Effect of Point of Sag Initiation on Performance of Induction Machine

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Abstract: **In this paper a simulation based study has been made to analyze the effect of voltage sags on the performance of the induction motor. Voltage sag can be characterized on the basis of magnitude, duration and point of sag initiation on the wave. In this paper the effect of voltage sag has been studied on the basis of various sag magnitude and different initial point on wave. The effect on the induction motor has been observed in terms of current & torque peaks and speed loss. Initially the effect of intensity of symmetrical voltage sag with different starting point has been observed on the induction motor and then effect of unsymmetrical voltage sag has been studied. The simulation work has been done in MATLAB-SIMULINK.**

***Key words*: voltage sag, sag magnitude, initial point on wave.**

I. INTRODUCTION

There are various power quality issues that can affect the induction motor performance in many ways. Voltage sag is one of them. In recent time a great emphasize has been given on the issues related to voltage sag because of power requirement of sensitive equipment and increased voltage-frequency pollution [1]. According to IEEE standards 1159-1995, voltage sag is defined as a decrease in rms voltage down to 90% to 10% of nominal voltage for a time greater than 0.5 cycles of the power frequency but less than or equal to one minute." Voltage sag may be symmetrical or asymmetrical, depending upon the type of fault [2]. In symmetrical voltage sag the magnitude of the individual phase voltages are equal and their phasor are displaced at 120^0 from each other. The main reason of a symmetrical voltage sags are three phase fault or starting of a large induction motor. The single line to ground faults, line to line fault or two lines to ground fault results in unsymmetrical voltage sags in the system.

The voltage sag may cause the current and torque peaks and speed loss in the induction motor. All these changes can be observed just after the time of sag initiation and recovery instant.

In this paper the effect of the instant of symmetrical voltage sag initiation has been observed for different sag magnitudes. Later these results are compared with the results of unsymmetrical voltage sag effects on the induction motor. The induction motor of 10 hp, 400V, 50 Hz has been considered for simulation purposes.

Section II describes the characterisation of various voltage sags. Effects of voltage sag initiation point have been compared in section III. Conclusion has been given in section IV.

II. VOLTAGE SAG CHARACTERIZATION

Voltage sags experienced by three phase loads can be classified in to seven different types, namely A,B,C,D,E,F and G. Type A sag is a symmetrical sag whereas other sags are of unsymmetrical type. Phasor diagrams of various voltage sags and their equation has been shown in Figure 1 and Table 1 respectively. h is the sag magnitude having a value between 0 and 1.

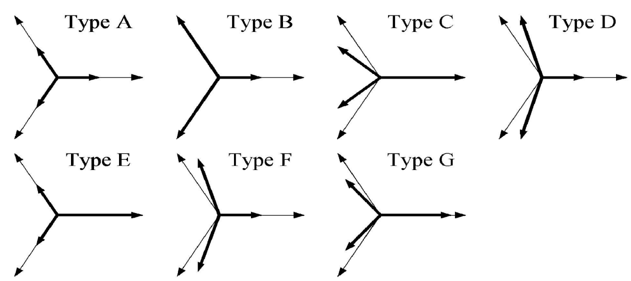

Figure 1: Voltage sag classification for h=0.5

Type A	Type B
$\underline{V}_a = hV$	$\underline{V}_a = hV$
$\underline{V}_b = -\frac{1}{2}hV - j\frac{\sqrt{3}}{2}hV$	$\underline{V}_b = -\frac{1}{2}V - j\frac{\sqrt{3}}{2}V$
$\underline{V}_c = -\frac{1}{2}hV + j\frac{\sqrt{3}}{2}hV$	$\underline{V}_c = -\frac{1}{2}V + j\frac{\sqrt{3}}{2}V$
Type C	**Type D**
$\underline{V}_a = V$	$\underline{V}_a = hV$
$\underline{V}_b = -\frac{1}{2}V - j\frac{\sqrt{3}}{2}hV$	$\underline{V}_b = -\frac{1}{2}hV - j\frac{\sqrt{3}}{2}V$
$\underline{V}_c = -\frac{1}{2}V + j\frac{\sqrt{3}}{2}hV$	$\underline{V}_c = -\frac{1}{2}hV + j\frac{\sqrt{3}}{2}V$
Type E	**Type F**
$\underline{V}_a = V$	$\underline{V}_a = hV$
$\underline{V}_b = -\frac{1}{2}hV - j\frac{\sqrt{3}}{2}hV$	$\underline{V}_b = -\frac{1}{2}hV - j\frac{1}{\sqrt{12}}(2+h)V$
$\underline{V}_c = -\frac{1}{2}hV + j\frac{\sqrt{3}}{2}hV$	$\underline{V}_c = -\frac{1}{2}hV + j\frac{1}{\sqrt{12}}(2+h)V$
Type G	
$\underline{V}_a = \frac{1}{3}(2+h)V$	
$\underline{V}_b = -\frac{1}{6}(2+h)V - j\frac{\sqrt{3}}{2}hV$	
$\underline{V}_c = -\frac{1}{6}(2+h)V + j\frac{\sqrt{3}}{2}hV$	

