

AN EMPIRICAL PERFORMANCE ASSESSMENT
OF INFRARED THERMOGRAPHY FOR REAL-TIME
MONITORING OF ELECTRICAL SYSTEMS
IN THE COCO FIBRE INDUSTRY

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Abstract

The quality of the electrical network, which includes MV panels, DBs, MCBs, sub-circuits with fuse units, and electrical motors for machine tools, determines production in any sector. Most drive systems employ induction motors. System temperature indicates health. Excess temperature is rarely detected due to breakdown. This case study presents real-time data for a leading coir industry from each electrical circuit and motor in several machine tools. Every section is thermographed and compared to the allowed temperature range. Thermographic analysis is non-contact and uses fewer meters and instruments. A harmonic analyzer measures THD using data from the full testing period. Modern energy audits save 10–15% on energy. Suggestions include modest restructuring of electrical network load distribution, little investment in capacitor banks in each section of induction motors, and thorough analysis and corrective measures based on customer needs.

Key words: carbon fibre, electrical network, restructuring, thermography images, total harmonic distortion (THD), non-contact type of testing

Introduction. Over 60% of electrical energy is used by induction motors; therefore, they must be operated with care to have a healthy network. The anomalous temperature rise affects electrical motors and networks. Electrical networks generate extra heat as a result of loose contacts, overloaded cables, unbalanced

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three-phase load distribution, and unauthorised loads. Induction motors generate extra heat due to imbalanced drive systems, overworked motors, loose terminal contacts, and bearing overload. Different motor capacitors allow each machine to run at either a low or high power factor. Electrical studies examine the configuration of an electrical network's main circuit boards (MCBs), distribution boards (DBs), medium-voltage (MV) panels, and fuse units. There are many *types* of topologies proposed by many researchers for improving the power quality of the system. Voltage injection using Unified Power Flow Control (UPFC) improves power quality and prevents transmission system issues.

Literature survey. In this method, an enhanced voltage profile increases transient stability [1]. THD and load voltage unbalance are reduced via a PWM-controlled Dynamic Voltage Restoration DVR [2,3]. Using different control algorithms for series and shunt APFs, the UPQC architecture can correct PQ at the load at a lower DC-link voltage [4]. It shows how STATCOM-BESS controls power quality [5]. Single-phase to ground faults, three-phase faults, and voltage swell occurred in 500–900 ms for inductive and capacitive loads, respectively. VSC and PWM control are in D-STATCOM. Voltage is measured through PWM. Swells of 11%, interruptions of 25%, and sags of 13% are reduced [6]. Short and long pauses, voltage spikes, and voltage swells cause power distortions, and the PWM-controlled autotransformer-based voltage sag compensator has been presented to suppress them. PWM-controlled autotransformer voltage sag compensation has been presented. By keeping load voltage within limitations, the suggested method can detect and minimize disturbances [7–9]. Control principles and solutions for large industrial loads using a dynamic voltage restorer, an active power filter, and a static compensator are discussed. GHG emissions and grid electricity use decrease with DGs. PQ Control strategy selection depends on response time, tracking precision, complexity, computing burden, resilience, and cost [10]. Harmonic reduction is essential for hybrid power systems. The study found solutions for improving the power quality of advanced hybrid power systems [11]. Air-gap Torque Monitoring, Vibration Analysis, Acoustic Analysis, Thermography, Partial Discharge, Axial Flow, and Motor Current Signature Analysis were addressed as defect detection methods [12]. Motor Current Signature Analysis is straightforward to apply and cost-effective [13]. Motor Current Signature Analysis (MCSA) and Zero-Sequence Voltage Component (ZSVC) can detect stator defects in squirrel cage induction motors [14]. RGB colour space monitoring compares healthy and unhealthy induction motor bearing defects [15]. JEFFALI et al. [16] discussed thermography-based induction motor failure diagnosis, which provides insights into the thermal health of the machine. Healthy DC motors have been compared to rotors with short-circuited armature coils. Faults are diagnosed using thermography [17–19]. Induction machine rotor failure diagnostics use vector control. Healthy and defective motor stator currents are compared using the wavelet transform [20].

Materials and methods. The proposed power quality analysis is carried out in a leading *coir industry*. Major recommendations are based on the field data. The following analyses are used to make observations and recommendations: thermography analysis and power analyzer analysis.

