PREDECTIVE MAINTENANCEOF INDUSTRIAL MOTORS

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1.INTRODUCTION

1.1 Overview

This paper presents current methods of electrical test and trend analysis of the operational health of electric motors in the context of successful predictive maintenance programs. The benefits and features of these various types of test equipment and motor testing methodologies are conveyed in the context of motor/machine "systems," which accounts for conditions that can impact the health of a motor, but can be external to the motor itself. This paper outlines the concepts of static motor testing, or testing on a motor that is not running, as well as dynamic motor monitoring, which involves performing analysis on motors while they are in service, or operating within their application environment. It also covers an emerging type of online dynamic monitoring involving a permanently-installed networked motor analyzer that enables maintenance professionals to monitor motor system conditions from any Web-accessible computer .

1.2 Purpose

Predictive maintenance programs are crucial to an organization's ability to avert unplanned or unnecessary downtime that can adversely affect its ability to produce or operate. Predictive maintenance programs are most effective when all available means of measuring health and analyzing health trends of electric motors, cables, power quality and load are rigorously implemented. In other words, safe and continuous operation of plants and facilities drives revenue and profit, and depends upon high motor reliability. Predictive maintenance of motor systems is a necessity when it comes to supporting reliability objectives that in turn support a company's or organization's business objectives. The power generation industry, as an example, ranks at the top of this requirement for uninterrupted operation and safe, continuous production. A number of motors run equipment that is ancillary to the production or health of a company (e.g., one of a few rooftop motors for an HVAC system, which won't have an immediate impact on the HVAC system if it stops working). Other motors, however, are "critical" to a company's ability to conduct business; that is, they are motors that drive such things as conveyor systems, fluid pumps, or production-line machinery that a company relies upon to generate revenue and profit each and every day.

2. LITERATURE SURVEY

2.1 Existing Problem

Static testing (or off-line testing of motors in their static, powered-down state) is commonly performed just once in a given period of months, usually up to a year. It's also performed opportunistically during outages when a motor is shut down for other reasons.. identify potential problem areas identify potential problem areas identify potential problem areas Off-line testing is often used as a quality assurance measure. The goal of a predictive maintenance program is almost always to reduce unscheduled downtime. An effective predictive maintenance program is measured by how well it works to predict imminent failures and identify potential problem areas before they fail and create expensive recovery costs for an organization. They should also work to determine the root causes of failures and, ultimately, save money by extending the service life of motors and rotating equipment. This is why electrical testing of motors is such a critical component of predictive maintenance.
The present system mainly is the offline testing which cannot address all the potential problems often, because we cannot test the motors manually everyday and thus we need a system which can be achieved only by some Dynamic(Online) testing Online motor monitoring for the dimension of gathering motor system health data at regular intervals throughout a day, 365 days a year. A small amount of voltage unbalance coupled with minor harmonic voltage distortion may result in a NEMA (National Electrical Manufacturers' Association) de-rating that will not be seen with simple multi meters and amp probes. Current levels and current unbalances also affect motor performance and monitoring them is essential when trending motor health

2.2 Proposed Solution

- Dynamic, or on-line monitoring is performed while the motor is powered on and working within its normal system or application. Data collection with dynamic motor testers is safe, fast and nonintrusive. Dynamic testing provides information regarding power quality and conditions such as voltage levels, unbalances and distortion. Besides electrical issues with motors that the technology can monitor, many mechanical issues with a motor and its system are also discernable with data that dynamic analyzers can collect. Torque and current spectra have proven to be highly useful in determining mechanical issues, including bearing faults, looseness (vibration or misalignment) and eccentricity. Again, considering a motor is part of a motor/machine system with three aspects (power source, load source, and the motor itself), a good dynamic analyzer provides relevant condition information about all three. Many motor problems are created by adverse or mismatched loads, or by poor supply power. Without a means of analyzing data from monitoring across a motor system, the true root cause of motor failure often goes undetected. The ability to acquire and define such adverse impacts as torque provides a maintenance professional the means to separate the mechanical from the electrical issues, improve decision-making concerning repair or replacement, and otherwise extend the service life of the motor .Dynamic testing provides health information about motor systems across power source, motor and load source. It monitors power quality and conditions such as voltage levels, unbalances and distortion. Current levels and current unbalances also affect motor performance and monitoring them is essential for analyzing motor health trend data For proper working conditions, the equipment is continuously observed for its temperature, current ,humidity in the environment and any vibration in its operation. Values ranging beyond the threshold are indicated through LEDs at the equipment and also in the mobile, Web App. Users can stop the motor from working manually through switches and also automatically from the Web App. All values are stored the database cloud.

