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CONTRIBUTION OF THE BRUSH COMMUTATOR SYSTEM TO NOISE EMISSIONS OF SERIES FHP MOTORS

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1. INTRODUCTION

The brush commutator system of the universal motors has more complicated and unfavorable structural features when considered the noise. The structure of brush commutator system, the material properties and manufacturing technology, the tolerances and deflections under load have a determining effect on brush noise. The effect of various factors can not be seperated depending on the mutual and complicated effects of one on another. The typical high pitch brush noise is produced by friction between the brush and sliding surface.

This study presents a methodological approach to understand the noise emissions that comes through brush and commutator system. In this study, Mechanical features of the brushes are identified, and specific effects of material , shape and dimensions of the brush are sought as causes of noise when combined with contributions of brush housing structure and features on the lamelled structure of commutators. The results indicate that mechanical resonances and commutation are the two significant sources of noise. In order to understand the dynamic and mechanical features of brush commutator system, mechanical resonances and changes on the commutator frequency should be analyzed in details.

2.CAUSES OF BRUSH VIBRATION

Basic features of the system

Commutation besides being dependent on correct electromagnetic design, is also influenced by a number of purely mechanical factors and in some circumstances these can have overriding effect on the performance of a machine. The reason for this is that the current transformer from bar to bar can not take place smoothly

unless a conducting path is maintained continuously between the brush and all bars in the commutating zone; the contact is usually subjected to a succession of disturbances produced by a slight imperfections in the construction of brush and commutator assembly.

Vibration can be a major factor in determining the quality of commutation in a commutator motor. Excessive motor vibration results in deterioration of the brush-commutator contact. Also, lack of roundness of commutator above certain limits will result in the brush momentararily breaking the contact with commutator. Such performance will inevitably lead to increased sparking and brushwear.

Causes of brush vibration

Every brush makes movement and oscillations relative to the armature and relative to the brush holder. These movements sometimes have an adverse effect on the contact resistance of the sliding contact. The conditions of contact may also be influenced by setting up the mechanical vibrations within the brush through the action of frictional forces at the contact surface (1). The existence of such vibrations is often revealed by the emission of high pitched sound from the brush. Brush vibrations are influenced by a great number of factors. Friction excited vibration is not only dependent upon the carbon brush material and the commutator material, but also on the atmosphere and current loading. The typical high pitch brush noise is produced by friction betwen the brush and sliding surface . The friction itself is a function of the film, the patina formed on the sliding surface consisting of copper oxide - graphite dust and moisture. The patina layer diminishes while overload causes it to overgrow, forming an insulating layer that breaks down here and there. This process again deteriorates frictional conditions and brush sound grows louder. The discrete lines in the noise frequency spectrum are found to be ;

$$f_h = l \times Z_{cs} \times f_n \qquad (1)$$

at where f_h is commutator frequency, l is a positive integer, f_n frequency that corresponds to rotational speed and Z_{cs} is number of commutator segments.

3.INHERENT FEATURES OF BRUSH MECHANICS

The inherent mechanical features of the brushes are identified by using experimental techniques and numerical analysises. Mode frequencies are obtained at free-free conditions Results of numerical and experimental analysis indicated that significant mechanical resonances of brush mechanics generally appears above 8 Khz and longitudinal vibrations generally can be negligible when compared with the bending modes. Figures 1-4 illustrate mode shapes of the brush that appear at frequencies 8.0 , 10.5 , 11.7, 16.8 kHz respectively

