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Wireless Sensor Network to Monitor Environmental Parameters of Spinning Unit of Cotton Industry

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ABSTRACT

It is found that, the industrial sector is demanding sophisticated electronics system, wherein the industrial parameters should be centrally monitored. The industrial parameters such as environmental humidity, temperature, leakages of hazardous gasses from process plants etc are widely distributed and depict spatio-temporal variations. In cotton yarn manufacturing industry, monitoring of the environmental parameters such as environmental temperature and relative humidity is essential to maintain the quality of the cotton yarn. The environmental temperature and relative humidity is maintained at the précised level in cotton industry. In fact, these parameters depict site specific variability (SSV). For monitoring the indoor environmental parameters of spinning unit of textile industry, deployment of the Wireless Sensor Network is most suitable solution. To monitor such parameters the wireless sensor network is implemented, wherein the wireless sensor nodes play a important role. With the greater reliability and flexibility the wireless sensors nodes are designed, wherein ARM microcontroller, ARM LM4F120H5QR, is used as a core for computational task and RF transceiver module Xbee series-2 chip, from DIGI International Inc, is used for Wireless communication. Deploying embedded technology the sensor nodes have been designed for monitoring of the two parameters such as, environmental temperature (0C) and relative humidity in spinning unit the textile industry. The smart sensors, SY-HS-220 for humidity measurement and LM35 for temperature measurement are deployed. Deploying such sensor nodes and the coordinator node, the wireless sensor network is established by employing Zigbee technology and implemented for monitoring of the dedicated parameters of the textiles industry. The results of implementation of WSN for monitoring of environmental parameters of spinning section of textile industry are interpreted in present paper.

Keywords : Sensor Node, Wireless Sensor Networks, RF Module, ARM.

I. INTRODUCTION

It is found that, the industrial sector is demanding sophisticated electronics system, wherein the industrial parameters should be centrally monitored. The industrial parameters such as environmental humidity, temperature, leakages of hazardous gasses from process plants etc are widely distributed and depict spatio-temporal variations. The industrial environmental pollution monitoring has global significance. Therefore, emphasizing present needs of the industries, it is proposed to develop the Wireless Sensor Network (WSN), wherein typical industrial parameters are precisely monitored at central station. In fact, the WSN consists of autonomous sensor nodes, battery powered, connected to the base station using wireless networking topology[1-3]. Deploying a ubiquitous embedded technology the sensor nodes of required features can be designed. Recently, ARM technology is resulting into the microcontrollers of promising features, deploying which the wireless sensor node can be designed. The Zigbee technology is pervasively advancing. Therefore, to overcome present day problem of industrial sector and to ensure wireless data transfer with high accuracy and reliability, it is proposed to design Wireless Sensor Network and implement the same for industrial applications. The WSN is developed to monitor typical parameters of the dedicated industries and design issues are presented in this report. Present research work encompasses the field such as WSN, Zigbee, IEEE 802.15.4, embedded design etc. Therefore, it becomes possible to design the intelligent, autonomous and energy efficient sensor nodes to facilitate the desired WSN. Emphasizing an implementation at textile

industry, the WSN is designed and results of investigation are reported in this paper.

II. METHODS AND MATERIAL

1. Wireless Sensor Network (WSN):

Wireless sensor network (WSN) is the distributed network of large number of wirelessly connected autonomous devices, called Wireless Sensor Nodes, which collaboratively collects the information about physical world and disseminates the same towards the monitoring stations called Base Station (BS) for the deterministic analysis and presentation [4-6]. The WSN is an infrastructure comprised of sensing, computing and communication elements, which provides the information about area and process of interest to the administrator, to ensure the sustainable management [7]. The WSN comprises an assembly of distributed Sensor Nodes, an interconnecting wireless network in suitable protocol, smart base station.

2. Development of Wireless Sensor Network for Industrial Applications:

The processes of the textile industries were studied and it is observed that, to maintain the quality of the cotton yarn, the parameter such as temperature and humidity etc of the environment, should be precisely controlled. To optimize the quality of the yarn, essentially, the temperature is maintained precisely at 320C [8-9]. The relative humidity of an environment should be controlled at 55%RH [10-11]. At present, for monitoring of temperature and humidity, electronic, monitoring units, are installed, wherein usually only local values of these parameters are displayed. This unit of textile industry is spread over wide area and the said parameters are depicting Site Specific Variability. To monitor the parameter values very few numbers of such devices have been deployed. Therefore, these rarely spaced monitoring units could not cover the area of textile industry. Moreover, normally these monitoring units are not networked. Therefore, it is essential to collect the data manually. This hardly provides the data in real time. Therefore, precision controlling of the temperature as well as relative humidity of the environment is not ensured. This may adversely affect the quality of the yarn. Therefore, textile industry is demanding electronic system to cater this need.

