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INDUSTRIAL INTEGRATED ELECTRO-MECHANICAL FACTORY FOLK-LIFT RICE LOADING AND TRANSIENT CONTROL USING SYNCHRONOUS MACHINE DRIVE

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Abstract *Industrial integrated electro-mechanical factory folk-lift rice loading and transient control using synchronous machine drive is presented. Electro-mechanical fork-lift was powered using electrical and mechanical processes for factory rice handling in the ware-house for better performance instead of the traditional internal combustion engine using rechargeable batteries due to the mechanical movement causing an electrical output transient and an emission of carbon dioxides and leakage of fluid on food meant for human consumption and constituting negative impact on rice used as food and on environmental system. Synchronous machine drive is an AC electrical motor that has a steady state, the rotation of the shaft that is synchronized with the frequency of the supply current, the rotation period is equal to an integer number of AC cycles. Experiment was carried out in standard research laboratory. The dc excitation of factory folk-lift was adjusted to ensure that* $E_1 and E_2$ *is equal. The factory folk-lift synchronizing switch was closed and the current* I_1 *was recorded as 0.3 ampere. Closing the factory folk-lift synchronizing switch when all the lights are dark, the stator current jumps quickly to 0.3 ampere and return to zero at the moment of the closure because the two-line voltage are not equal in phase with each other. Electrical and mechanical models of the factory fork-lift synchronous machine drive were obtained by solving synchronous machine equations governing electrical and mechanical using Runge-Kutta method. MATLAB/SIMULINK software with the Mathematical characteristics was used to model the factory folk-lift machines by setting its component transients to zero to obtain the complete reduced transients. Results presented graphically show that the factories fork-lift performance is very highly sensitive to load variation and recommended for factories fork-lift designers and fork-lift industrial operators.*

Key words: *Electro-Mechanical, Factory Folk-lift, Synchronous, Combustion, transient, Industrial and Rice.*

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1.0 Introduction

Industrial integrated electro-mechanical factory folk-lift rice loading and transient control using synchronous machine drive is presented. Electro-mechanical fork-lift powered by both electrical and mechanical processes for factory rice handling in the ware-house for better performance instead of the traditional internal combustion engine using rechargeable batteries due to the mechanical movement causing an electrical output transient and emission of carbon dioxides and leakage of fluid on food meant for human consumption constituting negative impact on rice used as food and on environmental system. The fork-lift is use as a mode of operation in transportation sector, for lifting, lowering of rice product in the ware-house needs urgent attention that call for this paper. It is a small vehicle that has two metal forks in the front to lift rice product and is just like truck.

Synchronous machine drive is an AC electrical motor that has a steady state, the rotation of the shaft that is synchronized with the frequency of the supply current, the rotation period is equal to an integer number of AC cycles. [2, 3, 4]

Modern-day forklifts widely known as an industrial vehicle that lifts and maneuvers heavy loads to changing elevations, its historical genesis lies in separate previous developed technologies in isolation of each other. Technologies slowly embraced into a singular solution and redefining what mechanized material handling equipment could be. Carrying is one of the rudimentary advanced technologies that forklift platforms are built upon [7, 8]

2.0 Laboratory Research on factory fork-lift synchronous machine drive:

The following tools and equipment were used in University of Port Harcourt standard research laboratory: Synchronous Generator, D.C. Motor, factory folk-lift synchronizing Switch, Power Supply, AC Voltmeter, AC ammeter, Hand Tachometer, Connection Leads and Timing Belt.

The circuit was connected as shown in the figure1. The factory folk-lift output was connected through the factory folk-lift synchronizing switch to a three-phase fixed power supply 415Vac and the rotor was also connected to a fixed power supply 220Vdc output. The DC motor was connected to a variable power supply 220V dc.

The factory folk-lift and the DC motor was couple together with timing belt. The fixed rheostat of the DC motor was adjusted to full clockwise position for minimum resistance while the synchronous switch was setted for full anticlockwise for maximum resistance.

