Implementation of IOT for Real Time Monitoring and Fault Diagnosis of Wind Turbine

Edison prabhu. K, AP/EEE NIET, Sanoofar.A.N, EEE NIET.

Abstract

In future the world’s most of the energy demands are mainly depends on renewable energy, as such one the wind energy gains greater attention in research area and practices and when compared to other renewable sources it has possibilities like ecofriendly, negligible wastes, get a clean energy and so on. But most of the problems faced by wind turbines are structural faults. The internet of things IOT is a new and future technical paradigm and there are so many researches and studies are going on this field and researches says that in future the IOT becomes an unavoidable one in day to day life like electricity. In this paper proposes a real time monitoring and fault diagnosis technique for wind turbine using IOT enabled. Through this model live status monitoring, early fault identification and analysis of historical status of turbine are made possible.

Keywords: Real time monitoring, wind turbine, IOT, Fault diagnosis.

I. Introduction

The wind energy is the world’s fastest growing renewable energy source, it is the energy of future and so many large initiations are currently happening in this field for utilize the wind energy in an exact manner. The countries like US, China or Germany provide much attention to wind energy and US targets to 300 GW power productions from wind in the year 2030 [8] and china needs to solve 10-15% total energy demand by 2020 using wind energy [9]. From the beginning of time, the main problem faced by wind energy is the structural faults [11] (Fig 1) occurs in the wind turbine, the major parts of turbine [13] are rotor, blades, generator and bearings among these the major faults happen in bearings. The 10-15% of total income is essential for operation and maintenances of turbine parts [12], so the monitoring of turbine and early detection of faults are necessary; it helps for an efficient manner operation. When follow the traditional ways so many difficulties meet undesired downtime, expensive, frequent checking suffers large number of labors and in case of component replacement there is a need of crane crew and sophisticated technology and technicians [14]. In this traditional way the condition of turbine in between the period of checking remains unknown. Hence it is urging to search an alternative way for live monitoring and early fault diagnosis of wind turbine.

Figure 1: Structural faults of wind turbine blades
Through IOT enabled way the required sensors deployed on the proper parts of the machine and data’s can be collected using suitable connectivity methods to the central server, after that the real time data’s are visualized to the end user. In this model certain predetermined limit values are set in the central server [4] and incase of any wrong happenings there is some sudden fluctuation happens in the machine parameters, if the sensed data value is exceeding the maximum or goes below the minimum limit value the system alerts the user. It helps to identify the errors easily and early.

In this work the suitable sensors such as temperature sensor [9], vibration sensor, force sensor and torque sensor are attached on the proper positions on the parts of wind turbine an RFID module [4] [5] i.e., an RF tag are attached with each part for identify it uniquely. Next the live updating of turbine parameters is done to the central server, a smart connection [7] mode is used for connect the sensors and central server, from the server the end user can able to view and observe the real time data through a smart visualization method.

The remaining of this paper is arranged as follows, section 2 defines the proposed scheme in detail, a case study is explained in next section 3, result and conclusions are described in section 4 and 5 respectively.

II. Proposed model: Real time monitoring of wind turbine using IOT enabled approach

The figure 2 shows the flow diagram of proposed IOT enabled real time turbine status monitoring solution.

![Architecture of proposed model](image)

There are four major layers in the proposed scheme smart turbine, smart connection, smart data model and smart view. The sub sections next explain in detail about these layers.
A. Smart turbine

In this model a smart turbine is build i.e., the arrangement of turbine with required sensors attached on its various parts in a suitable manner and along with these sensors RF tags also placed in each component for identify it individually is termed as smart turbine, the existing turbine one is converted as a smart turbine by this arrangement. Vibration sensor, temperature sensor, torque sensor and force sensor are the sensors used here, vibrations sensors are attached on the bearings and blades whereas the temperature sensor plays its role in generator and rotor, the torque sensor also used in rotor and force sensor attached with blades. The real time status of wind turbine is tracked and traced with the help of data’s collected by these sensors so the turbine is always under 24*7 monitoring.

B. Smart connection

The data’s collected by sensors are received by a central server i.e., the smart turbine is connected to a central computer, for this a connectivity layer is need here it is termed as smart connection. This work use Wi-Fi as a smart connection for connect the sensors and server, while the RF tags are connected to the server by using a RF way of communication and 4G connection is used for access the server by user’s smart phones. In this smart connection it is also possible to control and manage the connectivity methods by central computer effectively and efficiently, hence it is reliable to capture and collect the real time data’s.

C. Smart data model

To ensure the full use captured and collected data’s, it is necessary for process and analyze it, for this data models are used. This data model layers classify and standardize the collected heterogeneous data to a formatted scheme by processing and analyze it, this formatted scheme is used for real time status identification and decision making. MT connected, STEP and XML are the data models suggested here. By using these data models complete utilization of collected turbine parameters is done.

D. Smart view

For monitor the real time parameters of wind turbine by end user’s this layer is used. In smart view the data’s captured by various sensors are visualized to the end user graphically like in the form of pie chart or bar chart, so the user can easily recognize the current status of turbine. Here not only shows the live data’s but also the user can able to check the historical data status of turbine, it helps to take advanced decisions. The registered users can also able to see the status of turbine by using their smart phones.

III. Case study

A laboratory tested framework of proposed scheme is demonstrated in this section. IOT enabled cloud manufacturing technique is applied to a small 16KW wind turbine and tests are conducted experimentally. The figure 4 shows the experimental setup.
The following sub sections explain about the frame work in more detail.

