TORQUE CONTROLLER FOR THREE PHASE INDUCTION MOTOR

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***Abstract*-This paper presents an assessment of using TQ compared to SD starter by analysing the initial current drawn by a loaded 7.5hp induction motor during starting and when it is motoring. The case study was done in a KTDA tea factory (Toror tea factory) withering plant section, two identical motors was chosen, loaded equally and the duration of motoring of both motors was equal. Data was recorded at intervals of 3 hrs, conventional formulae of energy analysis was used to determine energy used in KWH and KVA demand. This data was presented and the case study shows that the two experiments i.e. by SD and TQ reveal different outcomes, the TQ approach which is mainly focused on the SPD for its switching showed its superiority in terms of efficiency when compared to SD which uses CEMD in its switching. A thorough analysis of a business case on a classical class C12 industry to explore on the cost benefit of adopting the TQ device and payback period was done, the analysis showed the period of 18 months basing on latest rates of KPLC.**

Keywords -Kenya Tea Development Agency (KTDA); KiloWattHour(KWH);KiloVoltAmpere(KVA);StarDelta(SD);TORQCO(TQ);Semiconductor Power Devices(SPD);Classical Electromagnetic Mechanical Devices (CEMD);Kenya Power Lighting Company(KPLC)

I. INTRODUCTION

In an industrial set up energy is essential because it powers machinery. With the rapid development of society and the economy, higher requirements are put forward for energy use, which include more reliability, more flexibility, more efficiency, more adaptability to various actual application situations("Research on the Torque and Back EMF Performance of a High Speed PMSM Used for Flywheel Energy Storage," n.d.).This is also true in all sectors of production. Energy requirement has surpassed its availability and therefore, human has devised ways and techniques of utilizing this resource, however energy saving with focus on energy efficiency is still far from being realized, consequential response requires major multiform research and an analytical effort. No doubt that analysis of the interaction between energy efficiency policies and energy efficiency performance of economies accounts for a significant part of the effort.

Electrical energy is utilized differently by different machines in industries. The most familiar equipment are motors, there are different types of motors but for this purpose we shall observe the induction motor. Since its invention over one hundred years ago the standard 3-phase induction motor has become one of the most used industrial equipment ever known("Electrical Energy Conservation in Automatic Power Factor Correction by Embedded System," n.d.). This is due to its simplicity of construction, low cost, reliability and relatively high efficiency, it is also likely to remain the prime source of mechanical energy for industrial applications.

To switch on an induction motor from stand still is quite an energy demanding process, from the moment the machine is switched on, all the requisite energy to magnetize the motor, to provide acceleration force to the rotor coupled to the load alongside kinetic energy to overcome force of inertia besides electrical and mechanical losses must all be accounted for(“Thermal Management of a Soft Starter: Transient Thermal Impedance Model and Performance Enhancements Using Phase Change Material,” n.d.). To achieve this, at full supply voltage allows a significant surge of current that induces a considerable amount of stress on the entire system including the adjacent appliances. This energy demand make the motor to start with a very high torque which is unbearable to the entire motor system.

II. RESEARCH GAP ADDRESSED.

In light of the above cited energy requirements and losses, it is necessary to develop a device that may enable machines routinely overcome the stresses caused by the energy demand through the regulation of the initial torque. Currently, the types of starters available in the market such as direct-on-line, star-delta starters use classical mechanical switches that are prone to problems like switch disconnection, fundamental wave form distortion and interference. The proposed torque controller device is an improved model that is devoid of torque oscillation, switch disconnection and harmonic distortion.

TORQCO is a three phase electronic device which is used to control the torque of an induction motor during starting and running of the machine in industries.The device integrates electric force, electronic techniques, computer techniques and modern control theory. It is the new generation product to replace the conventional star-delta starter, self-coupling voltage-drop starter and magnetic control voltage-drop starter. The torque controller device is an improved model that is devoid of switching disconnection, harmonic distortion and eliminates torque oscillations which cause rapid wear and early machine failure. Adoption of the device has the potential of saving energy, improving efficiency and expanding the life span of motor.