The dc excitation of factory folk-lift was adjusted to ensure that E_1andE_2 is equal. The factory folk-lift synchronizing switch was closed and the current I_1 was recorded as 0.3 ampere.

Closing the factory folk-lift synchronizing switch when all the lights are dark, the stator current jumps quickly to 0.3 ampere and return to zero at the moment of the closure because the two-line voltage are not equal in phase with each other.

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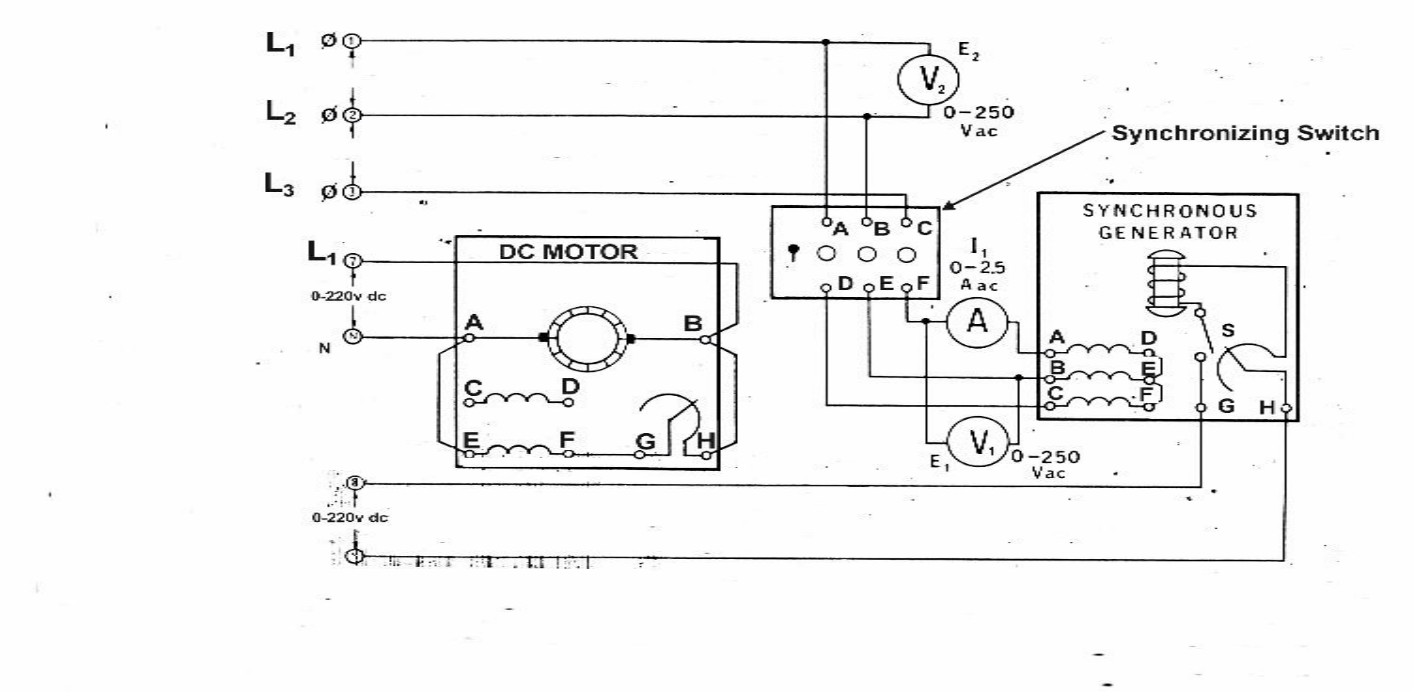

Figure1: Factory fork-lift synchronous Machines circuit diagram [UNIPORT]

