



## ROLE OF COAL MILL IN P.F. BOILER COMBUSTION

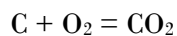
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Performance of boiler depends mainly on combustion. Efficient the combustion, efficient is the boiler. All the problems of boiler originate from inefficient combustion. Hence it is important to maintain the auxiliaries taking part in combustion religiously. Coal mill is one of these. Let us first understand fundamentals of combustion.

**Combustion:** Temperature, Time, & Turbulence normally called 3 'T's which are prime requirement of combustion. The main combustible ingredients of fuel are carbon, hydrogen and sulphur, which (during combustion) react with oxygen in the air to form different products of combustion. Air contains 23.2% of oxygen & balance 76.8% of nitrogen. To supply 1Kg of oxygen it is necessary to provide 4.31Kg of air. Mass is proportional to molecular weight. So the equation can be



$$(12) + (32) = (44) \text{ gm}$$

$$12/12 + 32/12 = 44/12$$

To burn 1Kg of carbon, 2.67Kg of oxygen is required to form 3.67Kg of carbon -dioxide. For supplying this O<sub>2</sub> air required is 11.49 Kg. Similarly it can be worked out for H<sub>2</sub> & S. For all the three elements we need minimum (2.67C +8H +S) Kg of oxygen per Kg of fuel to burn completely. Air required will be 4.31(2.67C+8H+S) Kg per Kg of fuel. This minimum air required is called theoretical air or 'stoichiometric' air.

For combustion to take place, ignition temperature should be available in furnace to ignite fuel. (For bituminous coal it is around 410°C). Once the combustion starts, the heat produced will be sufficient to produce high temperature to sustain further ignition.

Time required for complete combustion depends on the particle size of the combustible provided other conditions are met. Coarse particles take longer time to burn than fine particles. Better physical contact between oxygen and coal can be achieved when the coal is pulverized and then further chemical combination takes for combustion. Rate of combustion is controlled by the rate at which contact is made between oxygen and combustible. It is difficult to obtain complete combustion of coal with only theoretical air as it would require every molecule of fuel & oxygen to be in right place at right time. It may happen that some molecules will have ample supply of oxygen while others may not have enough. It may result that some particles will remain as un burnt (incomplete combustion) and may form CO. Consequently heat release from the coal will be incomplete. To ensure complete combustion excess air is supplied. It is normally 20% for P.F. boiler. Secondary air in addition to supplying O<sub>2</sub> creates turbulence required for combustion.



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Having revised mechanism of combustion let us turn to COAL MILL .