3.THEORITICAL ANALYSIS

Predictive maintenance (PdM) is a technique to predict when equipment might fail so that the component can be replaced before the failure. This helps in reducing downtime and maximizing the component lifetime.

3.1 Block Diagram

The processes involved in monitoring the Motors are :

- Industrial motor maintenance plays a key role in its operation. For proper working conditions, the equipment is continuously observed for its temperature, humidity in the environment and any vibration in its operation.
- Current to and from the equipment is continuously monitored to avoid any short circuits and line breakage.
- Values ranging beyond the threshold are indicated through LEDs at the equipment and also in the mobile, Web App.
- Users can stop the motor from working manually through switches and also automatically from the Web App.
- All the measured values are stored in the database.
- The users Are Notified after performing Analysis on the Data and is also notified about the Motor’s parameters
- The required actions are take in order to find out the conditions of motor and Sort, any problems through continuous monitoring of them through dynamic testing and then, operating motors Remotely

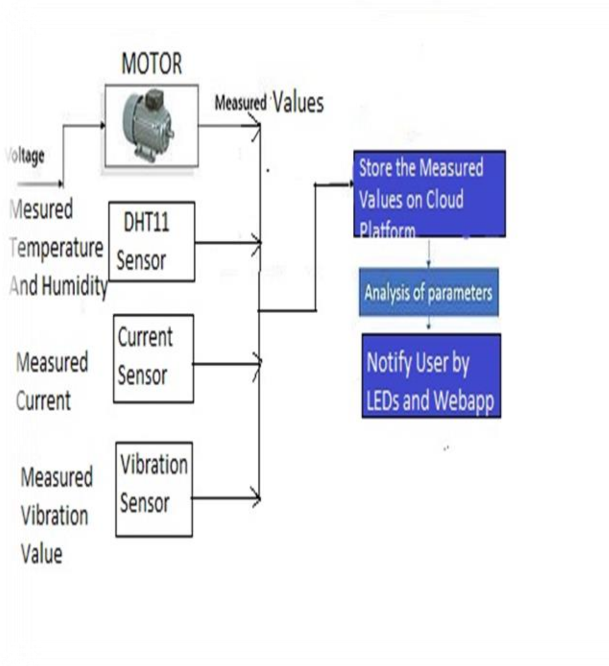

Figure 1:Block Diagram of the System

3.2 Hardware/Software Designing

The following processes are carried out to make the system :

1. A Node Red Application is made , for wiring together hardware devices, APIs and online services . It provides a browser-based editor that makes it easy to wire together flows using the wide range of **nodes** in the palette that can be deployed to its runtime in a single-click. After this an MIT app is also made.

2.A python code is made for measuring humidity and temperature values sensed by a DTH11sensor,and also to measure other important parameters of a motor like vibrational values and current etc Sensed by the sensors also for making LED glow when the values are above a threshold value as specified by the python code and in a app it is notified and all these data are also published in IBM cloud

3. NodeRed flow is made for getting the values of the measured data from the devices ,The dashboard nodes are used for creating the UI (Web app) and then Http requests are made for commute the value's information with the user ,After this the mobile app is made and a UI is designed to show the tempeature, humidity ,current and Vibration values to the user and then it is configured to get the data from the cloud and for controlling the system or motors by buttons in mobile .

4.EXPERIMENTAL INVESTIGATIONS

Predictive maintenance consists of detecting the operation conditions of the motor at full load and under the effective temperature and wetness conditions while working. This is in contrast to regular methods where values are collected by starting the stationary machine.

By having this knowledge of values, you can carefully and accurately predict when the equipment might fail. This further helps in preventing that failure on time.This technology enables maintenance professionals to make better decisions faster than the “spot-testing” method of testing that is characterized by route-running once every few months to yearly. It captures information that can’t otherwise be captured in a single testing session performed with a portable tester. Alerts can be set to flag maintenance professionals of the need to investigate and/or replace critical motors the online analyzer is monitoring. Moreover, the trend data from months of monitoring provides valuable insight that frames predictive maintenance planning and helps prioritize resources and actions. Finally, because the monitoring is effectively performed remotely, online dynamic analyzers all but eliminate safety hazards associated with testing in-service motors in the field. Dynamic monitoring also provides efficiency information allowing maintenance professionals to make wise and practical decisions when confronted with choices to repair or replace a given motor. Improving such efficiency by just two percent may result in thousands of dollars in excessive annual energy costs