Thermographic analysis of electrical system. Table 1 shows the thermographic analysis of the incoming point, distribution board, and decorticator machine (I). It is found that an excessive temperature rise occurs in one phase due to a loose connection, which causes a supply interruption. Therefore, it is recommended to follow the precautions and connections frequently during maintenance. Bearing failure is caused by bearing weakness, high belt tension, and tightness in the front cover in Decorticator Machine I, as shown in Fig. 1e. Care must be taken to overcome this belt tension, and oil or creasing in the contact points should also be checked.

Power quality analysis of electrical system. Figure 2a) shows the results of an analysis of the system's power quality as well as the power trend as measured by the Fluke meter. A low power factor of 0.52 was discovered in the decorticator I motor, which was caused by capacitor loading. In order to avoid this, bigger values of capacitors should be connected at this point, which will lead to a high demand in kVA and a higher active energy consumption. A capacitor with the appropriate value should be attached in order to improve the power factor. The power trend is depicted in Fig. 2b), c), d) which are found in the decorticator I motor. Because of the power trend, it was determined that the decorticator I motor suffers a significant amount of power loss as a result of the improper value of the power quality assistance devices that are used together with the motor. This not only causes thermal abnormalities in the machine, but it also results in other losses, which may result in a decrease in the product's quality.

Results and discussion. From the name plate detail of the decorticator I motor presented in Table 1 it is evident that the maximum power output of the decorticator I motor is 37.5 kW.

Hence the Input power taken by the motor at full load is given by

$$(1) \quad \text{Input power } P_i = \frac{\text{Output power}}{\text{Efficiency}} = \frac{37.5 \text{ kW}}{0.92} = 40.76 \text{ kW}.$$

The power quality analyzer is placed on the input side of the motor and observed for 30 min. According to the data, the motor drew a power of 37.02 kW between 10:51:19 AM and 10:51:20 AM (just one second). As a result, during the 30-min loading condition, the motor never reached full load power. During the remaining time, the motor's power consumption is close to 30–32 kW. From Table 2, a comparison of the following recommendations may be suggested for saving an appreciable amount on energy bills. It is recommended that the current motor (with 37.5 kW) be replaced with a 30 kW motor from the same manufacturer. Even though the load is higher for a longer period of time, the motor only

T a b l e 1

Name plate detail of the decorticator I motor

Type	Three Phase Induction Motor		
Manufacturer	Kirloskar Electric. Co. Ltd., India		
Power	37.5 kW	Voltage	415 V
Speed	Not clear	Protection	IP 55
Frequency	50 Hz	Duty	S 1
Current	62 A	Efficiency	92.0 %
Insulation	Class F	Connection	Delta

