Failure Of Dust Suppression Systems At Coal Handling Plants Of Thermal Power Stations - A Case Study -

By Makarand Joshi

1.0 Abstract: -

Many thermal power plants use coal as their fuel. To handle the coal, each power station is equipped with a coal handling plant. The coal has to be sized, processed, and handled which should be done effectively and efficiently. While working in the coal handling plant the major factor which reduces staff efficiency is the working environment i.e. a dusty atmosphere. Lots of care is always taken to reduce dust emission.

Generally all systems used in power station coal handling plants are wet dust suppression systems. In this paper the reasons for failure of these type of dust suppression system are discussed. The remedy for the improvement of this system is also given in this paper. The existing system can be easily modified by using ultrasonic system. The spray discharge should be proportional with dust emission. The solenoid valve should be open with proportion with quantity of dust generation. The possibility of such type of this system is discussed in this paper.

2.0 Introduction: -

The Dust Suppression System is meant to suppress the coal dust generated during transfer of coal at feed/discharge points of conveyors in various transfer towers. There are several existing methods of controlling dust but many are ineffective, costly and have detrimental effects on plant and machinery. An effective system for the control of fugitive dust in industry should meet the following objectives.

1. Must be efficient to meet Health & Safety requirements.
2. Be practical and simple in operation.
3. Have low initial cost.
4. Have low operating costs.
5. No adverse effects on product quality or plant and machinery should be created.

But the system used in the plant is not meeting the entire requirement, especially it does not meet Health & Safety requirements.

2.0 Existing dust suppression system: -

The existing dust suppression system in the coal handling plant is a wet dust suppression system. Wetting Agents are chemicals that are added to water to improve the rate at which spray droplets wet dust particles.

This system consists of three main parts.

1. Proportioner units.
2. Spray headers with pipe lines & pumping system.
3. Control units with electrical systems.

PROPORTIONER UNITS include feed water pump, metering pump, feed water tank, solutions tanks. The water required for the system is supply by feed water pump. Wetting agent, which is in liquid condition, is dosed by metering pump as per requirement.

SPRAY HEADERS WITH PIPE LINES PUMPING SYSTEM includes solution pumps, isolating valves, spray nozzles, and pipe lines. The solution pumps are used to supply pressurized water to spray headers. The required quantities of nozzles are used to spray water.

CONTROL UNITS WITH ELECTRICAL SYSTEMS consists of sensing units, control panels. Coal flow is sense by sensor. The control panels are consisting of various relays and transformer.

3.1 <u>Operating principles of existing system</u>: -

Auto control or manual control governs the system. It has to be insured that main tank is filled with water. The water is pumped by feed water pump from main tank to feed water tank and at the same time metering pump doses proper quantity of chemical. The feed water pump operation is controlled by float switch automatically. The pump picks up at low level and stopped at high level. The interlock with low level of main tank will not allow to pickup the feed water pump.

The metering pump will stop the operation by sensing low chemicals in tank. After insuring proper level the solution pumps will start. If the pressure increase the pressure relief valve keeps the system in recalculation.

The sensing system for controlling spray at proper header ensures spraying solution if conveyor is running with coal. And will not allow spraying solution if conveyors are running empty. (See Figure No 1)

The solenoid valve headers are energized if conveyor is running with coal. If all or some of the solenoid valves are not energized the system will realize pressure through pressure relief valve, which protects the system. A solenoid valve is provided with bypass line, which operates when none of the spray header solenoid valves are operative.