Transients are observed in the voltage just after the start of voltage sag and just after the clearance of fault [3], [4]. There is always a chance that there may be a phase shift in the voltage or type of the voltage sag may change [5]. For keeping the things to be simple the shape of the voltage sag is assumed to be rectangular in this paper and no change in the sag type has been considered.

III. EFFECT OF INITIAL POINT-ON-WAVE AND SAG MAGNITUDE

In this paper the machine performance will be observed in terms of speed loss, current peak and torque peak.

The effect of various initial points on wave for various sags of different sag magnitudes (h=0.3, 0.6, 0.9) has been shown in figure 2 to figure 6 in terms of torque peaks. Figure 2 shows that there is no effect of point of sag initiation on the torque peak for sag A. It can also be observed that torque peaks for sag B and sag D are maximum when angle of sag initiation is 900 while it is maximum at 00 for sag C and sag E.

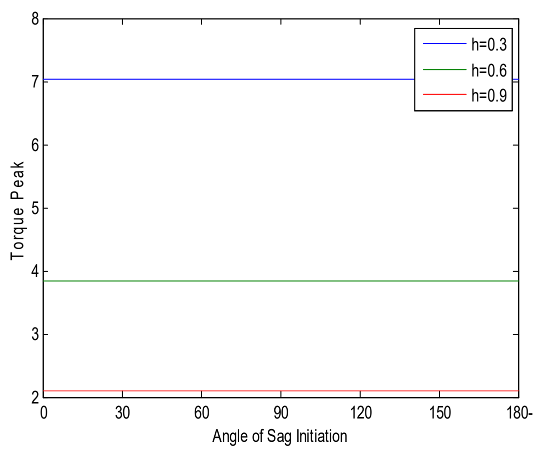

Figure 2: Torque Peak for Sag A for various initial point with different magnitude

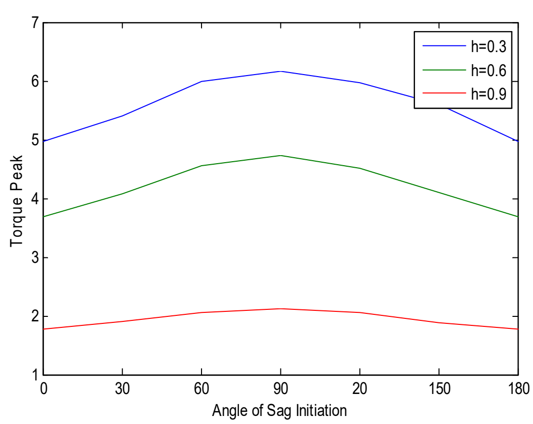

Figure 3: Torque Peak for Sag B for various initial point with different magnitude

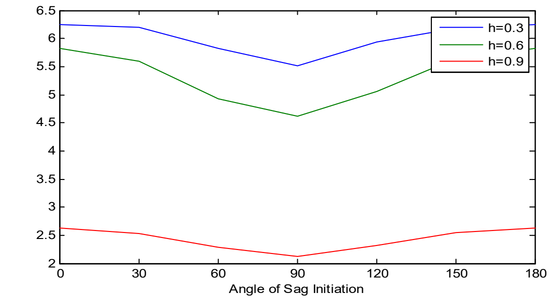

Figure 4: Torque Peak for Sag C for various initial point with different magnitude

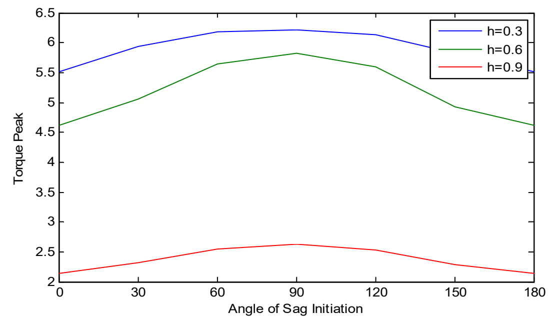

Figure 5: Torque Peak for Sag D for various initial point with different magnitude

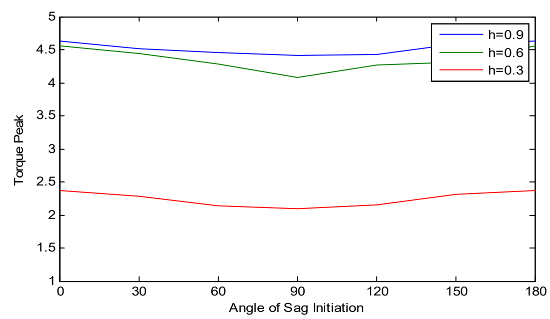

Figure 6: Torque Peak for Sag E for various initial point with different magnitude

The effect of various initial points on wave has been shown in figure 7 to figure 11 in terms of current peaks. It can be observed that there is very slight variation in the magnitude of current peaks for symmetrical sag A.