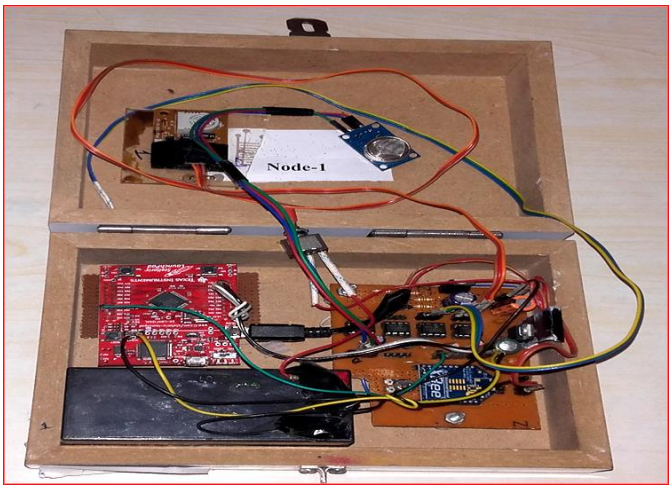


Figure 1. The photograph of Wireless Sensor Node

The Wireless Sensor Network can be suitably designed and implemented to monitor the various parameters, indoor as well as outdoor, of the textile industry, at control cabin. For establishment of the WSN to collect the site specific data, the five sensor nodes of promising capabilities have been successfully designed. In addition to this, to facilitate the Base Station, the inherent part of the WSN, a coordinator is also deployed. The Senor Nodes are identified with the name as Node1, Node2, Node3, Node4 and Node5. The photograph of the Sensor Node is shown in the figure 1. Moreover, figure 3 depicts the base Station. This coordinator is interfaced to the computer and the Base Station is designed and presented in figure 3. On inspection figures 1, it is found the sensor nodes are associated with the transducer interface modules, which comprises of an array of the sensors. To ensure autonomous operation, the nodes are facilitated with the chargeable battery. The Zigbee device is interfaced to the serial port of the microcontroller. The sensor nodes are encapsulated in box.

The Node ID and Parameter ID are allocated to each of the nodes and process of assembling and disassembling of the packets is carried out. Thus, the WSN of five sensor nodes and the Base Station is developed and deployed for monitoring of the environmental parameters at the site of manufacturing of cotton yarn in the textile industry [12].

3. On-Site Implementation of Wireless Sensor Network

The major objective of the present research work is to design and deployment of the Wireless Sensor Network (WSN) for monitoring of indoor industrial environment.

Emphasizing the features of the WSN, it is found that, the WSN is most suitable technology, which can be used for monitoring Site Specific and spatio-temporal data and management of the same. It is found that, in many industries monitoring and controlling of indoor environment is vital job. The quality as well as quantity of the products depends upon the environmental conditions. Unfavorable environment adversely affect on the Quality of Product. Therefore, indoor environment of the industry must be precisely monitored and controlled as well. As discussed earlier, the WSN is dedicatedly developed for monitoring of industrial environment and it is made ready for deployment. To ensure on site deployment various industries have been studied. Fabtech Group of Industries is performing pioneering job in establishment of renowned industries such as textile industries. This group of Engineers has established the textile industry at Ekatpaure near Sangola with title as "Fabtech Projects and Engineers Ltd (Textile Division), Ekhatpur, Tal SangolaDistSolapur". The indoor area of the Phase –I is 250m x 40 m (=10,000 sq.m.) wide. Therefore, monitoring the parameters of the indoor environment is very tedious task. Due to this wide area, it is found that, the environmental parameters are depicting Site Specific Variability (SSV). It is found that, the environmental parameters such as temperature and relative humidity are playing significant role on the process of manufacturing of the yarn. Therefore, it is attempted to monitor these two parameters by using WSN under investigation.

The WSN under investigation is arranged in such a way that, it will cover entire area of the phase-I. According to the architecture of WSN, to realize the site specific variability, an area under consideration should be divided into the cells of typical area. It is supposed that, a Sensor Node is collecting the information of the respective cell. In fact, the phase-I is fragmented into four sections such as blower section, prefatory section, spinning section and ring conner section etc. While deploying the WSN into phase-I, the spinning section is separately considered. The WSN is established and the parameters such as temperature and relative humidity are monitored in real time. Thus Wireless Sensor Network under investigation is implemented in Fabtech (Textile division) Sangola and results of investigation are interpreted.