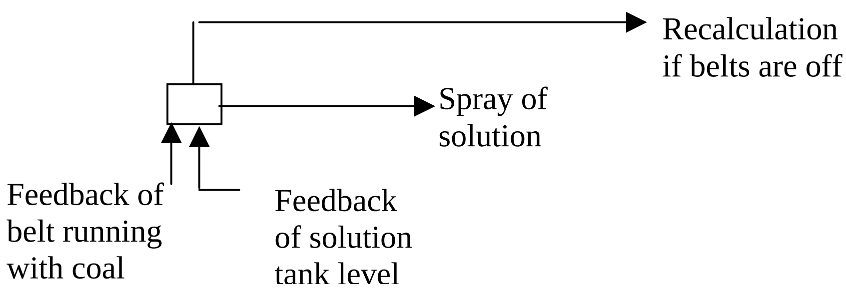

Figure No 1

3.2 <u>Existing system draw back</u>: -

This system does not effective on respirable dust. Typical water droplet sizes are 200 to 600 microns, which are much greater than the respirable dust. And it does not operate on the emission quantity. The spray of the system should be operated on emission quantity. Thus, water sprays can be improved by increasing pressure or by designing nozzles which produce smaller droplets. And also developing the control system which sense quantity of dust. Most of the improvements in this direction already have been made. The problem with this approach, and one, which prevents much additional improvement, is that introduction of very small water droplets into an atmosphere.

4.0 <u>Efficiency of system</u>: -

Over the years, water sprays has established the following facts:

1. For a given spray nozzle, the collection efficiency for small dust particles increases as the pressure increases
2. At a given pressure, the efficiency increases as the nozzle design is changed so as to produce smaller droplets.

The conclusion is clear, the smaller droplets [1] are more effective in knocking small dust particles out of the air. The reason for this is not hard to see. Consider a water droplet about to impinge on a dust particle, or what is aerodynamically equivalent, a dust particle about to impinge on a water droplet, as shown in the Fig No 2. If the droplet diameter is much greater than the dust particle, the dust particle simply follows the airstrip lines around the droplet, and little or no contact occurs. If, the water droplet is of a size that is comparable to that of the dust particle, contact occurs as the dust particle tries to follow the streamlines. Thus the probability of impact increases as the size of the water spray droplets decreases.

4.1 <u>Efficiency of water-droplet formation</u>: -

Factors affecting the efficiency of water-droplet formation are Particle size, Particle solubility, Particle (Hydrophobic or hydrophilic), Presence of hygroscopic salts, Charge, Temperature, Relative humidity, Pressure, Electric Fields, wettability.

The efficiency of spray dust capture will increase [2] by increasing the probability of water droplet and respirable dust particle contact.

It is increased by

1. Increasing the number of smaller sized spray droplets per unit volume of water utilized
2. Optimizing the energy transfer of spray droplets with the dust-laden air. Improving water droplet and dust particle interaction depends upon [3] spray nozzle technologies.

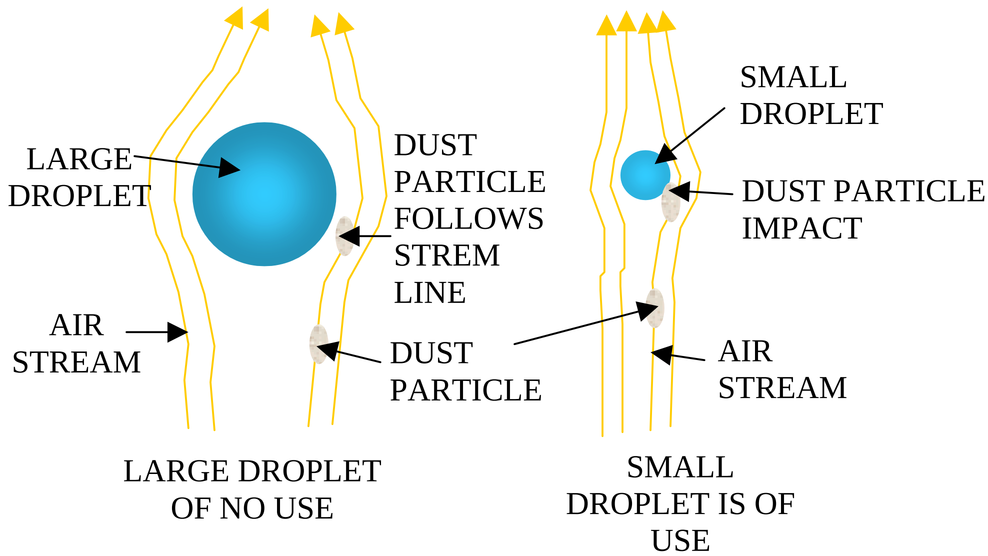

Figure No 2

5.0 <u>Ultrasonic dust suppression systems</u>: -

This system uses water and compressed air to produce micron sized droplets that are able to suppress respirable dust without adding any detectable moisture to the process. Ideal for spray curtains to contain dust within hoppers. Generally the system consists of three main parts. These are as follows.