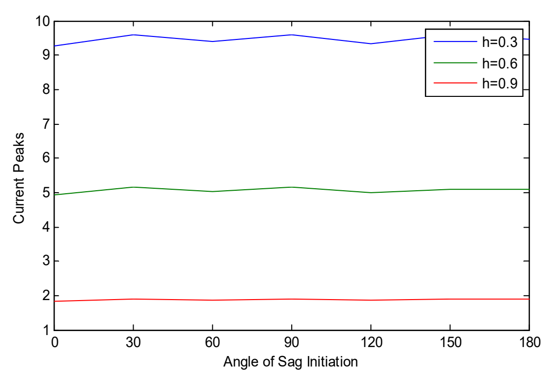

Figure 7: Current Peak for Sag A for various initial point with different magnitude

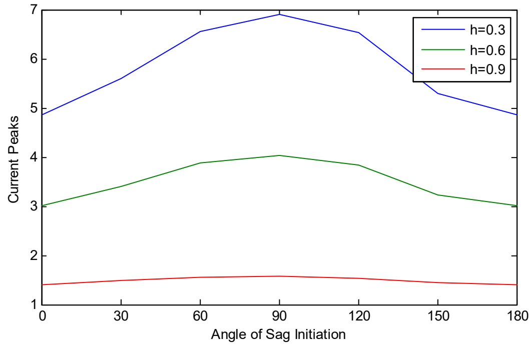

Figure 8: Current Peak for Sag B for various initial point with different magnitude

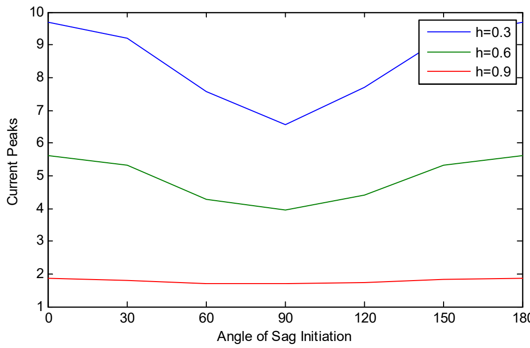

Figure 9: Current Peak for Sag C for various initial point with different magnitude

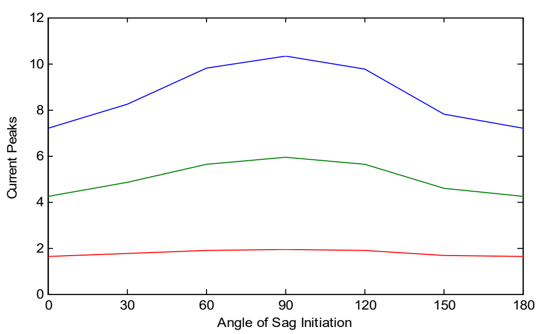

Figure 10: Current Peak for Sag D for various initial point with different magnitude

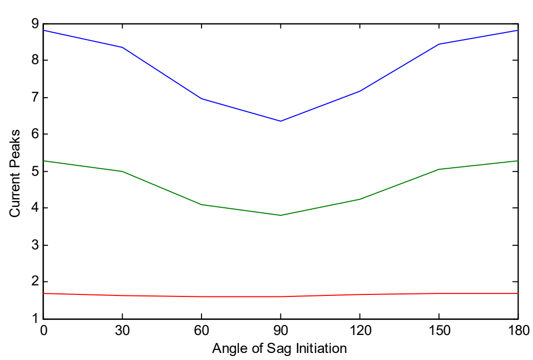

Figure 11: Current Peak for Sag E for various initial point with different magnitude

Whereas the current peaks are maximum at angle 90^0 for sag B and sag D, while it is maximum at angle 0^0 for sag C and sag E.

In the case of speed loss no effect of initial angle has been observed in the case of sag A.