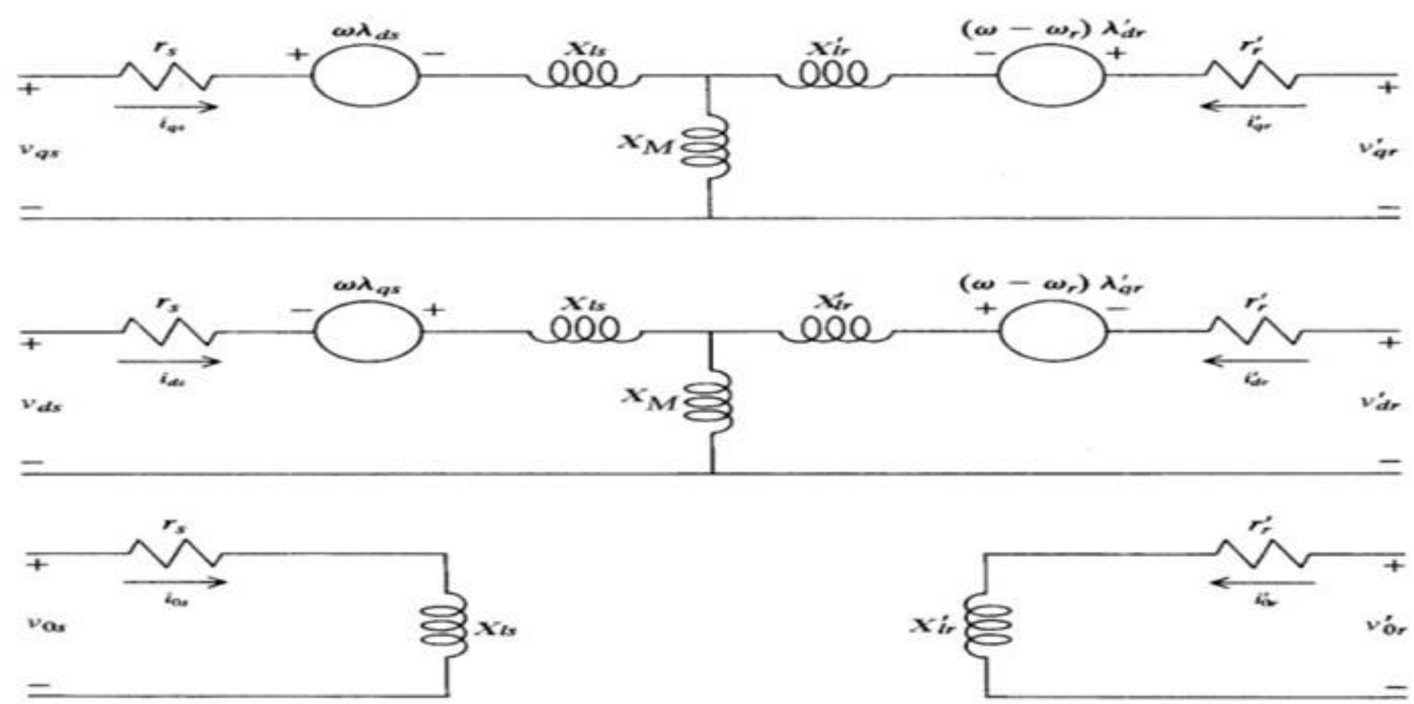

Figure2: Factory fork-lift equivalent circuit diagram

When all the three lights are dim as the factory folk-lift synchronizing switch was closed, the stator current jump quickly to 1.2 ampere and return to zero. This was because of small phase difference between the voltage which creates a greater voltage difference than when the lights are dark and the current surge to a higher value. When all the three lights are partially bright, the stator current jumped quickly to 2.0 ampere and returned to zero.as the factory folk-lift synchronizing switch closed, there is a relatively large phase difference between the two voltages that produced large voltage difference and current. The factory folk-lift jerk as the rotor was forced into the correction position by the large stator surge current, after the surge, the current again dropped back to zero. The dc excitation to the factory folk-lift was adjusted until the output voltage $E_2 = 450V.$ the motor speed was adjusted until the three lamps are synchronized with factory folk-lift.