5.FLOW CHART

The following is the system flow chart, the steps involved here are shown below:

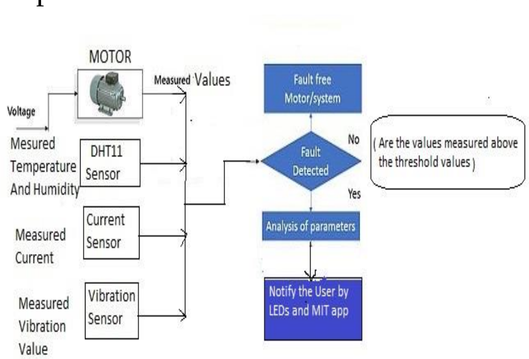

Figure 2:Flow Chart of the System

6.RESULTS

The System provides a way to monitor the industrial motors with ease through app and control it using the app :

The Snapshot of the Nodered and MIT app are below

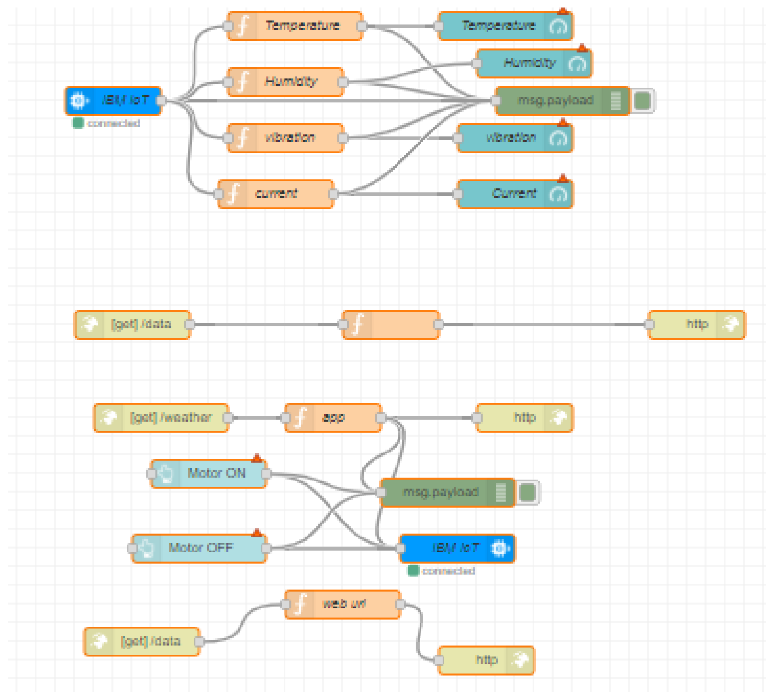

Figure 3:Nodered flow block interface

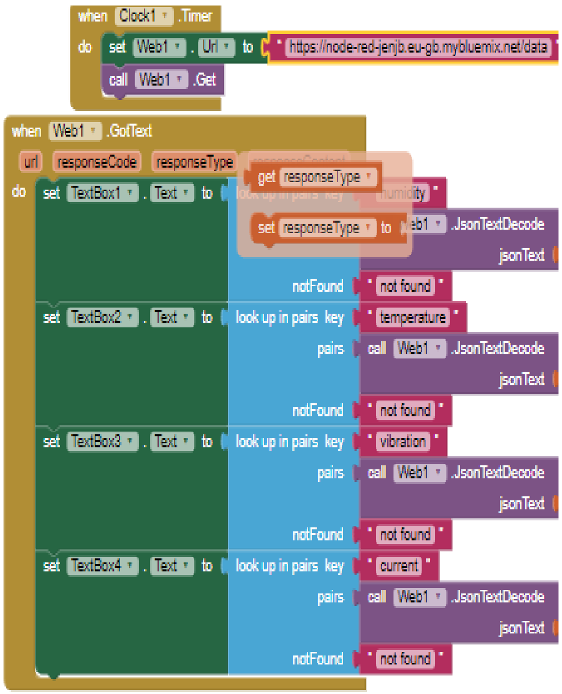

Figure 4:MIT app blocks of the System

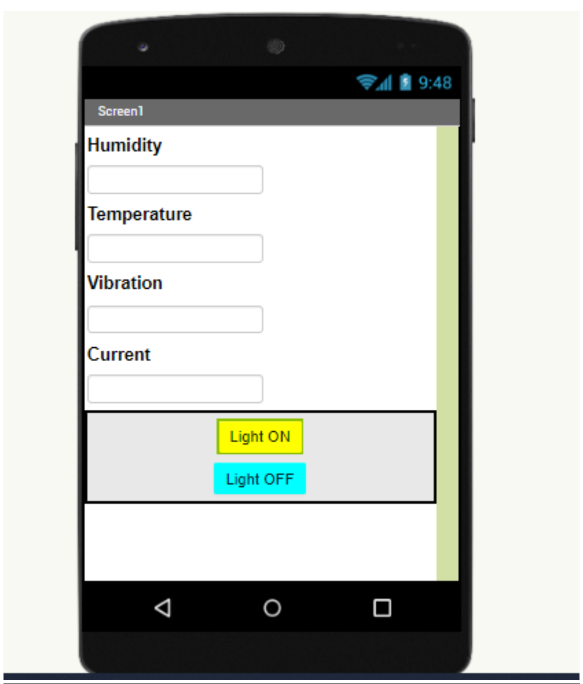

Figure 5:Nodered Design UI for the Mobile App

7. ADVANTAGES AND DISADVANTAGES

Advantages

- Provides increased component operational life and availability
- Allows for preemptive corrective actions
- Results in decrease in equipment and/or process downtime
- Lowers costs for parts and labour
- Provides better product quality
- Improves worker and environmental safety
- Raises worker morale
- Increases energy savings
- Results in an estimated 8% to 12% cost savings over which might result from a predictive maintenance program

Disadvantages

- Increases investment in diagnostic equipment
- Increases investment in staff training
- Savings potential is readily seen by management

There are many advantages of using a predictive maintenance program. A well-orchestrated predictive maintenance program will all but eliminate catastrophic equipment failures. Staff will then be able to schedule maintenance activities to minimize or eliminate overtime costs. And, inventory can be minimized, as parts or equipment will not need to be ordered ahead of time to support anticipated maintenance needs. Equipment will be operated at an optimal level, which will also save energy costs and increase plant reliability.

Past studies have estimated that a properly functioning predictive maintenance program can provide a savings of 8% to 12% over a program utilizing preventive maintenance strategies alone. Depending on a facility's reliance on a reactive maintenance approach and material condition, savings opportunities of 30% to 40% could easily be realized. In fact, independent surveys indicate the following industrial average savings resulted from initiation of a functional predictive maintenance program:

