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# Localised Flux Density Distribution in the Stator Core of 0.5HP Three Phase AC Induction Motor

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**Abstract:** In this paper, the localised flux density distribution in stator core of three phase AC induction motor will be investigated by using the search coil method. Different induction value within 1T to 1.8T will be applied to observe the distribution. The OPERA 2D software will be used to characterize and provide a qualitative explanation and quantitative correlation between localised flux density and localised power loss has of this stator. From the analysis, it shows that the flux distribution was decrease from the inner to the outer regions of stator and the distribution of flux density is observed to be superior at the stator teeth (induction area). This result demonstrates that when the stator is magnetised from 1T to 1.8T at 50Hz, the localised flux density at stator teeth and outer region decrease from 70% and 40% respectively. The localised power loss distribution pattern is similar to localised flux density distribution whereby its decrease from the outer by 56% to the inner region at 43%. It shows that the localised power loss is influenced by the harmonics content of flux distribution.

**Key words:** Induction motor, Stator Core Model, Localised Flux Density, Harmonics Components.

## INTRODUCTION

The stator and rotor magnetic cores are made of thin silicon steel laminations (non-grain oriented steel) to reduce hysteresis and eddy current losses (Ion Boldea, S.A.N., 2001). Non grain oriented steel have magnetic properties that are as isotropic as possible. This material produced multidirectional magnetisation is useful for the rotating machines (Li Min, E.A., 2007). Rotating machines are considered a source of harmonics as the windings will be embedded in slots which can never be exactly sinusoidally distributed so that the magnetomotive force (mmf) is distorted. Low-order harmonics have a larger impact on the three-phase induction motor than that of high-order harmonics (Ram Deshmukh, A.J.M., Fatih Anayi, 2006).

The investigation of the magnetic cores of three phase induction machines has shown that the regions behind the teeth of the stator cores exhibit the highest distortion of flux density (Shirkoohi, G.H., A.M.Y., 1994). The flux distribution in induction motor is significantly more complex compare to power transformers. The current concentration in stator slots distributed along the stator periphery and pulse width modulator (PWM) inverter supplies give rise to space and time harmonic distortion in mmf (Torres, A.G., B.J.C.F., 2002). Localised flux density is measured in various locations at the stator core, using small search coils, under the core induced at 1.0 T, 1.5 T and 1.8 T.

### *Structure of Stator Model Testing:*

An array of a single turn search coil was employed to measure in-plane (longitudinal and transverse) the normal component of flux density in the lamination within the stator core of induction motor. These search coils are placed on the layer of lamination in order to measure the in-plane flux density distribution at rolling and transverse the lamination. All the search coils when fixed into position were tested for continuity, insulation, strength and polarity. It was necessary to check the polarity of these coils, in order to determine the direction of the flux enclosed by each search coil. The locations of the search coil arrays for the three phase stator core is shown in Figure 1. The locations were chosen to cover the area where the flux was more to vary direction so as to find the distribution of the flux behaviour.

Figure 2 shows the equipment that used for the localised flux measurement at stator model. The stator is coupled to a variable transformer which the search coils at the stator lamination connect to selector box. That model is magnetised at 1.0 T (low excitation), 1.5 T (medium excitation) and 1.8T (high excitation). Measurements are taken from the stator in terms of the voltage induced for fundamental and third (3rd) harmonics appeared in that system. The readings can be obtained from the digital oscilloscope.

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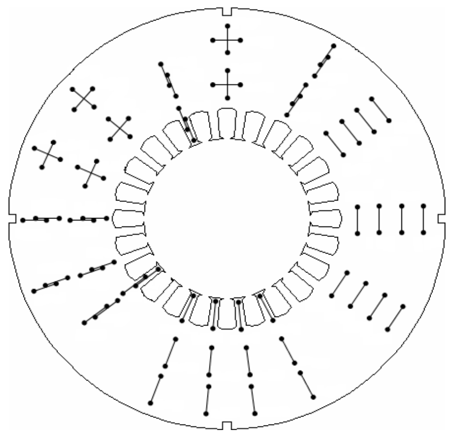