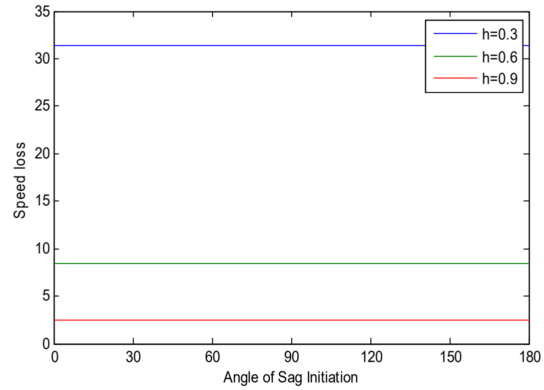

Figure 12: Speed loss for Sag A for various initial point with different magnitude

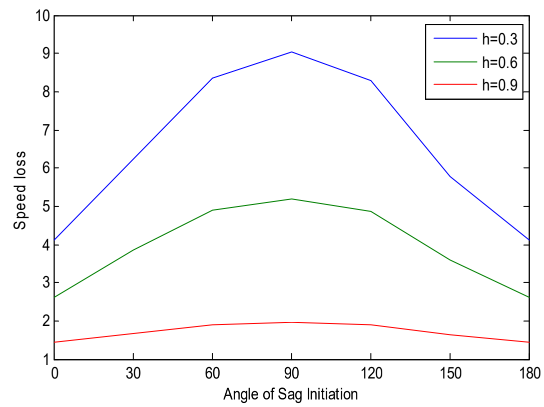

Figure 13: Speed loss for Sag B for various initial point with different magnitude

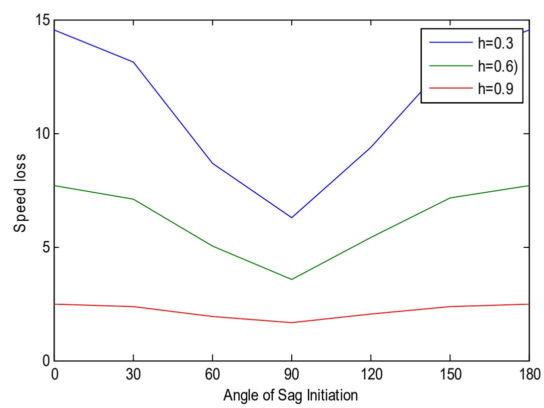

Figure 14: Speed loss for Sag C for various initial point with different magnitude

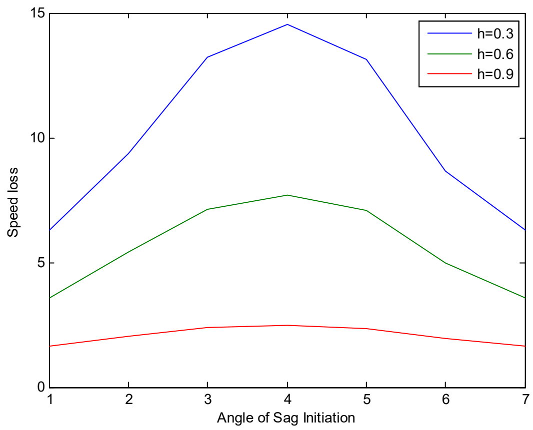

Figure 15: Speed loss for Sag D for various initial point with different magnitude

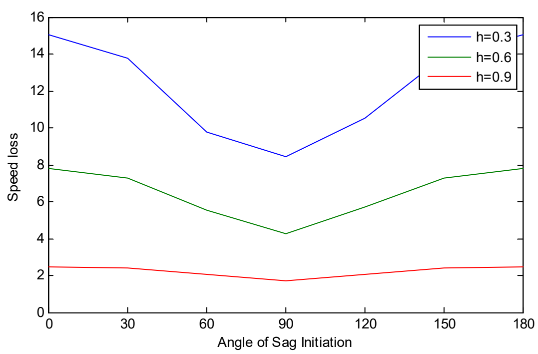

Figure 16: Speed loss for Sag E for various initial point with different magnitude

Maximum speed loss occurs at an initial angle of 90^0 for sag B and sag D while speed loss is maximum at an angle of 0^0 in case of sag C and sag E.

It can also be observed that as the magnitude of remaining voltage increases the torque peak, current peak and speed loss is increased. The sag A has the most seivier effect on the performance of induction motor.

IV. CONCLUSION

The effect of various sag initiation angles on the performance of induction motor has been studied for different sag. It can be concluded that there is no effect of initial angle in case of Sag A. But in case of sag B and sag D the maximum speed loss, torque peaks and current peaks have been observed for an initial angle of 90^0 but the values of speed loss, current peaks and torque peaks are maximum in case of 0^0 initial angle. It can also be concluded that the sag A affected the motor performance more than any other sag type. It was also observed that as the sag magnitude increases the value of parameters under consideration also increases.

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