### COAL MILL :-

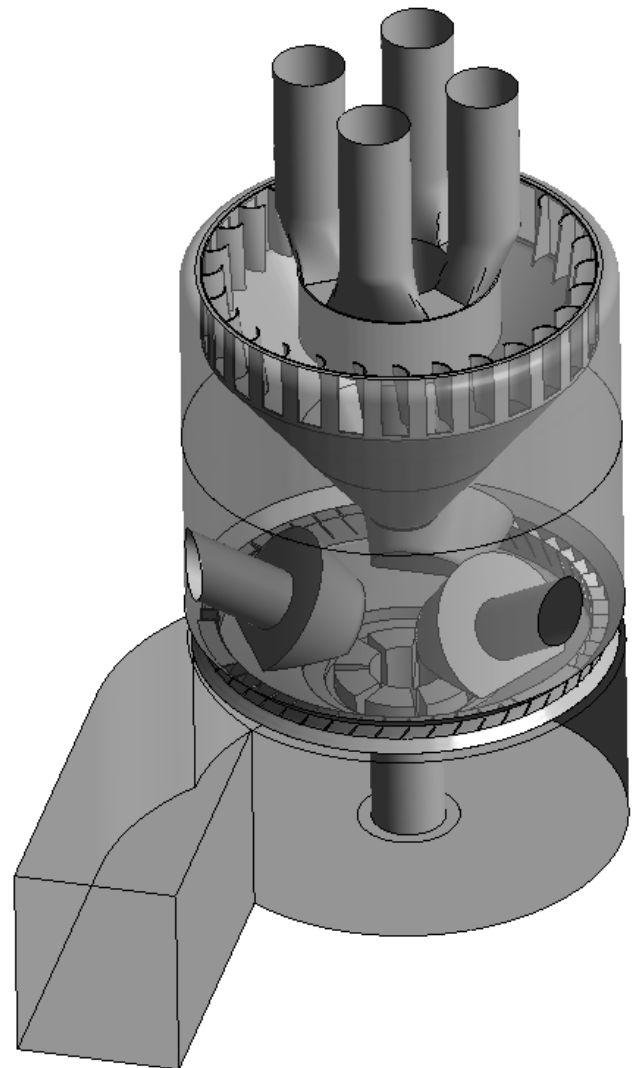
Inputs and output of coal mill are :-

Coal is first crushed by coal crushers to a size of 20 to 25 mm and is then fed to coal bunkers. Coal feeders feed this crushed coal continuously to coal mill as per requirement. Coal gets ground by grinding elements in stages. Coal particles get re-circulated around four times before achieving required fineness. Classifier allows finer particles to escape mill outlet while coarse particles are returned to mill for further grinding.

Primary air is supplied by P.A. fan through air pre heaters to coal mill or in some boilers, P.A. fan pressurize hot air received from air pre heaters and then supply to mills. Hot primary air drives moisture from coal and acts as carrier to transport pulverized coal to the boiler through pipes.

Output is pulverized coal having required fineness. For complete combustion coal should have fineness of 75% through 200 mesh and 99.5% through 50 mesh. Primary air + coal mixture flowing through each coal pipes should have minimum velocity of 18 m/sec, Temp. around 80 degrees C , and air/coal ratio of 1.8 -2. Fuel flow through pipes be balanced within range of +/-10%. Finer is the coal, better is the flow distribution. Higher velocity with inferior distribution, will allow

less time to burn the coal particles within furnace. Combustion may take place in upper part of furnace, and increase temperatures at furnace exit, super heaters, re heaters etc.



**3D Computational Model of Coal Pulveriser**



## ROLE OF COAL MILL IN P.F. BOILER COMBUSTION

In Indian power stations, coal mills are of ball and race design or Raymond vertical spindle with rolls and bull rings. These mills are designed to pulverize coal from size 25mm to fineness of 70% through 200 mesh. Hence it is essential to supply coal to mills with correct size and correct quantity by coal feeders. Coal mills have to use extra power when higher size coal is fed to the mill. Similarly correct quantity of primary air needs to be supplied to mill so as to maintain air to coal ratio of 1.8 -2 in mill outlet pipes. For 30MT capacity mill 55 MT of primary air needs to be supplied per hour. Gravimetric coal feeders can ensure correct and measured quantity of coal to coal mills, hence are preferred. Similarly to supply correct quantity of primary air, accurate measurement of flow is essential i.e. within +/- 2%. Hence venturies are preferred for flow measurement. Periodic calibration however is necessary. Many times it is observed that the operator supplies more primary air with the ratio of 2.2 to 2.5 or more to avoid high quantity of reject through pyrite hopper. In doing so, primary air convey heavier particles also in addition to finer particles to mill outlet. In stead of getting recirculated for further grinding these particles find way to burners, affecting combustion and flow distribution. Coal particles escape

as un burnt along with flue gases or delayed combustion occurs at pendent super heaters causing high enough temperature to form slag. Operator thinks that it is the best mill as there is no problem of spillage of coal as reject and sharing more load (handling more tonnage of coal). In one of the boiler, it is observed slag getting formed on H.V.T. probe during its travel in furnace, bellow Goose neck within minutes. Hence keeping P.A. to coal ratio more than 1.8 works satisfactorily as far as boiler loading is concerned but is detrimental for combustion for following reasons.