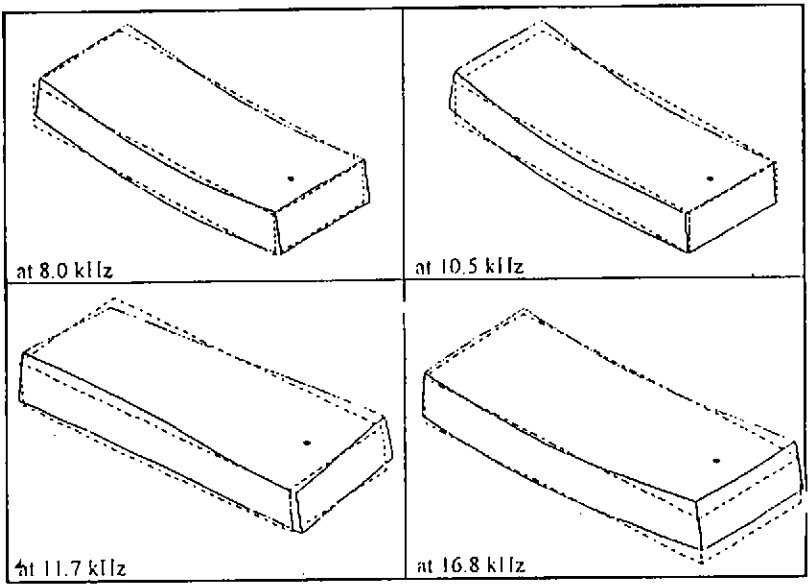

Figure -1 Mode shapes of the carbon brush at 8, 10.5, 11.7 and 16.8 kHz respectively

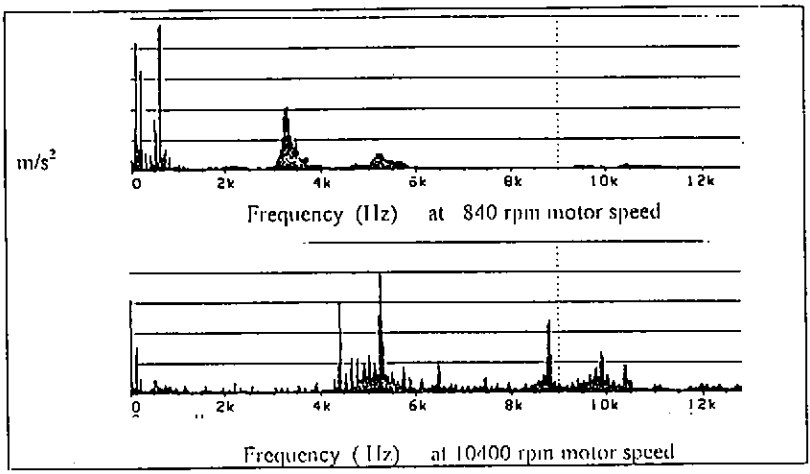

Figure-2. Vibration spectrum of the universal motor when obtained at 840 and 10400 rpm.

4. MEASUREMENT OF BRUSH VIBRATION

Vibration measurements are performed on the specific points that were determined at the back end shields Before specifying exact locations of transducers, optimization of measurements is performed by trial and error. When the motor is loaded in the washing machine, shaft speed, brush material and brush geometry is considered as the changeable parameters to observe the posibble effects on brush noise. Vibration energy changes depending on changes of speed, loading and cross sectional area of the contact.

Brush vibration is a source of brush noise. the source of disturbance giving rise to brush noise can be diagnosed from pitch of the note produced. Noise due to armature out of balance or to the commutator being out of true will be of machine rotational frequency. Forces that are the source of vibration are present all time , but main variable is the force of friction that is changing continuously from bar to bar.

5.CONCLUSIONS

Results of studies enabled the project team involved in this studies to develop possible remedies to reduce brush and commutation noise that appeared around the specific frequencies. Amongst these possible remedies, optimum geometry and brush material, impovement on the roundness of commutator surface and pumic stone applications after machining, significance of atmospheric conditions , improvement on armature balancing, further consideration on the reaction angle, clearance between brush and brush holder , optimization of the spring forces and holding pressures, are advised to the manufacturer.

Behind the remedies to improve epidemic brush and commutation noise problems of universal motors, it was determined that mechanical resonances and commutator frequency are identified as the significant noise sources of brush and commutator system. They have tendency to vary depending on the changes of effective parameters, considered within the scope of these studies. The difficulties faced during studies indicated that non contact measurements should be considered for continuation of the works.

REFERENCES

(1) P.L.Timar, "Noise and Vibration of Electrical Machines (Elsevier, 1989)