The factory folk-lift synchronizing switch was closed as the three lights dimmed. The moment of closure, the stator current jump from zero to a peak of 0.5 to 1.0apere and after closure the stator current fall back to as low as 0. 4ampere.The factory folk-lift synchronizing switch was open and the voltage returned to zero and the power supply was turned off. The rotation of the dc motor was reversed by interchanging the shunt field to synchronize the factory folk-lift as before. The lights flashed in sequence instead of all at the same time. This indicated that the phase sequence of the power supply and the factory folk-lift are difference. This was remedied by without again reversing the dc motor by interchanging any of the two of the lead from the stator of the factory folk-lift.

3.0 Factory folk-lift modeling and simulation

$$\begin{bmatrix} V_{qs} \\ V_{ds} \\ V_{0s} \\ V_{qr} \\ V_{dr} \\ V_{0r} \end{bmatrix} = \begin{bmatrix} r_s + \frac{p}{w_b} X_{ss} & \frac{w_s}{w_b} X_{ss} & 0 & \frac{p}{w_b} X_m & \frac{w_s}{w_b} X_m & 0 \\ -\frac{w_s}{w_b} X_{ss} & r_s + \frac{p}{w_b} X_{ss} & 0 & -\frac{w_s}{w_b} X_m & \frac{p}{w_b} X_m & 0 \\ 0 & 0 & r_s + \frac{p}{w_b} X_{ls} & 0 & 0 & 0 \\ \frac{p}{w_b} X_m & \frac{w_s - w_r}{w_b} X_m & 0 & r_r + \frac{p}{w_b} X_{rr} & \frac{w_s - w_r}{w_b} X_{rr} & 0 \\ -\frac{w_s - w_r}{w_b} X_m & \frac{p}{w_b} X_m & 0 & -\frac{w_s - w_r}{w_b} X_{rr} & r_r + \frac{p}{w_b} X_{rr} & 0 \\ 0 & 0 & 0 & 0 & 0 & r_r + \frac{p}{w_b} X_{lr} \end{bmatrix} \begin{bmatrix} i_{qs} \\ i_{ds} \\ i_{0s} \\ i_{qr} \\ i_{dr} \\ i_{0r} \end{bmatrix}$$

Factory folk-lift model and simulation is very important in industrial world. Electrical and mechanical models of the fork-lift synchronous machine drive were obtained by solving equations governing electrical and mechanical using Runge-Kutta method. MATLAB/SIMULINK software with Mathematical characteristics was used to model the factory folk-lift machines by setting its component transients to zero so as to obtain the complete reduced transients. The mathematical equations of the factory folk-lift show the relationships for factory fork-lift synchronous machines drive circuit diagram in figure1 and its equivalent in figure2.

4.0 Factory Fork-lift Electrical Modeling

$$V_{qs} = r_s i_{qs} + \frac{W_s}{W_b}\psi_{ds} + \frac{P}{W_b}\Psi_{qs} \qquad (1)$$

$$V_{ds} = r_s i_{ds} + \frac{W_s}{W_b}\psi_{qs} + \frac{P}{W_b}\psi_{ds} \qquad (2)$$

$$V_{os} = r_s i_{os} + \frac{P}{W_b}\psi_{os} \qquad (3)$$

$$V_{qr} = r_r i_{qr} + \frac{W_s - W_r}{W_b}\psi_{dr} + \frac{P}{W_b}\psi_{qr} \qquad (4)$$

$$V_{dr} = r_r i_{dr} + \frac{W_s - W_r}{W_b}\psi_{qr} + \frac{P}{W_b}\psi_{dr} \qquad (5)$$

Where;

$$L_m = \frac{X_m}{W_b} \qquad (6)$$

Factory Fork-lift synchronous machine drive equations of flux are as follow and similar to conventional motor [1, 2, 6]

$$\psi_{ds} = X_{ls} i_{ds} + X_m \left(i_{ds} + i_{dr}\right) \qquad (7)$$

$$\psi_{qs} = X_{ls} i_{os} \qquad (8)$$

$$\psi_{qr} = X_{lr} i_{qr} + X_m \left(i_{qs} + i_{qr}\right) \qquad (9)$$

$$\psi_{dr} = X_{lr} i_{dr} + X_m \left(i_{qs} + i_{dr}\right) \qquad (10)$$

$$V_{ds} = r_s i_{ds} + \frac{W_s}{W_b}\psi_{qs} \qquad (11)$$

$$\psi_{or} = X_{lr} i_{or} \qquad (12)$$

These set of equation becomes:

$X_{qs} = X_{qs} + X_m$ (13)

$X_{ds} = X_{ds} + X_m$ (14)

Expressing it in Matrix form we have:

5.0 Fork-lift Mechanical Modeling

Fork-lift torque equation of mechanical model is expressed as:

$T_e = \left(\frac{3}{2}\right)\left(\frac{P}{2}\right) L_m\left(i_{qs}i_{dr} - i_{ds}i_{qr}\right)$ (16)

The set of equation becomes:

D = $X_{ss}X_{rr} + X_{m^2}$ (17)

Mechanical torque flux equation becomes:

$T_e = \left(\frac{3}{2}\right)\left(\frac{P}{2}\right)\frac{X_m}{D_{Wb}}\left(\psi_{qs}\psi_{dr} - \psi_{ds}\psi_{qr}\right)$ (18)

Complete reduce mechanical factory fork-lift model component for transient and simulation are set to zero [1, 4, 5], thus,

$\frac{d\psi_{ds}}{d_t} = \frac{d\psi_{ds}}{d_t} = 0$ (19)

Equation (1-3) becomes:

$V_{qs} = r_s i_{qs} + \frac{W_s}{W_b}\psi_{ds}$ (20)

$V_{os} = r_s i_{os}$ (21)

The results were presented graphically and these show that the performance of factory fork-lift is highly sensitive to load variation.

***Table1*: Fork-lift Synchronous Machine Drive Parameter**.

d-axis flux, ψ_d	1.4Mwb
q-axis flux, ψ_q	2.8mWb (1.4mWb)
Stator windings R_s	0.6 Ω (1.2 Ω)
Induced flux	0.12Wb
Number of poles, P	2
Rated Voltage, V	250 V
Rated frequency, f	50Hz
Combined rotor and load inertia, J_m	0.83Kgm^2
Shaft mechanical torque, T_l	3.2Nm

Source: [1, 5, 6]

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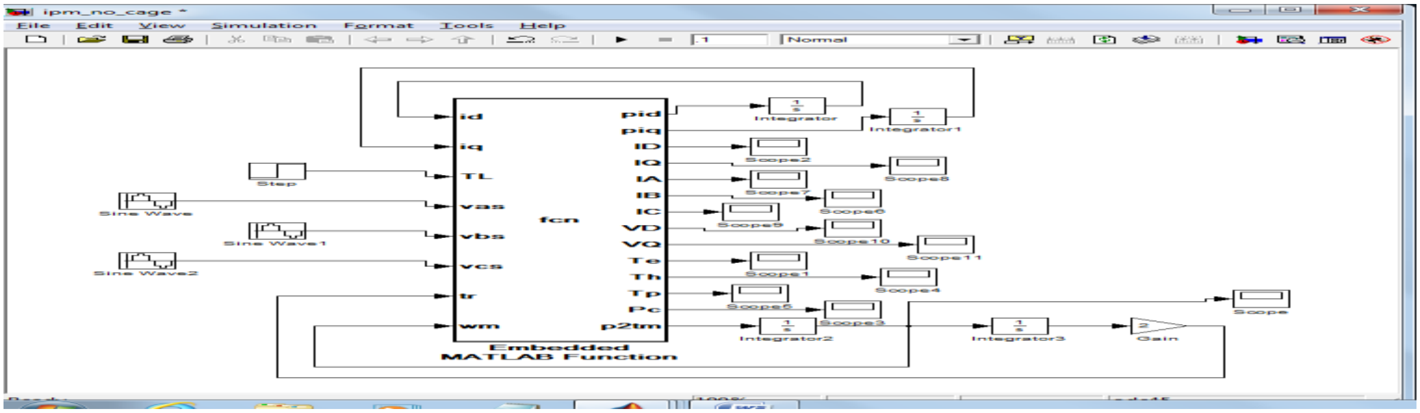