- 1.Reduction in coal retention time in coal mill for fine grinding.
- 2.Increase in velocity through classifier to carry coarse particles to coal pipes causing poor fuel flow balance.
- 3.Poor flame stability at lower loads,
- 4.Higher flue gas temperature leaving air pre heater.
- 5.Increased furnace exit gas temperature as delayed combustion occurs in upper part of furnace.
- 6.Higher slagging in furnace.
- 7.Increased wear on coal pipes and coal burners.



## ROLE OF COAL MILL IN P.F. BOILER COMBUSTION

Hence it is utmost essential to supply P.A. air only 1.8 times coal flow only. Solution to avoid coal spillage is not high primary air flow but reducing the throat gap. Velocity of 38 to 40 m/sec is required at throat of the mill to avoid coal spilling as reject. It will also maintain correct velocity of air and coal mixture in coal pipes.

Vane wheel be installed with correct annular gap to achieve this velocity. Moreover the air flow be directed towards centre of mill to achieve primary classification and also necessary turbulence to dry out coal. Further classification i.e. secondary classification can be achieved by classifier vanes set at equal and correct angle.

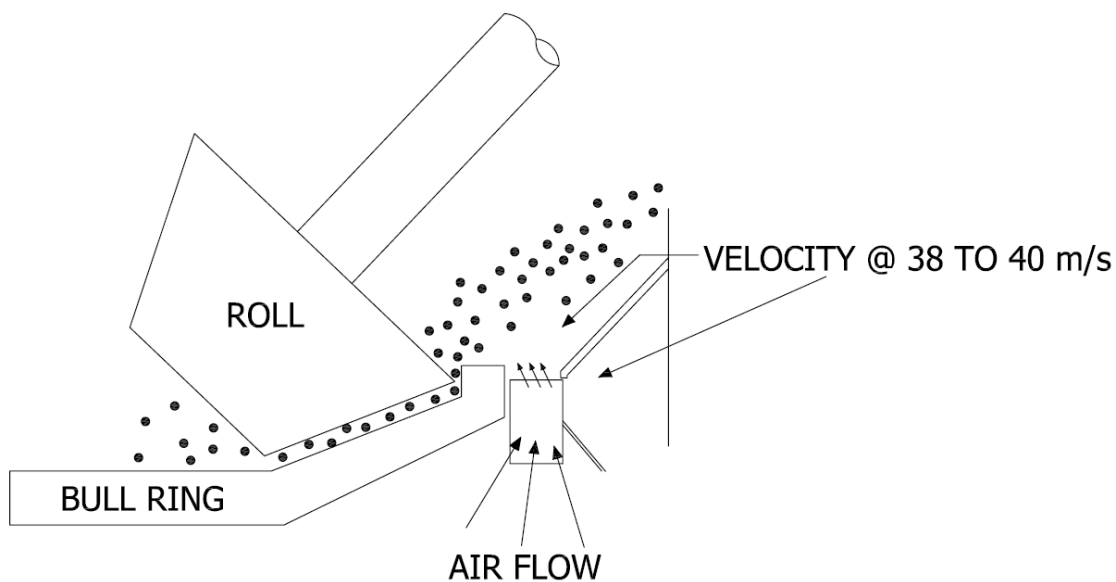
Routine checks and periodic maintenance be carried

out religiously. Healthy mill will ensure maintaining 75% fineness through 200 mesh and 99.5 % through 50 mesh.

Conduction of following tests periodically will help in keeping mill in healthy condition.

Clean air flow test, based on test results, orifices can be adjusted in coal pipes to achieve clean air flow balance within +/- 5%.

Dirty air flow test. Results will ensure fuel flow balance within +/-10% and will help to know velocity through each pipe along with fineness of coal through each pipe.



