, in previous report, we succeeded in observing occurrence of pumping effect by combining an ultrasonic transducer and an opposing block with tapered surface [5]. A common feature of such ultrasonic pumps are having no sliding parts. Therefore, the life time of these pumps seems longer than that of the conventional pumps, because there is neither wear nor damage in use. Since some medical devices like MRI use high magnetic field, the ultrasonic pumps have advantages for such medical cases as they can avoid use of magnetic material in their structure. In the present study, we show that influence of verious parameter for pump effect.

2. Principle of the pumping effect by ultrasonic vibration

Fluid medium between two parallel surfaces placed in close each other is considered. This situation is illustrated in Fig. 1. When one of the surfaces is vibrating, fluid repeats inflow and outflow at the end of the two planes [6]. However, in case fluid resistance at the time of inflow and outflow are different, flow in one direction increases. Therefore occurrence of pump effect can be expected. In the present study, it is expected that the flow can be limited in one direction by tapered surface of the opposing block.

3. Transducer and opposing surface

Fig. 2 shows a schematic view of an ultrasonic transducer used for experiment. An implemented bolt-clamped Langevin transducer had a resonance frequency of 28 kHz. An aluminum horn whose resonance frequency was matched with that of the transducer was attached on the top of the transducer. A hole with a diameter of 4.2 mm was machined in the horn as illustrated in the figure in order to provide the path for fluid behavior. The hole in the side was formed at the node of the vibration which was derived by the finite element analysis to reduce the influence of the vibration. Fig. 3 shows detailed view of the opposing blocks. The opposing surface was formed on the end of an aluminum cylinder whose diameter was the same as that of the transducer. In Fig. 3, α and β indicate the taper angle, and l and r indicate taper length.

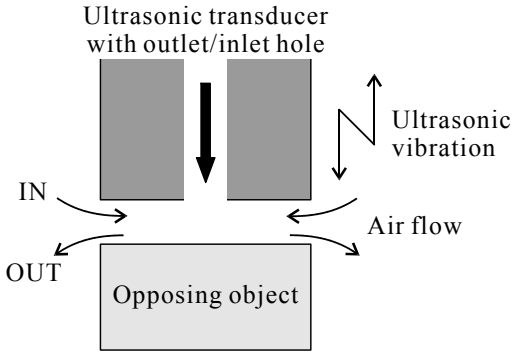

Fig. 1 Principle of pump effect

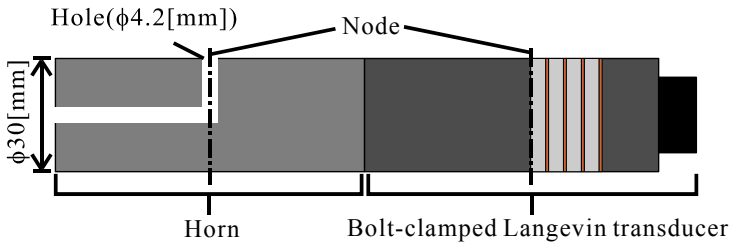

Fig. 2 Schematic view of an ultrasonic transducer with a hole