1-wire Technology for Cooling Tower monitoring

By S Bera

The culprit cell: While at peak summer when the outside temperature is touching 44 Deg cent, the inside temperature below the long concrete structure of Induced draft cooling tower is maintained at 35.5 deg cent. The expected cool water temperature is required to be minimum 10 degree [or more] below the outside dry bulb temperature which is 44 now or very near the wet bulb temperature [26.8 deg cent], at least that's what the massive cooling tower structure is designed for. But right now it is hardly 8.4 degree at this peak summer. This means some of the cooling tower cells are not cooling satisfactorily!

Each 500 MW steam turbine requires 1550 tons / hour steam flow which after expansion in the gigantic steam turbine goes back to condenser for cooling down back to form water again. But cooling such massive quantity of steam [at 50 deg cent] back to water at 50 degree centigrade requires somewhere about 540 kilo calorie / kilogram heat to be taken away. To achieve that cooling, huge circulating water to the tune of 60000 tons / hour is circulated through the steam turbine continuously. This huge circulating water is again cooled down to 35.5 deg cent by this cooling tower whose few cells somewhere is malfunctioning – not cooling effectively.

A cooling tower of a typical 500 mega watt boiler unit has 10 huge individual cells in which hot circulating water from steam turbine is poured from top and air is blown from bottom such that the water bubble comes in contact of the air and air takes away heat from the water. It's more like desert water cooler that is used during hot summer days in in the dry & hot Indian states like of MP, UP, Himachal Pradesh or Delhi. The more the air outside is dry the more it cools inside. However, the same desert cooler will not work effectively in the humid states like West Bengal , Tamilnadu or Kerala as because the air there is humid [dry bulb temperature is higher] which will not be able to take away much heat from water by the same size of Cooling Tower. There the cooling tower size will vary.

Both works on the same principle – cool air passes through hot water bubbles to take away it's heat by the air. The humidity is also an index which plays havoc in the entire cooling process. When humidity is more the cooling will be less resulting in a bigger designed cooling tower.

The measurement of dry bulb temperature and wet bulb temperature gives the indication of humidity of the area.

1-wire technology: DS18B20 from Dallas Instrument is an wonderful 1-wire digital temperature sensor. It can measure temperature very precisely upto 4^{th} decimal precision but unfortunately the range of measurement is a paltry -55 Deg cent to 150 deg cent only with metal encapsulated sensors! That means hundreds of thousands of DS18B20 can be jammed on an 1-wire bus yet all the sensors will deliver individual temperatures separately because all the DS18B20s are separately addressable! Those who have read my write-up on neopixel can understand that like neopixel each addressable DS18B20 can also be fired up for measurement when called by their unique addresses.

Each sensor has a 64 bit identifier which can hold theoretically a billion devices! The bus length can reach upto 500 meter. The signal line can also serve as power supply line for individual sensors. We checked the single signal line upto 470 meters and it was held strong at that length with 20 sensors. Good quality cable is essential for this project. While we did not know which cable will fit our experiment we used the same single phase power cable [having 3 wires] that is used for motor power supply for our project. Later we tried to experiment with 17S SWG copper solenoid cable and it did not work.

However after few experimentation we found that the right cable is a simple 3 core 6 SQMM aluminum cable or 3 core 2.5 SQMM copper cable which will work upto 500 meters length.

The only disadvantage is that it has only one supported temperature sensor available in the market in the form of DS18B20 in many clone & variety. No other 1-wire sensor is available for use!!!

On going Project-1 Cooling Towers:

After having found the strength of 1-wire technology we quickly sorted out few projects – the first of the series is finding out the cooling tower outlet cold water temperature of each individual cell. There are 2 towers & 8 cells in each cooling tower for each 500 MW boiler. The water drops in showers below each cell. On a typical day during testing, the efficiency man pushes a small bucket below each cell. Once a good amount of water is collected in the bucket, he dips in a precision mercury temperature and takes the reading.

This is where we have to place a grid of 10 numbers metal encapsulated DS18B20 below each cells and then average readings are to be collected. For high precision we will set the DS18B20 to produce correct readings upto 4 decimal position. Look out the command like this...
sensors.setResolution(addsensor[i], 12); //resolution 9,10,11,12 , 12 is the slowest but highest precision upto 4th decimal places.

Resolution	Precision	Time requires
9 bit	0.5 Degree Centigrade	93.75 mSec
10 bit	0.25 Degree Centigrade	187.5 mSec
11 bit	0.125 Degree Centigrade	375 mSec
12 bit	0.0625 Degree Centigrade	750 mSec

We are also using the 1 wire technology for Pulverized fuel pipe monitoring for chocking. In coming days this technology could find its use in many more areas.