Figure3: Fork-lift model Simulation/Simulink Matlab Block diagram [2, 5, 6]

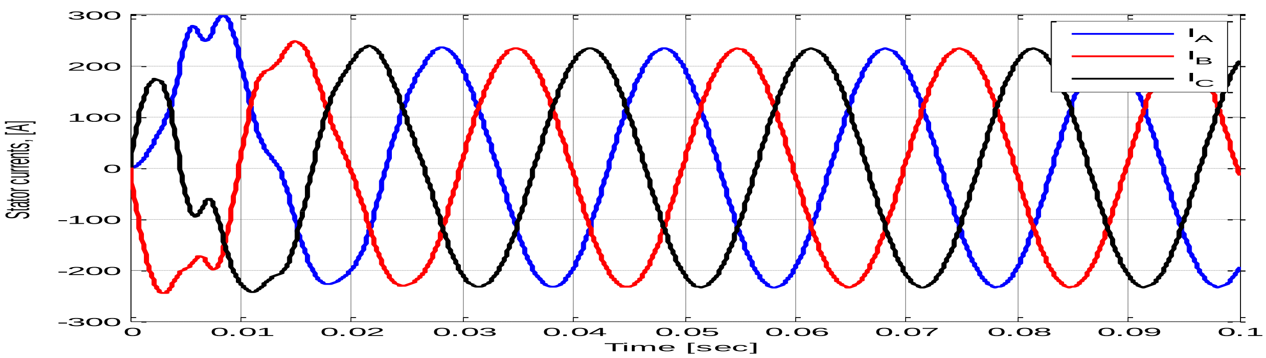

Figure4: Fork-lift stator current (A) versus time(s)