1. Air compressor units.
2. Spray headers with pipe lines & pumping system.
3. Control units with electrical systems.

5.1 <u>Operating theory</u>: -

The theory behind the Ultrasonic Atomizing System is based on research considering a water droplet from a spray that is about to impinge on a dust particle. The probability of impaction increases as the size of the water spray droplet decreases. This explains why conventional hydraulic water sprays are not effective on respirable dust. With typical diameters of 200-600 microns the droplets are much larger than the dusts they are attempting to suppress.

The Ultrasonic Atomizing System generates droplets averaging 10 micron in size and is capable of suppressing sub-micron dust particles. In addition to this particle size theory, the results of additional research indicate there is another significant phenomenon that occurs when Ultrasonic Atomizing Systems are applied to dust suppression. The effect can be compared to an electrostatic precipitator in which dust particles are charged and then collected on plates of opposite charge. It was found that dust particles generally carry certain negative potential depending on the nature of the dust and the ambient conditions. Water droplets produced by the nozzles carry a charge that is strongly positive in relation to the dust particles.

The result is that the probability of collision between a droplet and particle is greatly increased from the spatial probability, implying the need for fewer water droplets to ensure the desired efficiency.

If the diameter of the droplet is much greater than the dust particle then the dust particle simply follows the air streamlines around the droplet and little or no contact occurs. If, on the other hand, the water droplet is of a comparable size to the dust particle then contact occurs as the dust particle tries to follow the air streamline. Thus, a nozzle generating a dense fog of 1-10 micron size droplets can be used to envelop and smother dust particles at their source and prevent them from becoming airborne.

5.2 <u>Design</u>: -

The Ultrasonic Atomizing Nozzle takes the form of a whistle using compressed air which accelerates through a converge section and expands to a diverge section into a resonator chamber. This produces a powerful sonic shockwave. Water or other liquids delivered to this sonic area are shattered into droplets. Droplets produced by sonic atomization are small and relatively uniform in size, in the order of 10 micron, with a Low Mass and low forward velocity. The nozzles have a large liquid port which are not prone to blockage.

5.3 <u>Advantages</u>: -

The advantages of using Ultrasonic Atomizing Systems for dust suppression can therefore be summaries as follows.

- Reduced Health Hazards.
- Decrease in Atmospheric Pollution.
- Improved Working Conditions
- Efficient Operation with Minimum Use of Water. Thus Not Saturating the Product or Plant and Equipment.

5.4 <u>Design of nozzles</u>: -

The Design of [4] the system is based on a very unique device which can produce a very dense fog of 1 - 10 micron size water droplets which literally blanket the dust source and keep the dust particles from becoming airborne. It does this at low cost, both from a capital and a maintenance standpoint, while achieving all of the goals stated above for an ideal dust suppression system. The fogger [4] is an air driven acoustic oscillator for fogging liquids by passing them through a field of high frequency sound waves. This is accomplished by compressing air upstream of a specially designed converge section of the fogger. To further enhance the fogging capabilities, a resonating chamber in the path of the air stream reflects the air stream back at itself to amplify and complement the primary shock wave.

Once this standing shock wave [4] is generated, water is delivered through annular orifices where it is first sheared into relatively small droplets. These small droplets are then carried by the primary air stream into the intense shock wave where the sound energy is converted into work by exploding the droplets into thousands of micron size droplets. After having done its work, the air then escapes around the resonating chamber and carries the droplets downstream in a soft, low velocity fog. (See Figure No 3). The design of this fogger has obvious benefits regarding the control of respirable dust.

6.0 <u>Devices for the measurement and characterization</u>: -.

Devices for the measurement and characterization of respirable dusts matter are needed to assess worker exposure to these health hazards and to evaluate control technologies. There are various types of devices.