- Return on investment: 10 times
- Reduction in maintenance costs: 25% to 30%
- Elimination of breakdowns: 70% to 75%
- Reduction in downtime: 35% to 45% and saves 9000$ of cost of production
- Increase in production: 20% to 25%

The down side of using a predictive maintenance approach are its initial costs.

8. APPLICATIONS

Nearly all modern static and dynamic testers are portable. Static testers can be used in a shop or easily carried into the field. Dynamic testers are by nature used in the field (wherever running motors are located), but often test via a motor control center. However, emerging new technology has spawned a dynamic motor analysis tool known as an online motor analyzer that is permanently installed, and in proximity to the locations of up to 32 motors via motor busses within MCCs. The concept is to perform all of the same tests a portable dynamic motor tester does, but with the additional benefits of continuous monitoring and viewing the status of a given motor from a central office location—or for that matter, anywhere in the world with a PC and a good Internet connection.

9. CONCLUSIONS

Static and dynamic testing of electric motors is critical for successful implementation of predictive maintenance programs. Static testing is the most effective means of measuring the integrity of the motor’s insulation system, and can be used as well for quality assurance when a motor is out of service. Dynamic testing provides valuable information about motor systems, including power condition, load, and the motor, including physical aspects that can affect the life or operation of the motor. Online motor monitoring adds the dimension of gathering motor system health data at regular intervals throughout a day, 365 days a year. Combined, they present a comprehensive picture of motor and motor system health that can be a foundation for successful predictive maintenance programs. They provide the full spectrum of motor condition information required to accurately diagnose and predict imminent failures and as a result solidify electrical motor testing’s place as an essential part of a complete predictive maintenance program.

