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Study on Residual Vibration Control of High Amplitude Ultrasonic Transducer

大振幅超音波音源における残留振動の制御

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1. Introduction

We using ultrasonic in various fields such as processing,medicine and architecture engineering.

However, when we use ultrasonic processing the components, It is necessary to avoid the harm that residual vibration created on the components. Excessive residual vibration will cause the components to heat up even cut out or bending. To bring irreversible damage. So an excellent source of ultrasonic transducer wave should own very small residual vibration is and the rise time is also short.

2. Research method

To control the residual vibration, can not just depend on change the style of waveform. Residual vibration is hard be decreacel with any type of waveform. Ordinary, by adjusting the shape of the waveform, although the residual vibration is small, but the signal we actually used is small, too. The formation of high amplitude is an effect of various causes.We using NF WAVE FACTORY 's WF - 1974, to control every factors of the waveform, and using LV-1610 Laser vibrometer with Oscilloscope to monitor vibration. To explored the method of control the residual vibration in four directions.

3. Experiment result

The waveform which is applied on the transducer, by controlling four directions. They are:1. the time width of how many cycles waveform 2. the frequency of the waveform 3. the duty ratio of the waveform 4. the voltage to be applied.

Fig. 1 showed what the cycles and duty means.

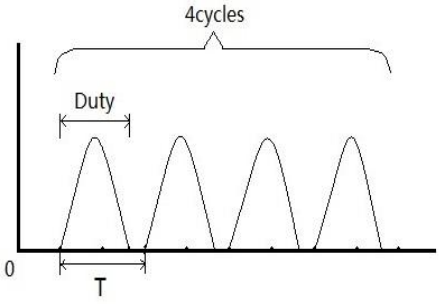

Fig.1 Number of cycles and duty ratio's description

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From these four directions we can own the possible to control the residual vibration. At first we talk about the type of the waveform. In the case of Half-sine, It can be better than Square and Ramp.It's the same with Half -sine if you use Sine waveform, the difference is you do not have to adjust the duty ratio when using sine, and sine is the most ordinary signal been created easy.However, compare to sine, the changes based on Half-sine with duty ratio will be more.

As shown in Fig. 2,we use the Bolt Clamped Langevin Type transducer with the Quality Factor of 150, it's resonance frequency is 61.4 kHz. If we make the waveform which is applied on the transducer at a constant voltage and duty ratio, The point above Fig. 2 showed line has the smallest residual vibration in one section frequency.

This line is meets the equation undered:

$$1/T = \frac{1}{\ln(x+2)} + a \qquad ①$$

The value "a" of ① can vary depending on the ultrasonic transducer, it is not a fixed value.

From the Fig. 2, we can see the relationship between frequency and the number of cycles. From 3 cycles to the + ∞ cycles,we call this section as"autologous vibration stopping section " temporarily.

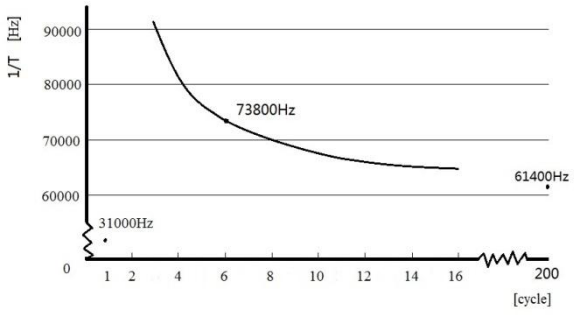

Fig.2 Relationship between frequency and the number of cycles.

For example, the Bolt Clamped Langevin Type transducer with a resonance frequency of 61.4 kHz.

On this line, the smallest residual vibration appeared at 5 or 6 cycles, and the frequency is 77kHz and 73.8k Hz. To how many cycles,there are corresponding frequencies we can find.In one cycle

and two cycles's case, in theory, the frequency will be over 91kHz. Actually, we try to find thefrequency till to 30MHz, there is no applicable frequency which can make the residual vibration small. One cycle is also called monopole pulse, When we use the half resonance frequency, it means about 31kHz, the residual vibration is the smallest. Of course, when applying the Half-sine waveform, it is also necessary to adjust the duty ratio and voltage. Actually, in one transducer, there are several lines like this line. For example, using the frequencies of 52.7k Hz, 73.8k Hz, 92.8k Hz, 125.8k Hz by 6 cycles,The residual vibration is the smallest in the corresponding "autologous vibration stopping section", But the section of Fig. 2 showed is the best one.