III. CASE STUDY

A study carried out at Toror factory withering section to evaluate the efficiency of the torque controller in terms of energy conservation and eliminating torque oscillation in the motor system. The study involved connecting two motors with the same output power in order to establish its energy consumed when starting and running the motor for 20 hrs. The data collected for 15 days were tabulated as follows

Data collected from torque controller

		TORQCO		**STAR- DELTA STARTER**	
Date	**Direction of air flow**	**Peak value(A)**	**Operating value(A)**	**Peak value(A)**	**Operating value(A)**
22.1.2014	IN	32	9.8	48	10.2
	OUT	31	9.4	47	9.9
23.1.2014	IN	32	9.8	48	10.2
	OUT	31	9.4	47	9.8
24.1.2014	IN	32	9.9	47	10.1
	OUT	31	9.4	47	9.9

25.1.2014	IN	32	9.7	48	10.2
	OUT	31	9.4	47	9.9
27.1.2014	IN	33	9.8	48	10.2
	OUT	31	9.4	47	9.9
28.1.2014	IN	33	9.8	48	10.2
	OUT	31	9.5	47	9.9
29.1.2014	IN	32	9.7	48	10.2
	OUT	32	9.8	47	10
30.1.2014	IN	31	9.4	47	10.3
	OUT	31	9.4	47	9.9
31.1.2014	IN	32	9.8	48	10.2
	OUT	31	9.4	47	9.8
1.2.2014	IN	33	9.8	48	10.2
	OUT	31	9.4	47	9.8
3.2.2014	IN	32	9.8	48	10.1
	OUT	31	9.5	47	10
4.2.2014	IN	32	9.8	48	10.2
	OUT	31	9.4	47	9.9
5.2.2014	IN	32	9.8	48	10.2
	OUT	31	9.4	47	10.0
6.2.2014	IN	32	9.8	48	10.2
	OUT	31	9.4	47	9.9

*A amperes

IV. DATA ANALYSIS.

Initial starting power consumed using TORQCO =√3*V*I*Cos ϕ
=√3*152*31*0.87
=7100.44W
=7100.44*0.00444
=31.53W/h

Running Power consumed using TORQCO =√3*V*I* Cos ϕ
=√3*415*9.4*0.87
=5878.36W
=5878.36*20
=117567.11W/h

Total power consumed in 20 hrs =31.53+117567.11
=117598.64W/h

Initial starting power consumed when started directly =√3*V*I*Cos ϕ
=√3*415*48*0.87
=30017.13 W
=30017.13*0.00444
=133.28W/h

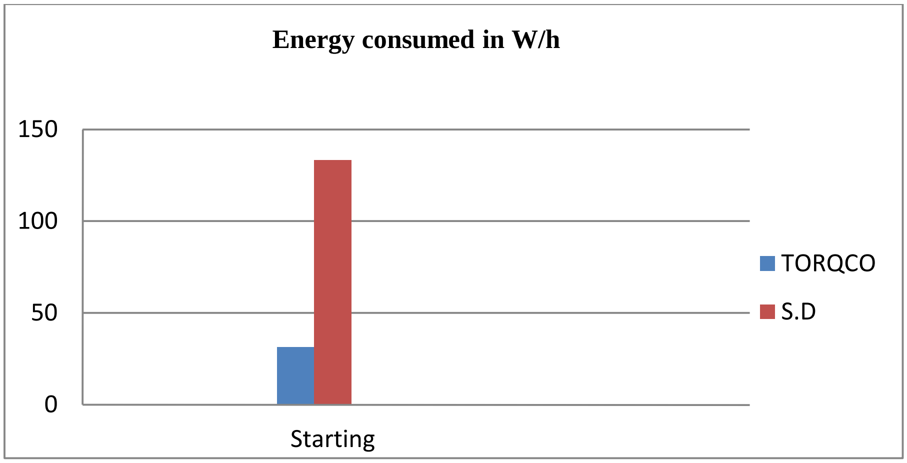
Running Power consumed when connected directly =√3*V*I* Cos ϕ
=√3*415*10.2*0.87