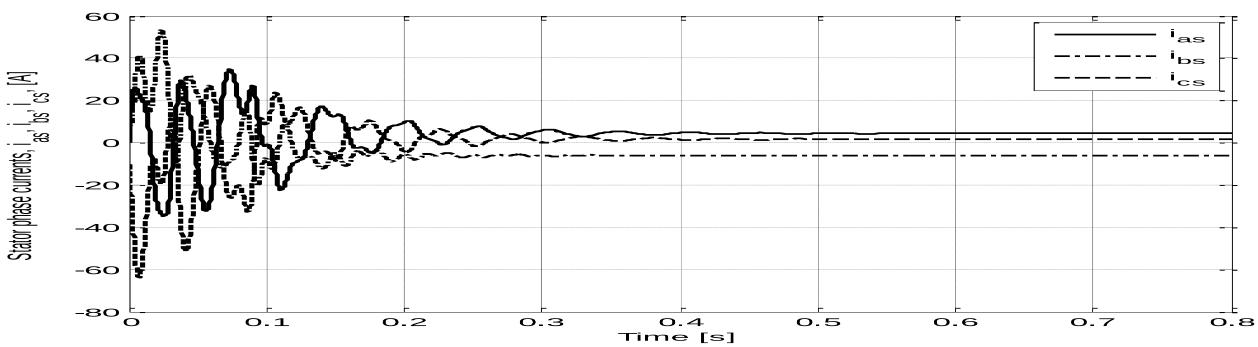

Figure5: Fork-lift Stator Phase Currents/time at run- up Condition

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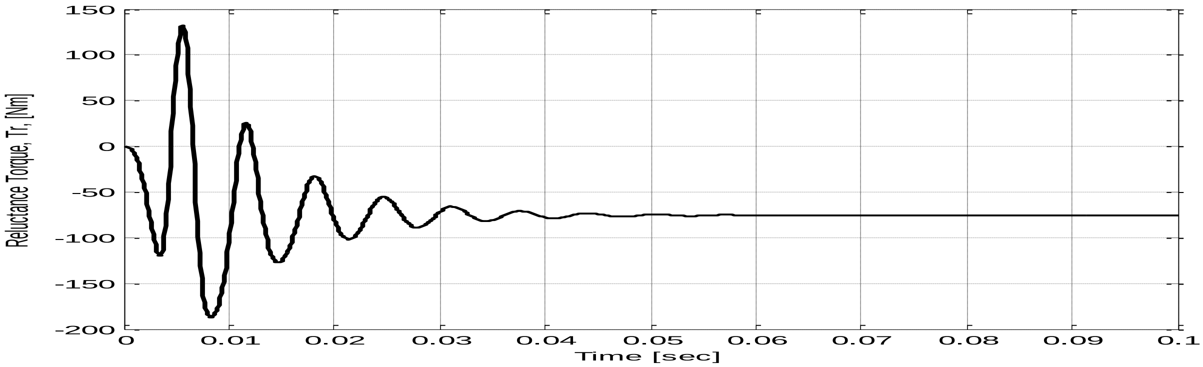