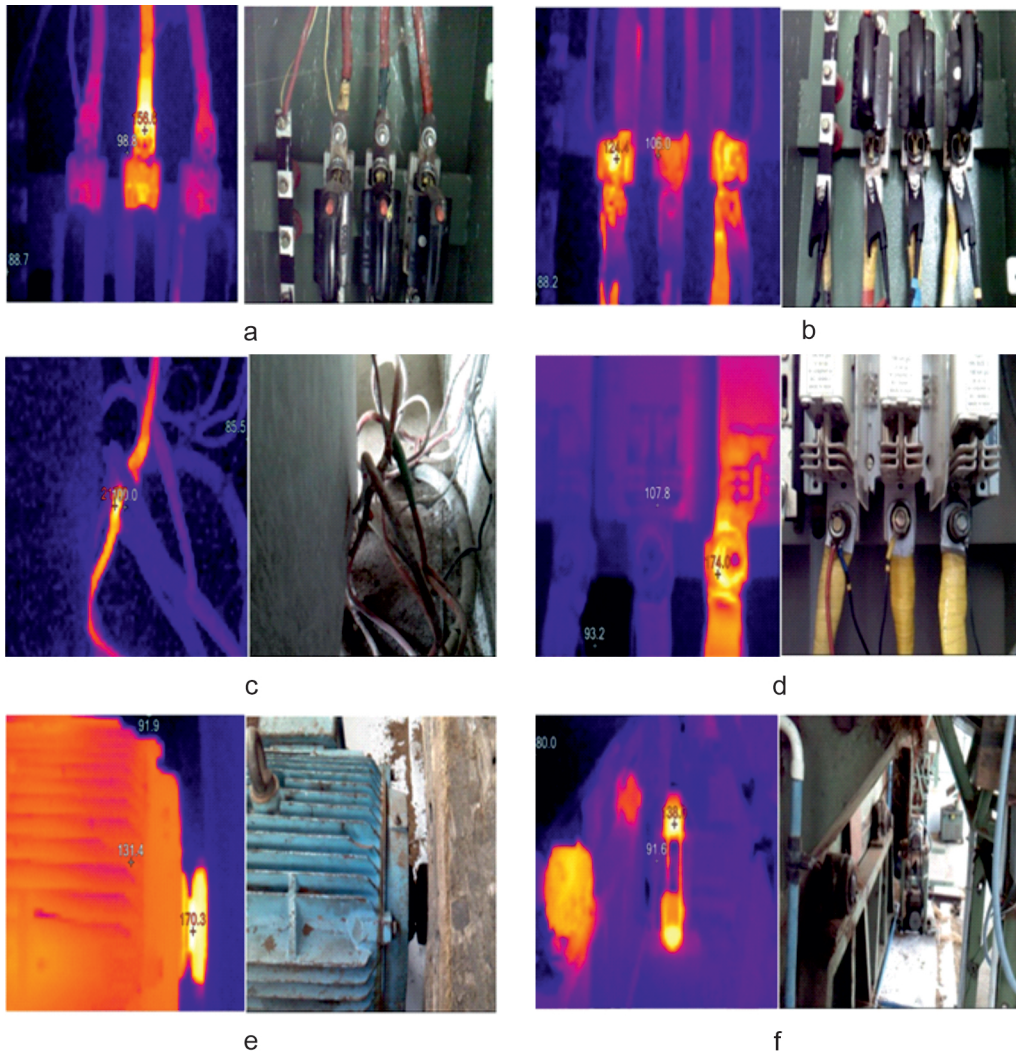


Fig. 1. Thermographic analysis. a) EB-main incoming – top, b) EB-main incoming – bottom, c) EB-main incoming – backside, d) Distribution board/motor side, e) Decorticator I (fibre screener-polishing motor), f) Small motor in decorticator machine – I

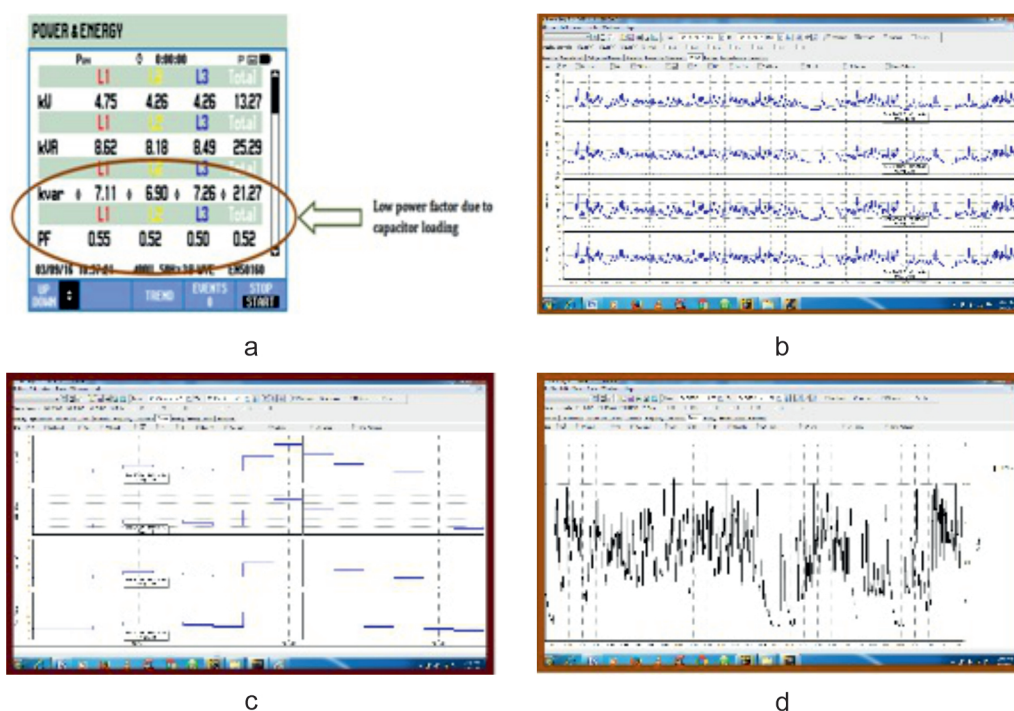


Fig. 2. a) Motor incoming point on decorticator I (fibre screener-polishing), b) Power trend recorded on decorticator I motor (30 min recorded at 1 s interval), c) Power trend recorded on decorticator I motor start point of maximum power at 10:51:19 AM, d) Power factor trend recorded on decorticator I motor

