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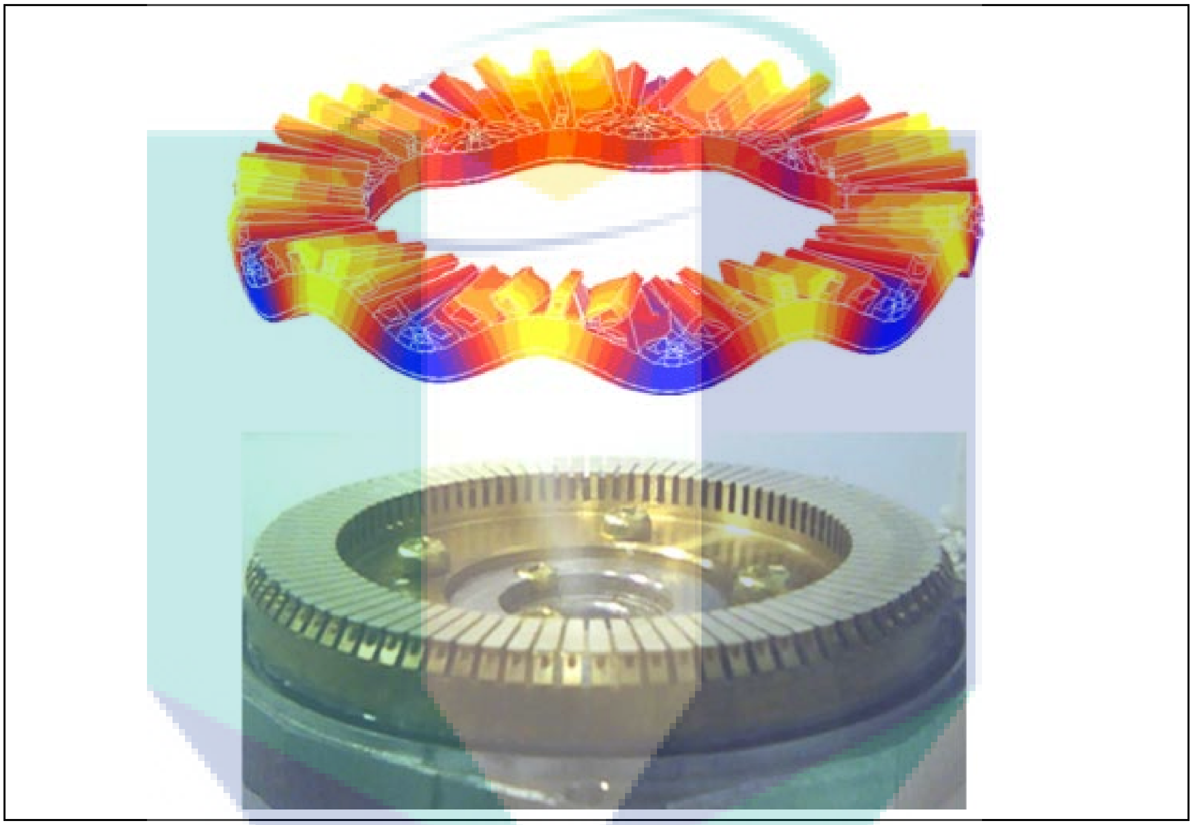

CHARACTERIZING OF ELECTRICAL AND THERMAL CHARACTERISTIC OF PIEZOELECTRIC ULTRASONIC MOTOR FOR A BETTER SPEED AND TORQUE PERFORMANCE

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ABSTRACT (120 words)

Current traveling wave ultrasonic motor (TWUSM) utilizes comb-teeth structure as deflection amplifier. The position of the stator neutral axis to the stator contact surface is one of the factors that influences the deflection amplifier. Stator deflection directly effects on motor performance. In this study, the modification of the comb-teeth stator design is proposed to see its effect on motor efficiency. The modification is done so that the neutral axis position is further distance from the stator top contact surface. The proposed solution is to remove a selected mass element from the comb-teeth structure. Modeling, simulation and experimental work of the proposed concept is carried out utilizing Shinsei USR60 as the chosen TWUSM. The modeling and analyses are conducted through multi-physic approach. The results of the analyses and experimental work reveal that the modified comb-teeth stator increases the position of the neutral axis from the stator top surface. Due to the neutral axis shifting, the results also confirm that the proposed modified motor has higher efficiency compared to the non-modified motor.