10. FUTURE SCOPE

Besides electrical issues with motors that the technology can monitor, many mechanical issues with a motor and its system are also discernable with data that dynamic analyzers can collect. Torque and current spectra have proven to be highly useful in determining mechanical issues, including bearing faults, looseness (vibration or misalignment) and eccentricity. Again, considering a motor is part of a motor/machine system with three aspects (power source, load source, and the motor itself), a good dynamic analyzer provides relevant condition information about all three. Many motor problems are created by adverse or mismatched loads, or by poor supply power. Without a means of analyzing data from monitoring across a motor system, the true root cause of motor failure often goes undetected. The ability to acquire and define such adverse impacts as torque provides a maintenance professional the means to separate the mechanical from the electrical issues, improve decision-making concerning repair or replacement, and otherwise extend the service life of the motor

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2 R.M. Tallam, T.G. Habetler, R.G. Harley, "Transient Model for Induction Machines with Stator Winding Turn Faults." IEEE Transactions on Industry Applications, Vol. 38, No. 3, May/June 2002.

3 https://www.skf.com/binary/21-285423/Motor-PdM-primer.pdf

4 Smartbridge tutorial lectures

5 IBM cloud blogs

APPENDIX INFORMATION

Source code

```
import time
import sys
import ibmiotf.application
import ibmiotf.device
import random
import requests
#Provide your IBM Watson Device Credentials
organization = "2u4wmg"
deviceType = "rasp"
deviceId = "12345"
authMethod = "token"
authToken = "123456789"


def myCommandCallback(cmd):
    print("Command received: %s" % cmd.data['command'])

    if cmd.data['command']=='motoron':
```

```
            print("Motor ON IS RECEIVED")


        elif cmd.data['command']=='motoroff':
            print("MOTOR OFF IS
RECEIVED")



try:
        deviceOptions = {"org":
organization, "type": deviceType, "id":
deviceId, "auth-method": authMethod,
"auth-token": authToken}
        deviceCli =
ibmiotf.device.Client(deviceOptions)
        #..............................................

except Exception as e:
        print("Caught exception connecting
device: %s" % str(e))
        sys.exit()

# Connect and send a datapoint "hello" with
value "world" into the cloud as an event of
type "greeting" 10 times
deviceCli.connect()

while True:

        hum=random.randint(0, 100)
        #print(hum)
        temp =random.randint(0, 100)
        vibration =random.randint(0, 100)
        current =random.randint(0, 100)
        #Send Temperature & Humidity to
IBM Watson
        data = { 'Temperature' : temp,
'Humidity': hum, 'vibration':vibration,
'current':current }
        #print (data)
        def myOnPublishCallback():
            print ("Published Temperature = %s
C" % temp, "Humidity = %s %%" % hum,
"vibration = %s %%" % vibration, "current
= %s %%" % current, "to IBM Watson")

        success =
deviceCli.publishEvent("Weather", "json",
data, qos=0,
on_publish=myOnPublishCallback)
        if(temp<50):
            r =
requests.get('https://www.fast2sms.com/dev/
bulk?authorization=dqF1h94caTEzStImNW
UD0gx3vQjrwsKLRpOoeilJ85PMVkYXGn
MOEUrL8KiwAPa0QxhoctVgkmXlCdWs
&sender_id=FSTSMS&message=Temperat
ure is low...please switch on the
motor.&language=english&route=p&numbe
rs=7999697504')
            print(r.status_code)
        if(hum<50):
            r =
requests.get('https://www.fast2sms.com/dev/
bulk?authorization=dqF1h94caTEzStImNW
UD0gx3vQjrwsKLRpOoeilJ85PMVkYXGn
MOEUrL8KiwAPa0QxhoctVgkmXlCdWs
&sender_id=FSTSMS&message=Humidity
is low ....please switch on the
motor.&language=english&route=p&numbe
rs=7999697504')
            print(r.status_code)
        if(vibration<50):
            r =
requests.get('https://www.fast2sms.com/dev/
bulk?authorization=dqF1h94caTEzStImNW
UD0gx3vQjrwsKLRpOoeilJ85PMVkYXGn
MOEUrL8KiwAPa0QxhoctVgkmXlCdWs
```

```
&sender_id=FSTSMS&message=The motor
vibration is too
high...&language=english&route=p&numbe
rs=7999697504')
                print(r.status_code)
        if(current<50):
                r =
requests.get('https://www.fast2sms.com/dev/
bulk?authorization=dqF1h94caTEzStImNW
UD0gx3vQjrwsKLRpOoeilJ85PMVkYXGn
MOEUrL8KiwAPa0QxhoctVgkmXlCdWs
&sender_id=FSTSMS&message=Current
consumption is
high.&language=english&route=p&numbers
=7999697504')
                print(r.status_code)
        if not success:
            print("Not connected to IoTF")
        time.sleep(2)

        deviceCli.commandCallback =
myCommandCallback

# Disconnect the device and application
from the cloud
deviceCli.disconnect()
```