=6378.64W
=6378.64*20
=127572.82W/h

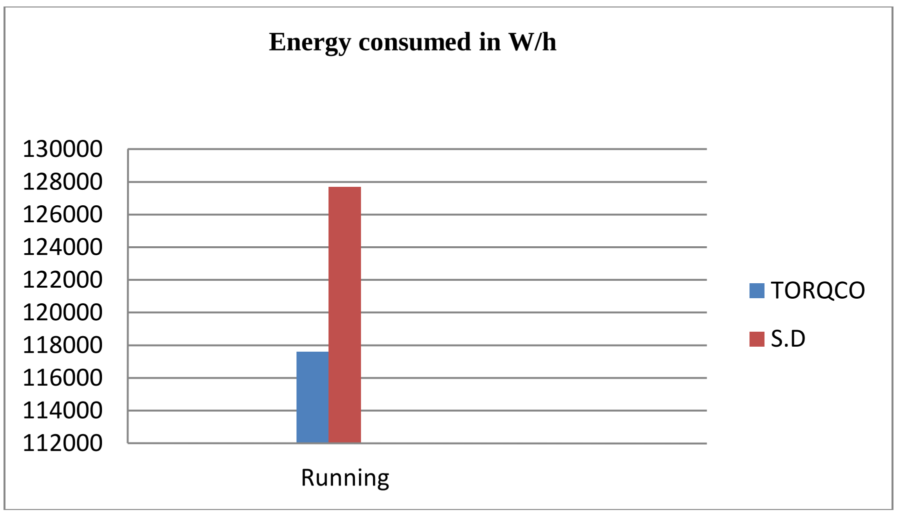
Total power consumed in 20 hrs =133.28+127572.82
=127706.1W/h

Graphical representation of energy consumed:

1. When starting the motor.



2. When running for 20 hrs



Energy saved in the 7.5Hp Motor =10107.46Wh
=10107/1000
=10.107KWh

Using the KPLC class C12 rates for KWh of Ksh 5.75 per unit
=5.75*10.107
=Ksh 58.118
When the motor is running for 20hrs a day Ksh 58.118 is saved
Assuming in a month of 30 days
=58.118*30
=Ksh 1743.54
KVA demand is when starting =0.06196/0.87
KVA demand =0.0712KVA
Total cost of energy saved =**Ksh 1743.54**

Clearly the novelty of the TORQCO is well demonstrated by the experiment (study) performed. The margin of current and voltage that was drowned by the motor initially during starting clearly shows that it consumed less energy compared to when the motor is started directly on line, while the smooth starting of the motor indicates that the entire system is free from electrodynamics stresses and torque oscillations and hence requires little maintenance because of less machine failures.

V. COST / BENEFIT ANALYSIS

Introduction

In an industrial set up of class C12 say a tea factory with 100 induction motors and assuming the energy saved by each motor is constant Kenya shillings 1743.54.exploring the amount of energy saved in terms of KWH and KVA demand("zcaJOzy5QmNN_Schedule of Tariffs 2013.pdf," n.d.):

a) **KWH**

Assuming in a tea factory with 100 induction motors
Then it will be:
=Kshs. 1743.54 * 100
=Kshs. 174354.00
In 1 year 174354*12
=**Kshs. 2,092,248**

b) **KVA DEMAND**

From the data collected and observing the deference of the initial starting current of the motor
=48-32=16
=16/48*100
=33.33%
This percentage represents the reduction of the KVA demand clocked by the plant assuming that the tea factory has a KVA demand of 700 KVA
Then 700 KVA will reduce by 33 percent to 467KVA whereby the 33% is equivalent to 233KVA.
Using the KPLC rates for a class C12 industry for KVA demand of Kenya shillings 600/=
Reduction cost =233*600

=Kshs 139,800 per month
In 1 year =139,800*12
=Kshs. 1,677,600
Total cost savings per year = Kshs. 2,092,248 + Kshs. 1,677,600

= Kshs. 3,769,848.00

Payback Period

In total a classic C12 factory with 100 motors running is estimated to save up to Kshs.3, 769,848 per annum in the cost of energy consumed having adopted the Torque Controller. Taking into account the cost of purchasing 100 Torque Controller Devices each to be fitted to the 100 motors at an average cost of Kshs. 60,000 per device, the organization will need to spend a total of Kshs. 6 million to obtain these energy cost saving devices. This translate to a payback period of one and a half years to counter the cost of adopting this device. The Torque Controller takes 8 years to be re-surfaced and therefore adopting this device will eventually be cost effective to the company.

VI. References

[1] Electrical Energy Conservation in Automatic Power Factor Correction by Embedded System. (n.d.).

[2] Research on the Torque and Back EMF Performance of a High Speed PMSM Used for Flywheel Energy Storage. (n.d.).

[3] Thermal Management of a Soft Starter: Transient Thermal Impedance Model and Performance Enhancements Using Phase Change Material. (n.d.).

[4] zcaJOzy5QmNN_Schedule of Tariffs 2013.pdf. (n.d.).