As we know, on this line, the very frequency, corresponding a number of cycles. When we multiple the number of the cycles can form the same residual vibration. For example, At 73.8k Hz,6, 12 and 18 cycles waveform can form the same residual vibration .

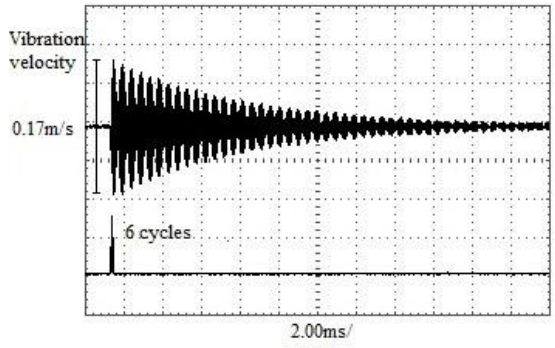

Fig.3 Half-sine waveform ,61.4k Hz in 6 cycles

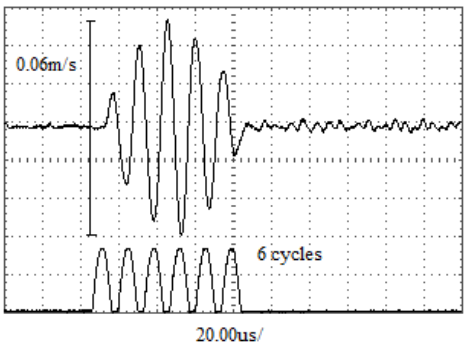

Fig.4 Half-sine waveform ,73.8k Hz in 6 cycles

Fig.3 and Fig.4 is the compare of the effect applying 61.4k Hz and 73.8k Hz in 6 cycles. We found that the influence of the frequency is huge. When applying 61.4k Hz , duration is up to 18ms. When we use the sine, we can find the effect is the same. As Fig.5 showed.

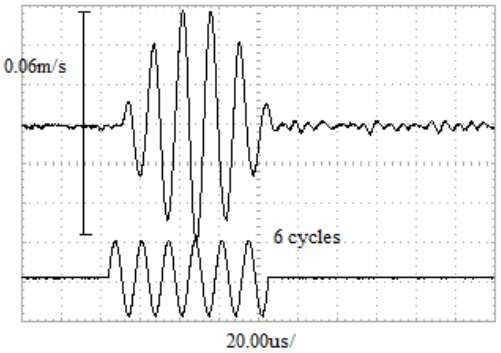

Fig.5 Sine waveform ,73.8kHz in 6 cycles

And Fig.6 is the situation applying 92.8kHz in 6 cycles, maybe the residual vibration is the smallest in its own "autologous vibration stopping section ", we still can tell the section Fig.2 showed line is the best.

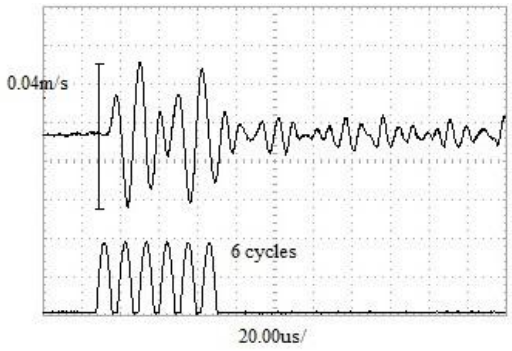

Fig.6 Half-sine waveform ,92.8k Hz in 6 cycles

The change of duty ratio and applied voltage depend on the transducer. For example, in the case of a transducer having the resonance frequency of 61.4 kHz,when the voltage is about 90 V and duty ratio is 76%, the residual vibration is the smallest. Other transducers are most about the same numerical value.

4. Future Challenges

Time width, frequency, duty ratio and voltage. Each of these elements can make influence on the residual vibration .In the future it is necessary to find the relationship between these four elements,to make higher amplitude and decrease the rise time .

References

1. The Japan Society of Ultrasonics in Medicine: Diagnostic Ultrasound.(1994) chap. 1
2. K.Takasaki,K.Imano,H.Inoue:Generation and sound field observation of monopole ultrasonic pulse,SICE,169-1,pp.1-9(1997)