**Fig. 1:** The Location of Search Coils

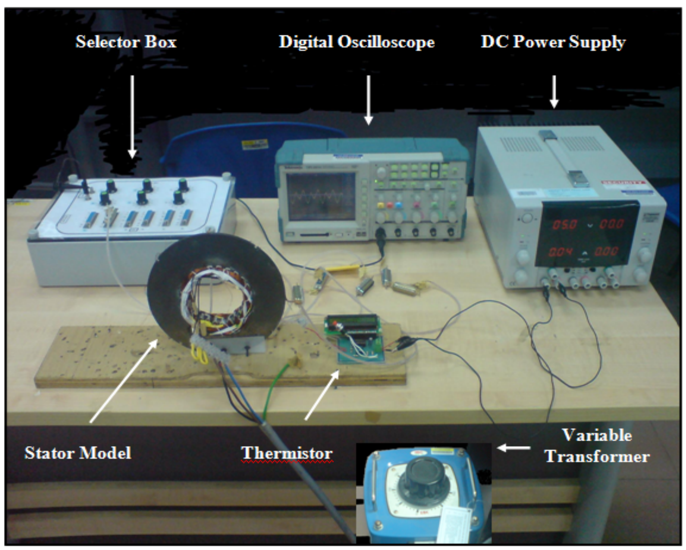



**Fig. 2:** Experimental Setup for Stator Model Testing

## RESULTS AND DISCUSSION

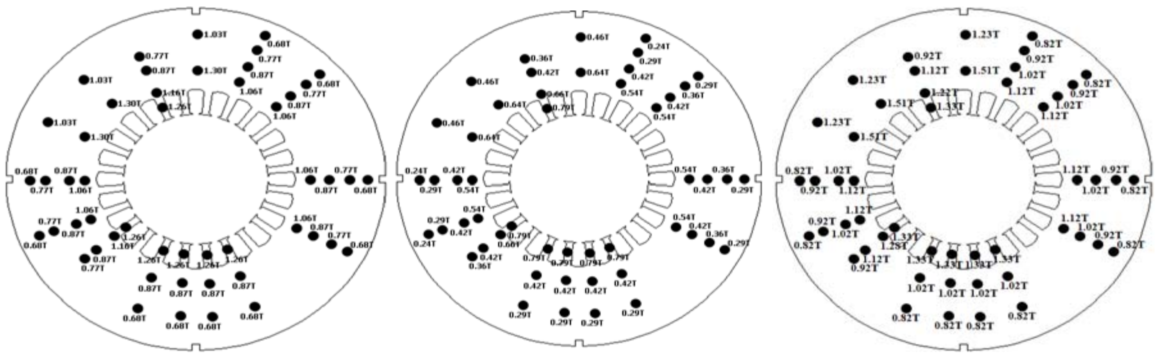
Results for localised flux density were obtained from search coil in voltage (V). Hence the results have been changed to flux density (B) by using equation (1).

$$V_{ind} = 4.44 \times B \times f \times N \times A \quad (1)$$

Where $B$ is the flux density, $f$ is the frequency, $A$ is the cross sectional of the surface of yoke and $N$ is the number of winding turns.