Figure6: Fork-lift Reluctance Torque versus time

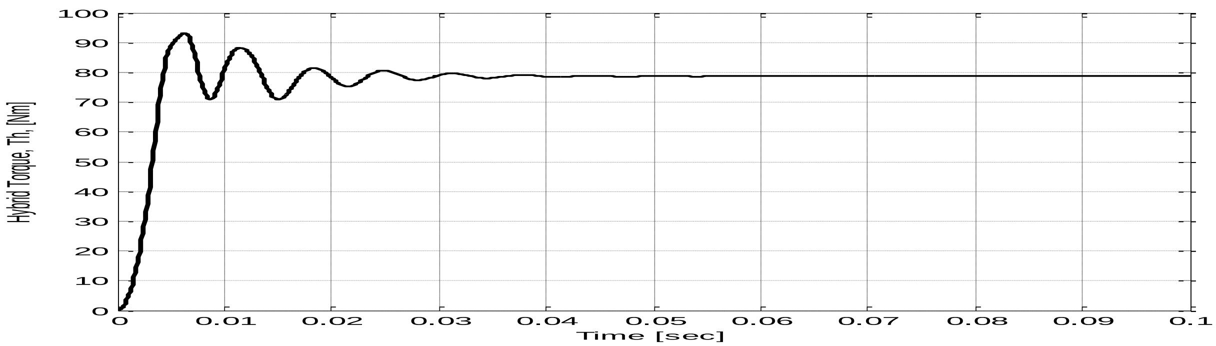

Figure7: Fork-lift Hybrid Torque versus Time

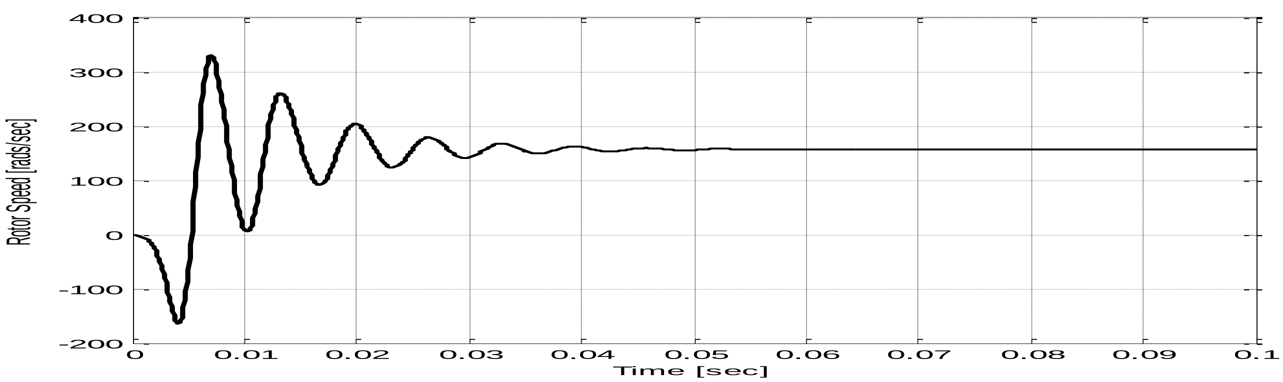

Figure8: Fork-lift Rotor Speed versus time

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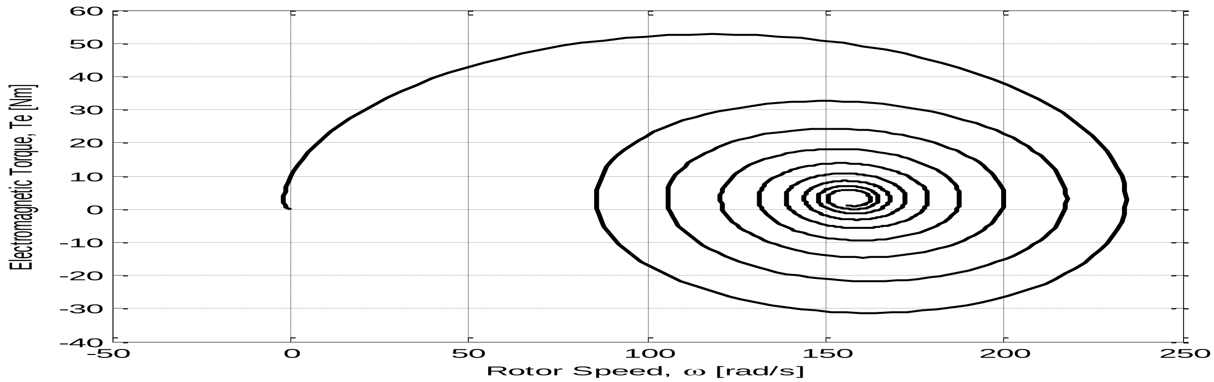

Figure9: Fork-lift Electromagnetic torque versus rotor Speed

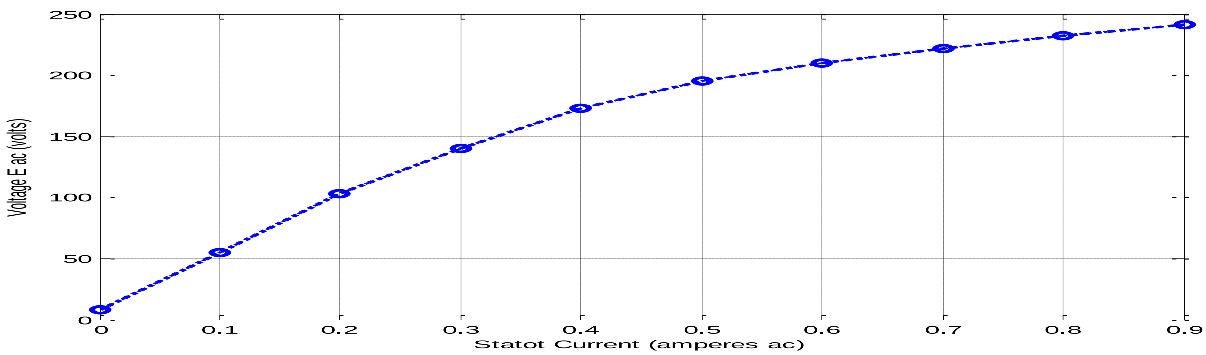

Figure 10: Fork-lift Graph of Voltage (V ac) versus Current (I)

6.0 Conclusion

Industrial integrated electro-mechanical factory folk-lift rice loading and transient control using synchronous machine drive is presented.

Electro-mechanical fork-lift was powered using electrical and mechanical procedure for factory rice handling in the ware-house for better performance instead of the traditional internal combustion engine that uses rechargeable batteries due to the mechanical movement causing an electrical output transient and an emission of carbon dioxides and leakage of fluid on food meant for human consumption constitute negative impact on rice used as food and on environmental system. Synchronous machine drive is an AC electrical motor that has a steady state, the rotation of the shaft that is synchronized with the frequency of the supply current, the rotation period is equal to an integer number of AC cycles.

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