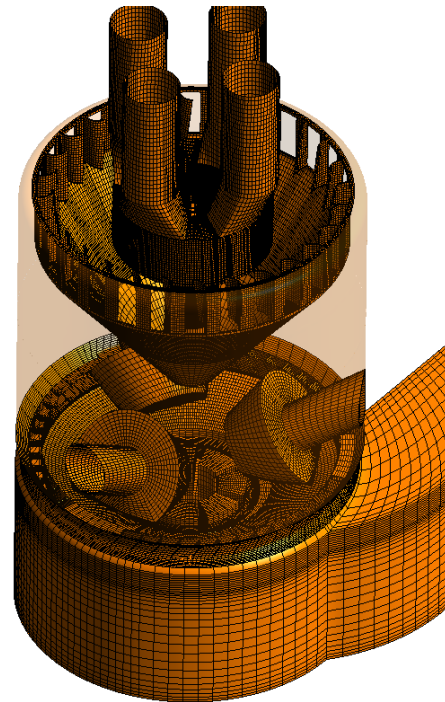
**Velocity of 38 to 40 m/sec is required at throat of the mill to avoid coal spilling as reject**



## ROLE OF COAL MILL IN P.F. BOILER COMBUSTION

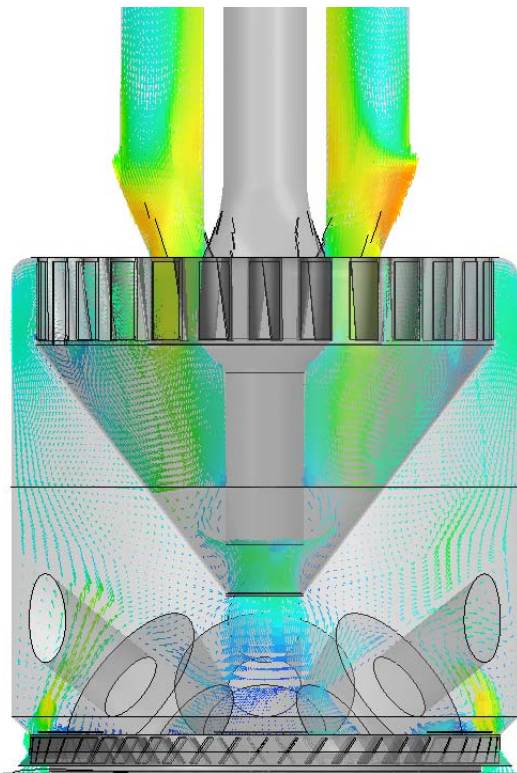
### HOW MECHWELL'S SERVICES CAN BE HELPFUL FOR ACHIEVING COAL FINENESS?

Mechwell utilizes state of art CFD software, Fluent & C.F.X for modeling & simulation of coal pulveriser. Three dimensional computational model has been developed for the complex coal mill. The coal mill has been split in to small elements called mesh. High quality structured mesh around 16,00,000 elements has been used for the analysis i.e divided in small spots. Velocity, pressure and other parameters can be viewed at each spot and accordingly actual conditions are simulated in model.



#### High quality structured mesh of the pulveriser

The governing equations describing the flow have been solved by numerical methods. Single phase flow analyses for clean air flow pattern and Multi phase flow analyses for the coal particle and air can be carried out in coal pulveriser. To account fluctuating velocities advanced turbulence model has been considered. To validate the results further, some of the indirect observations like wear pattern of the mill and associated experimental data from actual plant are compared. The numerical modeling has provided detailed information of flow field inside the pulveriser and further modification has been carried out in the numerical model to optimize the performance with respect to particle size, pressure drop and flow distribution.