6.1 <u>Device based on the light-scattering properties</u>: -

When airborne dusts or suspended particulate are irradiated with light, the light is scattered in all directions. The intensity of light scattered at any particular angle depends on the wavelength [5] of the light and the size, volatility, and mass concentration of the dust or suspended particles. Both theory and experiment indicate that at a scattering angle of around 20^0 to 30^0, the size and volatility of respirable coal dusts have a negligible impact on the measured intensity so that this intensity is directly proportional to the mass concentration of the dust. At an angle of 15^0, equal concentrations of either respirable coal dust or diesel particulate matter (DPM) yield equal intensities of scattered light. At larger angles, the intensities from DPM are significantly greater. (See Fig No 4) These results, while tentative, imply that devices that measure light-scattering signatures at one or more specific angles in the range of 15^0 to 30^0 offer significant promise for respirable dust or DPM measurement and, possibly, for determination of mass fractions of dust/DPM mixtures. As this basic research project progresses, these implications will be explored in greater detail.

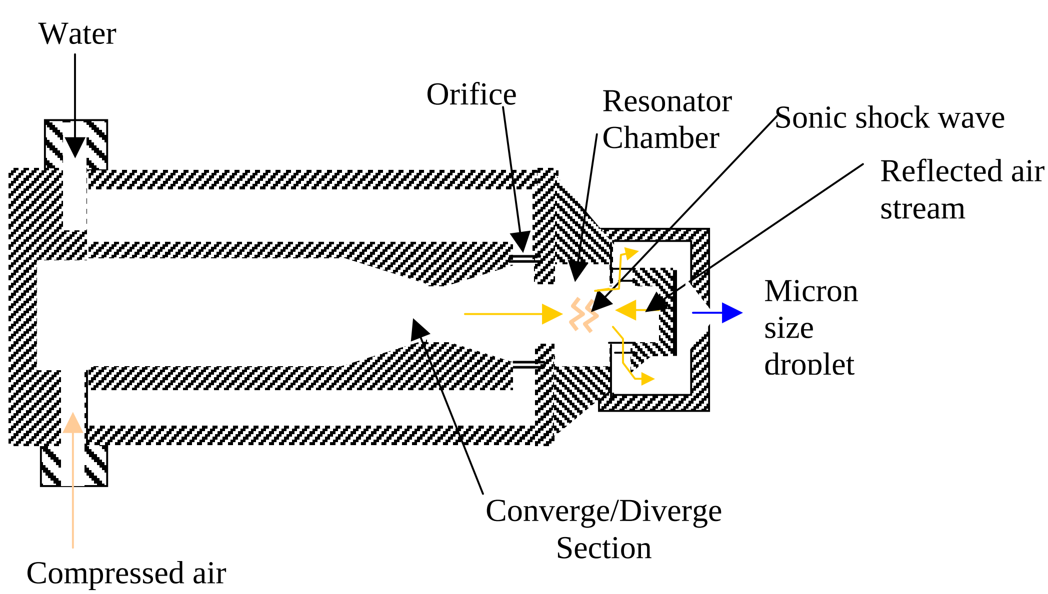

Figure No 3

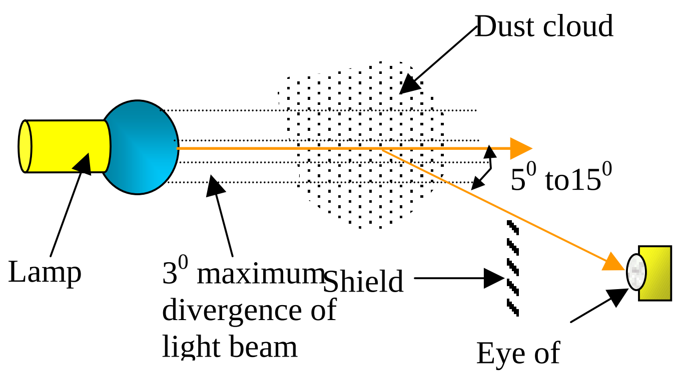

Figure no 4

6.2 Device based on the infrared light properties: -

The light emitting diode (LED) emits infrared light of high intensity. This highly penetrating infrared light beam is received by a sensitive phototransistor on the other side of the gap. This pulsing is repeated many times per second by the electronic control circuit (See figure no 5). Some of the beam energy is absorbed by the dust particles. Absorption of energy is proportional to dust emission.