### *A. Localised Flux Density of the Fundamental Harmonic:*

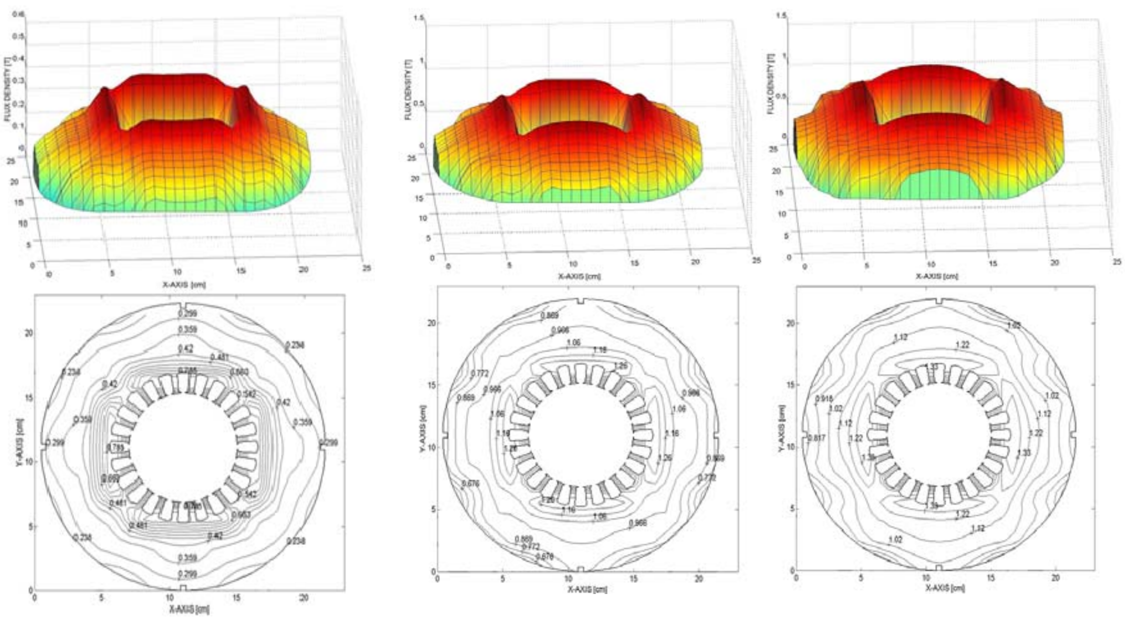
Figure 3 shows the localised flux density distribution at three different magnetization values. Figure 3(a) shows that the localised flux density distributions increase from the outer (0.24 T) to the inner region (0.79 T). Similarly to Figure 3(b) and 3(c), the maximum values of flux density were shown at inner region with the value of 1.26 T and 1.33 T respectively.



(a) (b) (c)

**Fig. 3:** Flux density distribution of the stator magnetised at (a) 1.0 T, (b) 1.5 T and (c) 1.8 T

From Figure 4, the contour graph clearly shows that the localised flux density is highest at the stator teeth and flux line becomes closer with each other compared to the flux line at the outer regions of stator. The mesh graph shows the relation of contour graph whereby the highest flux density place was observed at the red zone area. As the magnetization value was increase from 1.0 T to 1.8 T, the localized flux densities were increase as well.



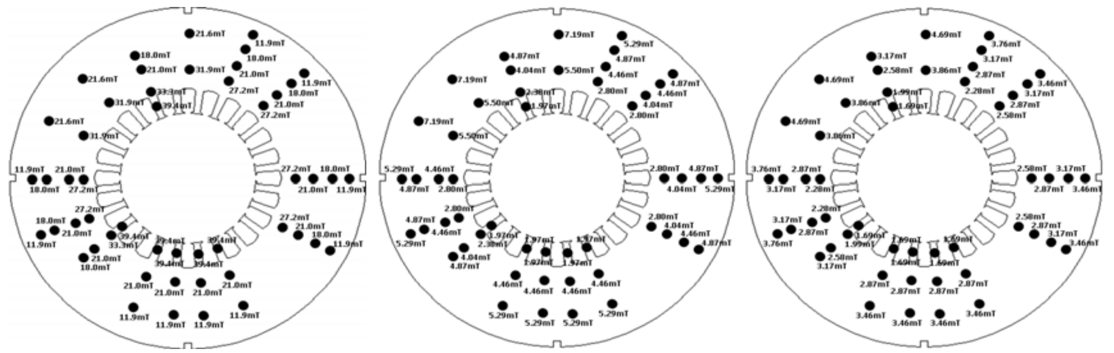

(a) (b) (c)