experiences a momentary overload. As per IS 325, any standard motor can be momentarily overloaded for 15 s. In our case, the momentary load (i.e., 1 s) is within the IS standard. In this case, the expected power saving is about 7.5 kW. Table 2 shows the bare minimum of energy-saving options for new motor installation.

Conclusion. The various machines in the coir industry are investigated in this study for causing excessive temperature rises in the middle phase of the main incoming panel (top). It was recorded at almost 156.60 °F at the time of measurement. In addition, there is an excessive temperature rise in lines 1 and 3 (124.4 °F and 106.00 °F, respectively) after the HRC fuse of the main incoming panel (bottom). A similar excessive temperature rise is found in the backside of the EB main incoming cable joint of a specific phase. The recorded temperature rise is about 212.7 °F. Also, a high temperature is recorded in the R-Phase Incoming of the Fibre Screener Incoming Point. It is also observed that, in some places, the main motor and auxiliary motors in the machine generate excessive temperature rises (front cover/ bearing, and belt/pulley) varying from 138 °F to 174.0 °F. It is found that the motor connected to the screen-polishing machine has a power factor too low (i.e., in the order of 0.52) and is also leading. The excessive capacitor con-

T a b l e 2

Comparison table for better energy saving

Description	Existing motor	New motor	Power saving
Power rating	37.5 kW	30 kW	7.5 kW
Running time	20 h (2 Shifts)	20 h (2 Shifts)	–
Energy consumption/day	750 Units	600 Units	150 Units
Cost of energy/day (@ Rs. 6.35/Unit)	Rs. 4762.50	Rs. 3810.00	Rs. 952.50
Cost of annual energy ($\approx$ 300 days/annum)	Rs. 1 428 750.00	Rs. 1 143 000.00	Rs. 285 750.00 (A)
Investment cost of the new motor	–	Rs. 70 000.00 (Inclusive of all taxes)	–
Cost of Installation & Transportation	–	Rs. 10 000.00*	–
Total Cost (B)	–	Rs. 80 000.00	
Simple payback period (A/B)	–	–	Approx. 3–4 months ^{\$}

nected at the motor side's input causes the leading power factor. The main cables running from the utility meter to the main incoming panel (EB main incoming) are open and loosely rooted. This may lead to severe safety issues and may also damage the cables, so it must be rooted properly with sufficient panel board. The appropriate sticker (naming the loads to which it is connected) should be easier to apply to the Decorticator machine's distribution panel, making it more accessible for maintenance and during faulty periods. It is good practice to connect the capacitor banks at the input side of the individual motors with adequate voltage. However, if the capacitor's kVAR rating is not properly selected, this may result in a slight lag or a low power factor. In order to avoid the above issue, the proper value of Automatic Power Factor Correction (APFC) must be connected at the main incoming point with a minimum value. A 3-CT-type APFC may be used instead of a single-CT-type APFC. This will average the PF across the phases and take corrective action accordingly. Oversizing of the motor is found in Decorticator I (the fibre screener and polishing machine), and this must be replaced with a 30 kW motor instead of the present power rating of 37.5 kW. Body earthing should be properly maintained with minimum resistance and checked periodically. This will prevent equipment (particularly electronic equipment) from failing prematurely.

REFERENCES

- [¹] LAKSHMI B. D., M. M. GUPTA, G. M. KUMAR et al. (2014) Enhancement of power quality in transmission line using Flexible AC Transmission System device U.P.F.C. (Unified Power Flow Controller), *Int. J. Eng. Res. Appl.*, 4(4), 319–323.