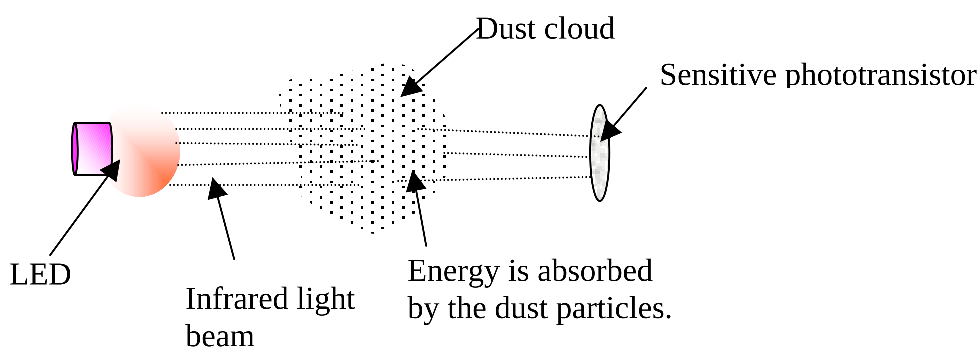

Figure no 5

6.3 Device based on the sound properties: -

The sound generator generates sound beam. The stainless steel reflector on the other side reflects the sound beam. The receiver who is built with sound generator receives the reflected sound beam (See figure no 6). The dust particles absorb some of the energy of sound beam and also deflect sound beam. The sound signal received is inversely proportional to the dust emission.

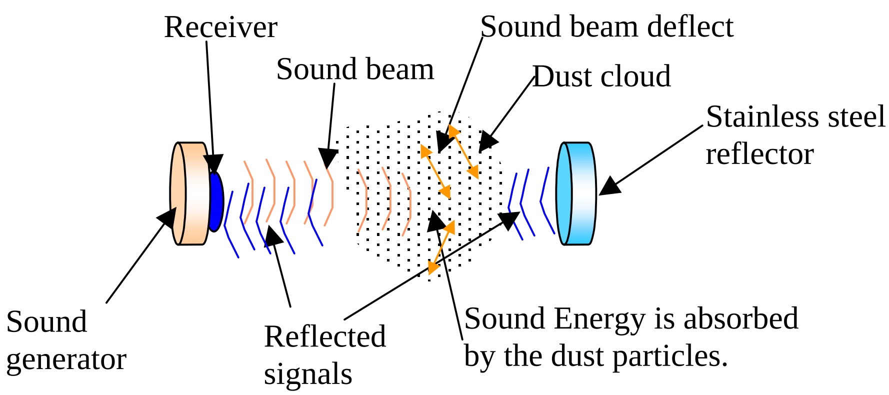

Figure No 6

7.0 <u>Modification of the existing system</u>: -

The unit of Air Compressor is required to erect near each proportioner unit. The airlines are to be erected near by the water line. The existing nozzles are required to change by new nozzles. There will be two lines for each header. One line for air and one line for water. The wetting agents can be used with this system. (See Figure No 7)
The control system on basis of dust emission is required to develop. This is not discussed in this paper.

7.1 <u>Operating principles of modified system</u>: -

Auto control or manual control will govern the system. It has to be insured that main tank is filled with water. The water is pumped by feed water pump from main tank to feed water tank and at the same time metering pump doses proper quantity of chemical. The feed water pump operation is controlled by float switch automatically. The pump picks up at low level and stopped at high level. The interlock with low level of main tank will not allow to pickup the feed water pump.

The metering pump will stop the operation by sensing low chemicals in tank. After insuring proper level the solution pumps will start. If the pressure increase the pressure relief valve keeps the system in recalculations.

The air compressors will run to fill air tank up to desire pressure. There will be two-pressure level for air tank. The high level pressure is for tripping of air compressor and low level is for pickup of compressor. There will be a safety valve if the pressure increased higher than set pressure. This pressure will reach if high level pressure for tripping of air compressor is not operated. There will be two solenoid valves for each header. One for airline and other for water line.