1. INTRODUCTION

The performance of TWUSMs greatly depends on the correct design of its stator, which are achieved through appropriate models. Since the invention of the piezoelectric traveling wave rotary ultrasonic motor, there have been many attempts to model the stator of the motor either experimentally or analytically [1,2]. On the perspective of optimum stator structure design, Sashida [17] proposed comb-teeth stator to amplify the amplitude displacement and reduce friction loss at the contact surface. This is done by shifting the position of neutral axis even lower from the top surface of the stator. As a result, the motor operates in higher speed and torque. Hagood and McFarland [3] in their approach of modeling piezoelectric ultrasonic motor stated that comb-teeth structure in motor design will increase the horizontal speed and widen the elliptical orbit on the stator top surface. In addition, Jeong et al. [4] investigated the vibration analysis of the stator of ultrasonic motor. In their research, the motor tangential velocity characteristics due to the variation of the tooth height and width are studied. They found that the ultrasonic motor can be operated without slipping, if the teeth height is appropriately selected.

2. LITERATURE REVIEW

The heat suppression of the piezoceramics is depending on the mechanical quality factor, Q which defined as a ratio of energy stored and loss for each of an oscillation [5]. With a high mechanical quality factor, Q, less heat was generated and this parameter must be taken into consideration [6]. The generated heat during the vibrations influences dielectric loss of piezoceramic material [7].

3. RESEARCH METHODOLOGY

Two structures of USR 6060 Shensei ultrasonic motor stator was used in the experiment of heat dissipation. The stators were made by copper material that divided into 90 pieces of segment and they are supported by piezeceramic at bottom side. One of the USR 6060 Shensei stator was modified by drilling holes at side surface for each divided segments. The holes makes the stator segments appears as hollow geometry instead of solid. The design was considered as a novelty for ultrasonic motor stator.

Finite element analysis (FEA) was applied to simulate the ultrasonic motor characteristic. Computational aided design (CAD) was utilized by integrating meshing elements as 3-D solid. The structure was simulated using harmonic mode analysis to identify the optimized frequency that provides the highest displacement on Z-axis. The range of the frequency is set up to 50 kHz. The optimum frequency of the harmonic analysis was used as an input for transient analysis. The transient analysis was further preceded by providing two sinusoidal input functions which were shifted 90° from each other. The vibration profile of the stator surface was analyzed.

4. FINDINGS

The thermal resistant, *R* is numerically appropriate to the temperature increment during the conversion into thermal energy. The increment of the piezoceramics temperature was able to influence driving frequency of the stator.

Harmonic finite element analysis of USR 6060 Shensei ultrasonic motor stator was run and mode shape results were obtained. The optimized mode shape frequency was determined by analysing the highest Z-axis displacement. From this point of view, frequency 40.6 kHz was the optimized frequency that provides the highest Z-axis displacement.

Based on harmonic analysis result, transient analysis at 40.6 Hz for USR6060 Shensei stator was run. The same frequency was applied for the hollow segments stator. The reason for using the same frequency was to investigate the effect of Z-axis displacements that cause by the hollow structure and not by other factor.

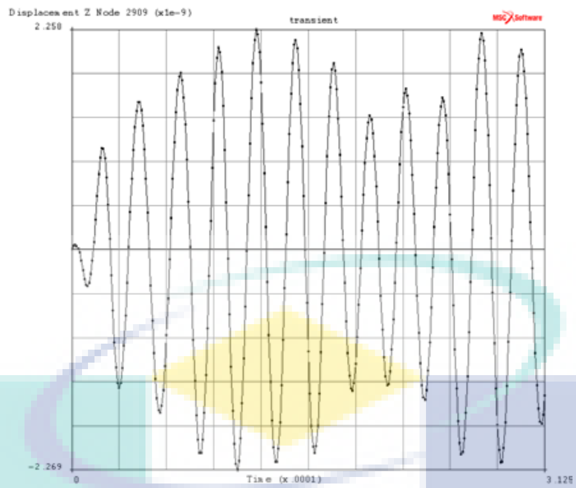

Figure 1: Z-axis displacement of ultrasonic motor stator profile.

For this purpose, Z-axis displacements for certain of period were established. The displacement profile for standard USR6060 Shensei stator and hollow segments stator were shown in Figure 1.

5. CONCLUSION

The results from simulation and experiment clearly indicate that by modifying the stator geometry, the speed, torque and power performance of the ultrasonic motor can be perform higher by manipulating the stator geometry. A better way of designing the stator will determine the stator surface deflection and directly contributed to the ultrasonic motor torque and speed improvement.

ACHIEVEMENT

Journal Paper
(1). M.F.M. Sunif and F.R.M. Romlay, Travelling Wave Rotary Ultrasonic Motor with Novel Hollow Segments Stator, International Journal of Control Theory and Applications (IJCTA)" Vol. 0, Issue. 3, pp. 277-282.
(2). FRM Romlay, WAW Yusoff, KAM Piah, Increasing the efficiency of traveling wave ultrasonic motor by modifying the stator geometry, Ultrasonics, 64, 177-185, 2016.

Human Capital Development

i) Kamal Afifin Mat Piah, Ph.D in ultrasonic rotary piezoelectric motor modelling
ii) Mohd Fathuddin Mohd Sunif, MS.C in Characterizing of piezoelectric ultrasonic motor performance.

iii) Patent,

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