- [2] REDDY V. U., S. D. CHOWDARY (2012) Detection and mitigation of power quality disturbances using DWT technique and DVR, *Int. J. Eng. Res. Appl.*, **2**(6), 766–771.
- [3] JAIN S., P. S. SINGH THAKUR (2012) Improve power quality and reduce the harmonics distortion of sensitive load, *Int. J. Eng. Res. Appl.*, **2**(6), 806–815.
- [4] SRAVANI K., T. S. SASTRY (2013) UPQC for power quality improvement of induction motor drive with reduced DC link voltage, *Int. J. Eng. Res. Appl.*, **3**(6), 1374–1380.
- [5] KUMAR K. S., K. S. KUMAR, S. BAJI (2013) A new control scheme for power quality improvement with STATCOM, *Int. J. Eng. Res. Appl.*, **3**(4), 2555–2561.
- [6] SIVAKOTI S. K. K., Y. N. KUMAR, D. ARCHANA (2011) Power quality improvement in distribution system using D-Statcom in transmission lines, *Int. J. Eng. Res. Appl.*, **1**(3), 748–752.
- [7] BAJPAI S. (2013) Power quality improvement using AC to AC PWM converter for distribution line, *Int. J. Eng. Inventions*, **2**(11), 60–66.
- [8] SINGH A., B. S. SURJAN (2020) Power quality improvement using GUPFC, *J. Inf. Optim. Sci.*, **41**(1), 185–194, doi: 10.1080/09720510.2020.1715015.
- [9] RAZAK N. A. A., S. JAAFAR, I. S. HUSSAIN (2013) Investigation of voltage swell mitigation using STATCOM, *IOP Conf. Ser. Earth Environ. Sci.*, **16**(1), doi: 10.1088/1755-1315/16/1/012079.
- [10] JADHAV S. (2016) *IJCA Proceedings on International Conference on Advances in Science and Technology ICAST 2015*(3), 16–19.
- [11] VIVEK M., P. K. SRIVIDHYA, K. SUJATHA (2016) Power quality improvement in hybrid power system: Review, *Int. J. Appl. Eng. Res.*, **11**(4), 2518–2521.
- [12] WARADE T. R. (2017) Induction Motor Stator Fault Detection and Health Monitoring Using Fuzzy Logic, *Int. J. Sci. Technol. Manag.*, **2**(1), 10–16.
- [13] GARCIA-RAMIREZ A. G., L. A. MORALES-HERNANDEZ, R. A. OSORNIO-RIOS, J. P. BENITEZ-RANGEL, A. GARCIA-PEREZ et al. (2014) Fault detection in induction motors and the impact on the kinematic chain through thermographic analysis, *Electr. Power Syst. Res.*, **114**, 1–9, doi: 10.1016/j.epsr.2014.03.031.
- [14] PRAKASAM K., S. RAMESH (2016) Testing and analysis of induction motor electrical faults using current signature analysis, *Circuits Syst.*, **7**(9), 2651–2662, doi: 10.4236/cs.2016.79229.
- [15] KHAMISAN N., K. H. GHAZALI, A. H. M. ZIN (2015) A thermograph image extraction based on color features for induction motor bearing fault diagnosis monitoring, *ARPN J. Eng. Appl. Sci.*, **10**(22), 17095–17101.
- [16] JEFFALI F., B. EL KIHIL, A. NOUGAOUI, F. DELAUNOIS (2015) Monitoring and diagnostic misalignment of asynchronous machines by infrared thermography, *J. Mater. Environ. Sci.*, **6**(4), 1192–1199.
- [17] KALASKAR C. S., V. J. GOND (2014) Motor current signature analysis to detect the fault in induction motor, *Int. J. Eng. Res. Appl.*, **4**(6), 58–61.
- [18] ASHISH V. (2014) Review on thermal image processing techniques for machine condition monitoring, *Int. J. Wirel. Commun. Netw. Technol.*, **3**(3), 49–53.
- [19] GLOWACZ A., A. GLOWACZ, Z. GLOWACZ (2015) Recognition of thermal images of direct current motor with application of area perimeter vector and Bayes classifier, *Meas. Sci. Rev.*, **15**(3), 119–126, doi: 10.1515/msr-2015-0018.
- [20] MEKRINI Z., S. BRI (2016) A modular approach and simulation of an

asynchronous machine, Int. J. Electr. Comput. Eng., **6**(4), 1385–1394, doi:
10.11591/ijece.v6i4.9646.

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