The sensing system for controlling spray at proper header ensures spraying solution if conveyor is running with coal. And will not allow spraying solution if conveyors are running empty. (See Figure No 8)

The solenoid valves (airline and waterline) of headers are energized if conveyor is running with coal. If all or some of the solenoid valves for water line are not energized the system will realize pressure through pressure relief valve, which protects the system. A solenoid valve for water line is provided with bypass line, which operates when none of the spray header solenoid valves are operative.

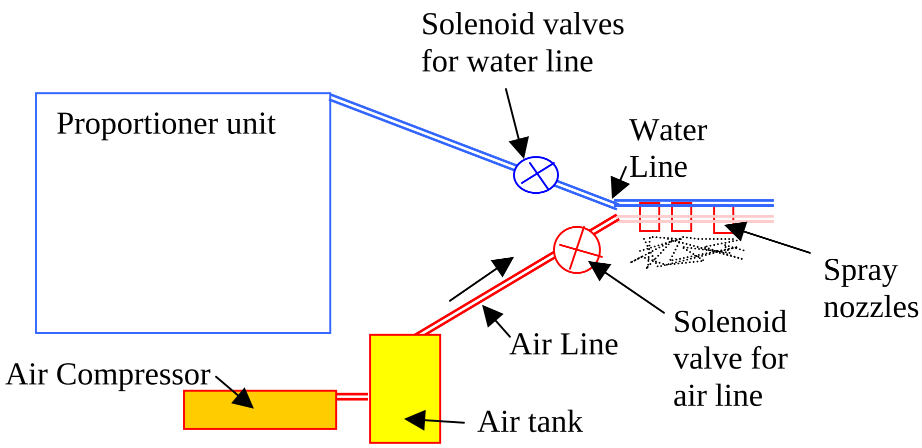

Figure No 7

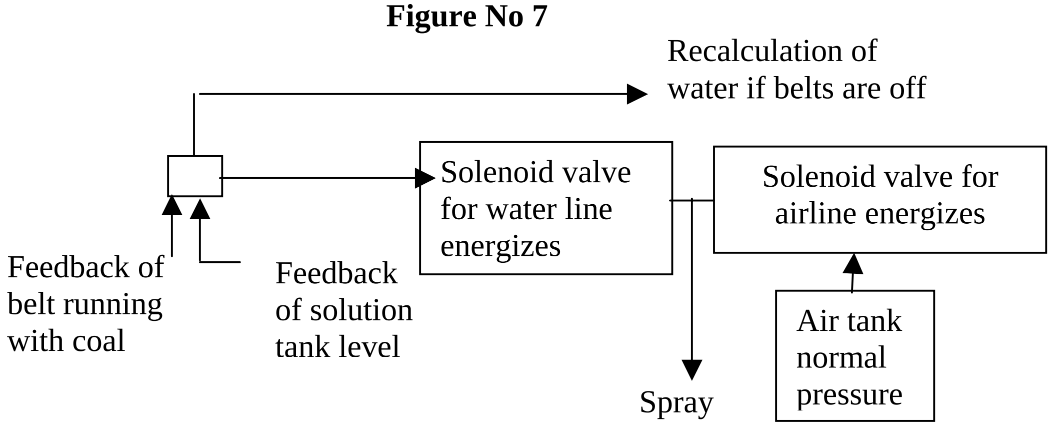

Figure No 8

7.2 <u>Advantages</u>: -

Its inherent design features also make it extremely reliable from a maintenance standpoint. As the fogger [4] does not rely on high pressure on the waterside to achieve maximum atomization, wear problems are virtually eliminated, as is the need for high-pressure water pumps.

The fogger cleans itself while operating [4] with high frequency sound waves much the same way that a sonic laboratory cleaner works. The nozzle has no moving parts and is constructed of 100% stainless steel as compared to some competitors who use brass parts. This eliminates wear and corrosion and insures years of maintenance free service even with poor water quality as many material handling plants have. Undissolved sediment in the water that is larger than the liquid orifice is easily filtered out by system

8.0 Conclusions: -

The existing system is failing due to very low working pressure.

In addition to this the control of the system is not depend on the quantity of dust emission.

To increase the efficiency of the system it will require to increase the efficiency of spray nozzle and control of the system should based on emission quantity of dust.

Using ultrasonic spray method existing system can be modified with less effort.

9.0 References: -

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