III. RESULTS AND DISCUSSION

1. Implementation of Wireless Sensor Network at Spinning Section of Fabtech (Textile Division) Industries Sangola

Out of four sections, the Spinning section is playing commendable role on the productivity of the yarn. This section has wider region than that of preparatory section. Therefore, it ensures wide distribution of the environmental parameters. Entire view of the Spinning section is shown in figure 2. The area of the spinning section is 70m × 40m. These machines are always spinning. Therefore, deployment of the Sensor Nodes either in rectangular cell or hexagonal cell is not possible. Therefore, within this section the sensor nodes have been installed linearly along the lines of the machines. The Wireless Sensor Network under investigation is established in the Spinning section of the textile division and results of investigation are reported in this section.

Figure 2. Photograph of Spinning Section of the Fabtech industry (Textile division)

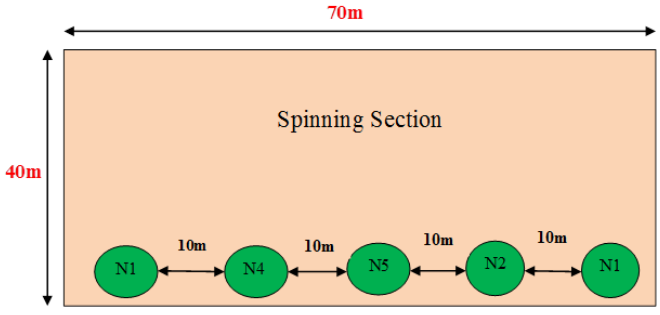
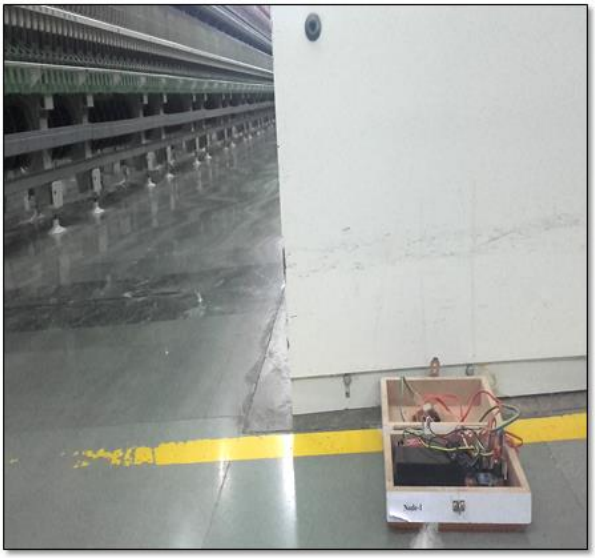


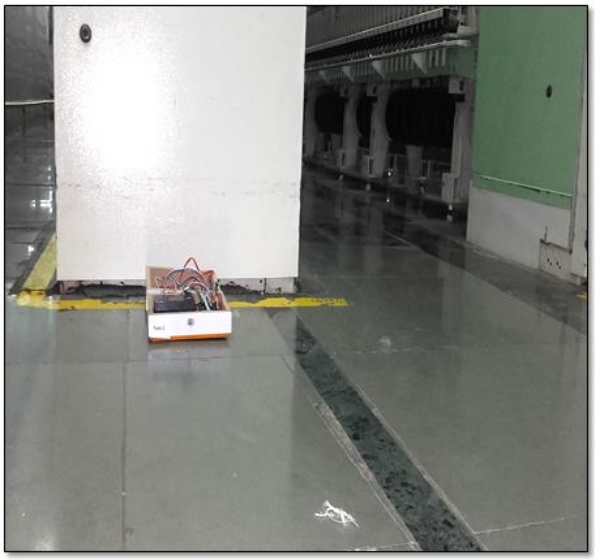
Figure 3. The schematic of WSN established in the Spinning section of the textile division

The schematic of placement of the sensor nodes is depicted in figure 3. The Wireless Sensor Network is established at the spinning section for the measurement of the temperature and relative humidity. To establish the wireless sensor network at the spinning section, the

five sensor nodes are placed. The exact position of the sensor nodes are depicts in the figure 4. Figures 4 (a-e) demonstrate actual placement of the nodes. The sensor nodes are distributed at the site, to cover the whole area of the site. The Nodes of the WSN measure the temperature and humidity at specific site and then disseminates the measured data towards the Base Station (BS) in Star Topology [13-14]. The base station records the received data and demonstrates on the graphical user interface for online monitoring. In fact, the system is established for 8 days and for different period of times. Entire data is recorded in real time. However, parameter values of typical period are used for presentation.