**Experimental setup**

1. **Deployment of IOT devices**

The various IOT devices such as RFID modules and sensors are properly attached on the components of wind turbine. First of all the RFID tags are placed in turbine generator, rotor, blades and bearing for identify these parts uniquely, next is placing of sensors. The vibration sensors are used in bearings and blades while the temperature sensors are attached with generator and rotor, the torque sensor also used in rotor and force sensor attached with blades.

2. **Communication networks**

The RF tags are read by a way of RF communication and Wi-Fi is used for the data transfer between sensors and server. Here the 4G connection also used for provide a communication between user’s smart phone and central computer through cloud storage.

3. **Interfacing of user**

The end users can interface with the system in two ways, first one is through a smart visualization device and other one is using a smart phone, so that the registered end users can visualize and monitor the real time and live status of turbine whenever he/she need.

**IV. Result**

From the laboratory tested experiment, it is seen that the proposed work provides a very effective, efficient and interesting way of wind turbine monitoring. The tests are made under different turbine condition including conscious human made errors also. The results show that the sensitivity of the system under error condition is very high, if the sensed data cross the predetermined limit value, immediately the system alerts the user by two ways. First one is the information about the fault is visualized in the display and next is by making an alarm it provides a facility of not necessary to monitor or pay the attention of user 24*7 in front of display, if any error happens in the turbine, the
system get the attention of user by itself. The registered users can also able to check the current and historical status of turbine at any time by using his/her smart phones.

V. Conclusion

How the utilization of IOT a most valuable future technical paradigm is done is shown in this paper, by applying an IOT enabled technique for the condition monitoring of wind turbine. When we follow the traditional ways for this purpose meets so many difficulties like undesired downtime, frequent checking suffers large number of labors, expensive and the status of turbine remains unknown between the period of checking’s. but when we apply the proposed model real time condition monitoring of wind turbine is possible, so the faults can easily and early have identified, it helps to improve the life of turbine and reduces the operation and maintenance cost. In this work an integrated framework of different sensors, various communication networks, embedded devices and a wind turbine are used.

In future makes and extend that the proposed system is applicable for monitor the entire turbines in a wind a farm so that it is applicable for smart grid applications.

References

[1] Ren L, Zhang L, Tao F, Zhao C, Chai X, Zhao X. Cloud manufacturing: from concept to practice. Enterprise Information Systems, 2015. 9(2): p. 186-209.
[2] Buckholtz B, Ragai I, Wang LH. Cloud manufacturing: Current trends and future implementations. Journal of Manufacturing Science and Engineering, 2015. 137(4): p. 040902-1-9.
[3] Xu X. From cloud computing to cloud manufacturing. Robotics and Computer-Integrated Manufacturing, 2012. 28(1): p. 75-86.
[4] Zhong RY, Dai QY, Qu T, Hu GJ, Huang GQ. RFID-enabled Real-time Manufacturing Execution System for Mass-customization Production.
[5] Caggiano A, Segreto T. Teti R, Cloud Manufacturing Framework for Smart Monitoring of Machining. Procedia CIRP, 2016. 55: p. 248-253.
[6] Wang LH, Machine availability monitoring and machining process planning towards Cloud manufacturing. CIRP Journal of Manufacturing Science and Technology, 2013. 6(4): p. 263-273.
[7] Wang XV, Xu X. A collaborative product data exchange environment based on STEP. International Journal of Computer Integrated Manufacturing, 2015. 28(1): p. 75-86.
[8] Flemming M L and Troels S 2003 New lightning qualification test procedure for large wind turbine blades Int. Conf. Lightning and Static Electricity (Blackpool, UK) pp 36.1–10
[9] Schulz M J and Sundaresan M J 2006 Smart sensor system for structural condition monitoring of wind turbines Subcontract Report NREL/SR-500-40089, National Renewable Energy Laboratory, CO, USA
[10] Farrar C R and Sohn H 2000 Pattern recognition for structural health monitoring Workshop on Mitigation of Earthquake Disaster by Advanced Technologies (Las Vegas, NV, USA, 30 Nov.–1 Dec. 2000)
[11] Caselitz P, Giebhardt J and Mevenkamp M 1994 On-line fault detection and prediction in wind energy converters Proc. EWEC (Thessaloniki, Greece) pp 623–7
[12] Giebhardt J, Rouvillain J, Lynner T, Busssel C, Gut S, Hinrichs H, Gram-Hanes K, Wolter N and Giebel G 2004 Predictive condition monitoring for offshore wind energy converters with respect to the IEC61400-25 standard Germany Wind Energy Conf. (DEWEK) (Wilhelmshaven, Germany)
[13] Germanischer L 2007 Wind Energy, GL Wind. “Possible Wind Turbine Damage” 30 September (http://www.gl-group.com/industrial/glwind/3780.htm)
[14] “Mid and long range plan for renewable energy development,” Chinese Committee for National Development and Reform, August 2007.
[15] S. Calvert, “Perspectives on an expanded wind role in the national energy portfolio,” in Proc. 2nd Sandia National Laboratories Wind Turbine Reliability Workshop, Sep. 2007.
[16] C. Hatch, “Improved wind turbine condition monitoring using acceleration enveloping.” Orbit, pp. 58-61, 2004.
[17] D. McMillan and G. W. Ault, “Quantification of condition monitoring benefit for offshore wind turbines,” Wind Engineering, vol. 31, no. 4, pp. 267-285, May 2007.
[18] Z. Hameed, Y. S. Hong, Y. M. Cho, S. H. Ahn, and C. K. Song, “Condition monitoring and fault detection of wind turbines and related algorithms: a review,” Renewable and Sustainable Energy Reviews, vol. 13, no. 1, pp. 1-39, Jan. 2009.