**Fig. 4:** Contour and mesh graph of the stator magnetized at (a) 1.0 T, (b) 1.5 T and (c) 1.8 T

### *B. Localised Flux Density of the Third (3rd) Harmonic:*

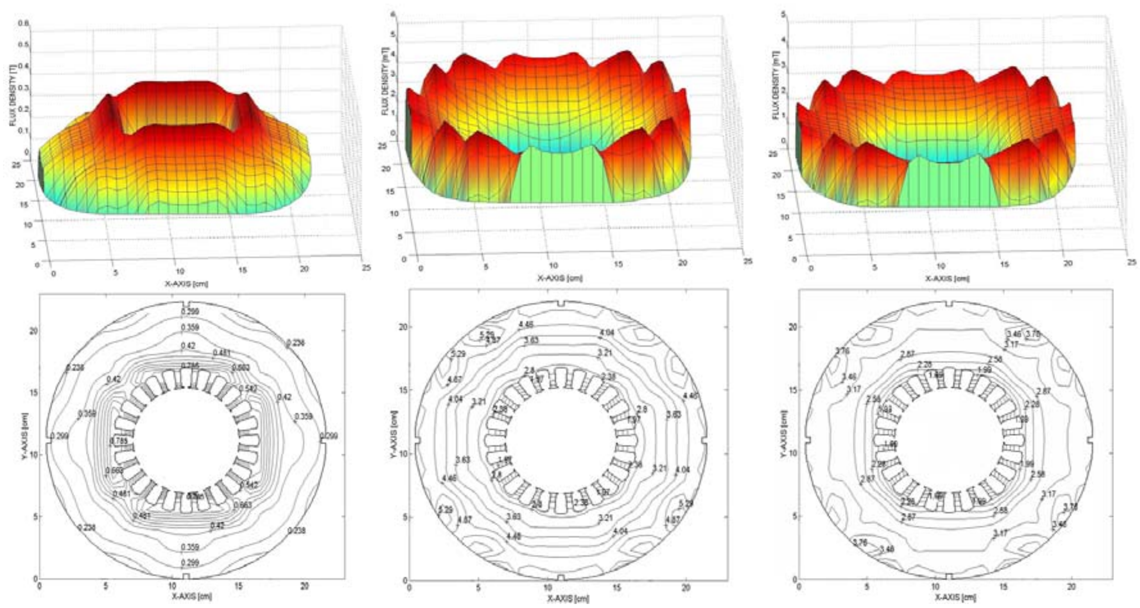
The fundamental flux, however, does not solely result in a variation of the iron loss. For effective realisation of the core, magnitude and phase angle of the harmonic components should also be known [4]. The same principle that presented by previous researchers (Torres, A.G., B.J.C.F., 2002; Torres, A.G., E.A., 2004) are applied in this investigation. The actual results of third harmonic components of the localised flux density will be presented in term of Tesla with respect to the fundamental components.

From Figure 5(a), the localised flux density of third harmonic component shows an increment from the outer to the inner region when the stator core model magnetized at 1.0 T. However, based on Figure 5(b) and 5(c), the distribution shows inconsistencies as the magnetization value of 1.5 T and 1.8 T.



(a) (b) (c)

**Fig. 5:** Third harmonic component of flux density distribution at (a) 1.0 T, (b) 1.5 T and (c) 1.8 T



(a) (b) (c)

**Fig. 6:** Third harmonic component of Contour and mesh graph magnetized (a) 1.0 T, (b) 1.5 T and (c) 1.8 T

A mechanical strain caused by shearing stresses, occurring during the process of cutting electrical steel sheets, will cause deterioration of the magnetic characteristics of the sheet. There is conflicting evidence of the quantification of the effect of cutting stress on the flux distribution and loss in non-oriented electrical steel laminations (Moses, A.J., *et al*., 2000) that will also contributed the unstable condition to the localised flux density.

***Conclusion:***

From the investigation, the measurement of fundamental localised flux density is decrease from the inner to the outer regions of the stator when stator core model induced by 1.0T, 1.5T, and 1.8T. The distribution of localised flux density is observed to be much higher at the stator teeth (induction area).

But, the third harmonic of localised flux density component turns out to be unstable when magnetised at 1.5 T and 1.8 T. It shows during magnetization of flux density at 1.5T and 1.8T (high excitation) the flux distribution is maximum in the outer core back area of the stator core because of high saturation level.

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