a) Node-1



b) Node-2

c) Node-3

d) Node-4

e) Node-5

Figure 4 (a-e): Experimental arrangement of the Sensor Node 1 – 5 within Spinning section of the Fabtech industry (Textile division)

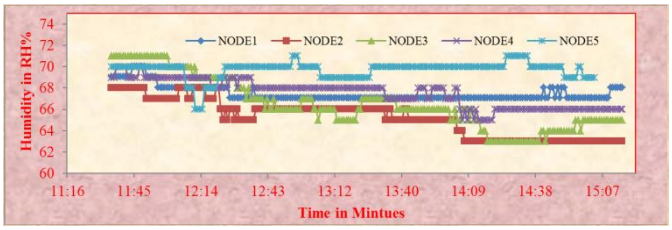


Figure 5. Instantaneous values of relative humidity in (RH%) measured in an environment of the Spinning section of the textile division of the Fabtech industry.

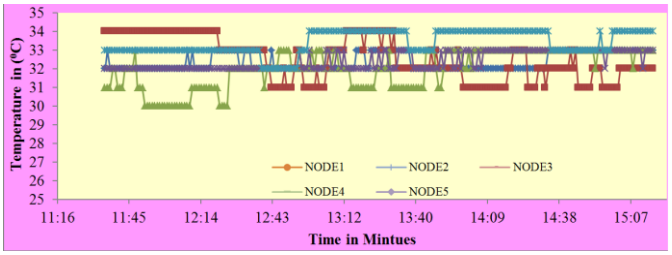


Figure 6. Instantaneous values of temperature measured in an environment of the Spinning section of the textile division of the Fabtech industry.

The WSN under investigation is established within wide area of the Spinning section of the textile industry and results of investigation are interpreted. Present WSN is established for monitoring of environmental temperature and relative humidity [15-16]. The Sensor Nodes, with the help of precise sensors sense these two parameters and then ensure analog as well as digital processing. The data is packetized in typical format. The data collected by the WSN is recorded with time and stored into the memory of the Base Station for future analysis.

2. Monitoring of Relative Humidity (RH%) of the Spinning section:

The Relative Humidity (%RH) recorded in the data base of the base station are availed for presentation. The instantaneous values of the relative humidity are plotted against time and presented in the Figure 5. As discussed earlier, relative humidity values of different sites of the Spinning section are collected from five nodes and presented in the figure 5. On inspection of figure 5, it is found that, relative humidity of the spinning section is more than that of other sections of the textile division. It is found that, at the environment of the spinning section, the area where sensor node 1 deployed varies within the range from 67%RH to 69%RH. The humidity of the region covered by the sensor node 2 was in the range from 63%RH to 68%RH. The sensor node-3 shows the humidity ranging from 63%RH to 71%RH. Moreover, the range of Humidity values shown by the sensor nodes-4 and 5 is from 66%RH to 70%RH and sensor node-5 shows the humidity in the range of 66%RH to 70%RH. The data collected by the WSN reveals site specific variability, which is the salient feature of the WSN.

3. Monitoring of Environmental Temperature (0C) of the Spinning section

The temperature of the environment plays vital role in textile industry. The Temperature (0C) recorded in the data base of the base station are availed for presentation. The instantaneous values of the Temperature are plotted against time and presented in the Figure 6. As discussed earlier, the temperature values of different sites of the Spinning section are collected from five nodes and presented in the figure 6. On close inspection of figure 6, it is found that the thermal status of the spinning section is not uniform throughout the region. It varies from site to site. However, the average temperature is about 320C. It is as expected. The temperature monitored by the WSN under investigation reveals spatio-temporal variance.

IV. CONCLUSION

The wireless sensor network of five sensor nodes and the coordinator node is successfully established and deployed for monitoring of industrial environmental parameters such as indoor relative humidity, indoor environmental temperature in the spinning section of textile industry. For realization of on-site implementation, the industries such as fabtech industry (Textile Division), milk processing industry and alcohol manufacturing plant of sugar industry are selected. The WSN under investigation is deployed for monitoring of above parameters. Under the frame of IEEE 802.15.4, the WSN is successfully implemented in star topology. On investigation of instantaneous values of various parameters, it can be concluded that the environmental parameters depict site specific variability with spatio-temporal variations. On investigation of the results of on-site deployment of WSN under investigation, it can be concluded that, the WSN under investigation is operating with great reliability and preciseness.

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