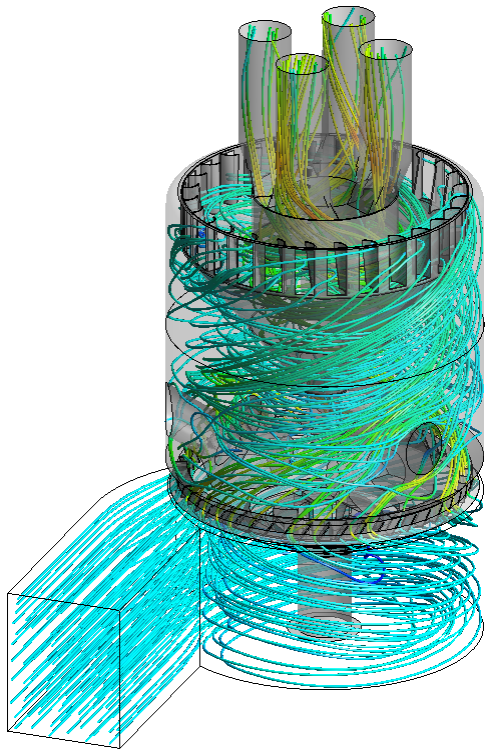


**Velocity vector in the vertical mid plane of the Pulveriser**



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### HOW MECHWELL'S SERVICES CAN BE HELPFUL FOR ACHIEVING COAL FINENESS?



Streamline illustrates Clean Air Flow pattern  
inside Coal Mill

CFD results can be used to examine a range of geometry modifications to improve the performance of the pulveriser.

**MECH-WELL INDUSTRIES LTD.** also offers services to

**conduct following Tests:**

- Clean air flow test
- Dirty air flow test
- H.V.T. probe test
- A.P.H. performance test
- E.S.P. gas distribution test
- Cold Air Velocity test in 2<sup>nd</sup> pass of boiler
- C.F.D. analysis of ducts to reduce DP, reduced noise level etc.



**MECHWELL INDUSTRIES LTD.**

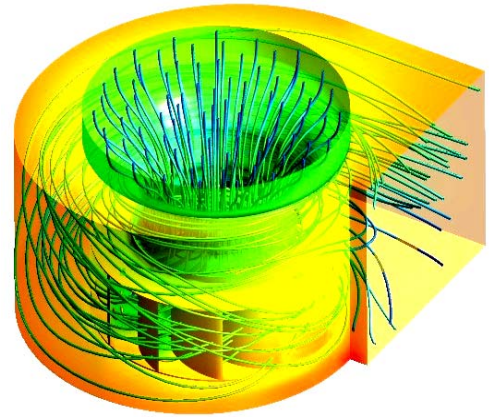
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*Let's Grow Green*



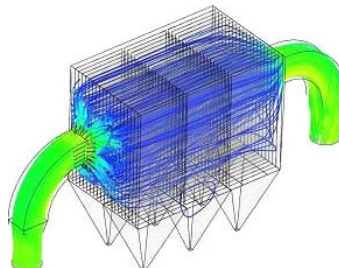
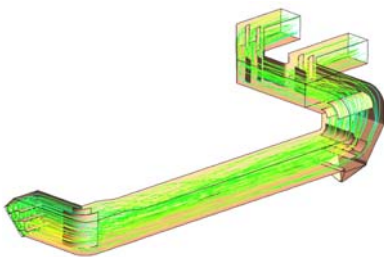
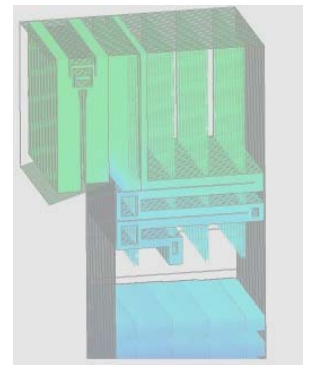
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[www.mechwell.com](http://www.mechwell.com)



**CFD CONSULTANCY**

Mechwell has the facilities for Computational Fluid Dynamics (CFD) Analysis & the same can be carried out for:-

1. Second pass of boiler.
2. Air Preheater.
3. Ducts.
4. ESP
5. Fans.
6. Silencers (Acoustics Solutions)



**Our vision is to conduct an integral program of research, consulting & professional development to promote & demonstrate globally the role of design & innovation in achieving environmentally sustainable future.**

