Full-scale testing of dust explosions in a roller mill

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Contents

Background

- Biomass is becoming a popular fuel for power generation applications replacing coal
- Grinding of biomass in a roller mill represents a hazard due to the presence of both flammable dust and possible ignition sources due to mechanical sparks, hot surfaces and smouldering combustion
- Overall project aim: determination of potential damage to roller mill under realistic operating conditions

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- Background
- **Description of experimental set-up**
- Experimental program
- Design of experimental conditions using CFD-tool DESC
- Experimental results
- Conclusions

Experimental set-up

- GexCon test site at Sotra near Bergen, Norway
- Experiments were performed in "Loesche LM 18" roller mill from a Danish power plant. The grinding capacity of the mill was 36 tons coal/hr.
- Basic parts of the mill are the mill room, the classifier area and "a top" with coal feeder pipe and coal dust pipes, total volume: 23 m^3.
- Mill is connected to a coal feeder of 5.1 m^3 via a 3.35 m long, 0.59 m diameter pipe

Roller mill

Experimental set-up

- Between mill table in bottom of the mill and mill housing open clearance (throat) with total cross section of approximately 0.42 m^2.
- Three coal dust outlets of 550 mm diameter with 2 m pipe and diaphragm to simulate long pipes (> 60 m) to burners
- On top of coal feeder an opening (0.27 m^2) was installed to simulate the connection to a coal silo.
- Primary air ducts were fixed to the mill foundation underneath the mill table (cross section of 0.85 m x 0.85 m, length 6 m)

Roller mill

Dust dispersion

- Parts of suppression system (20 l bottles, opening fast acting valve by torque motor).
- Delay time choice based on DESC simulations: 900 ms
- 20 bar driving pressure; 1 – 3 kg dust per bottle

Diagnostics/ignition source

- 10 pressure transducers regularly divided over mill, primary air ducts, outlet ducts and coal feeder.
- Video
- Ignition source: 5 kJ Sobbe igniter positioned 0.65 m above the centre of the milling table

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Experimental program

- Effect of dust cloud location/size
- Effect of dust reactivity
- Effect of dust type
- Effect of venting parameters

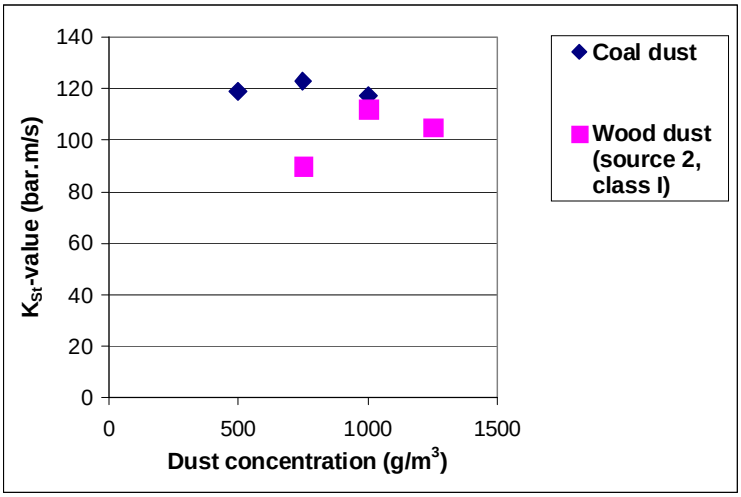
Dust properties

Coal dust	
Property	**Value**
Median particle size diameter (mm)	55-90
Moisture content (% w/w)	2.1-2.3
Maximum explosion pressure (bar)	7.0-7.8
K_{St}-value (bar.m/s) *	118-145

Dust properties

Wood dust sample / **Property**	**Wood dust from first source**	**Wood dust from second source (class I)**	**Wood dust from second source (class II)**	**Wood dust from second source (class III)**
Median particle size diameter (mm)	110	60-90	95-105	160-250
Moisture content (% w/w)	5.4	5.6-6.0	5.5-5.8	6.3-6.7
Maximum explosion pressure (bar)	7.3	7.6-7-7	7.3-7.6	6.5-7.2
K_{St}-value *(bar.m/s)	77	112-122	88-92	31-55

Dust properties



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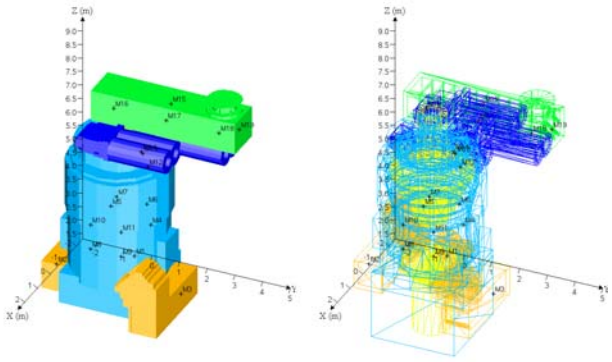
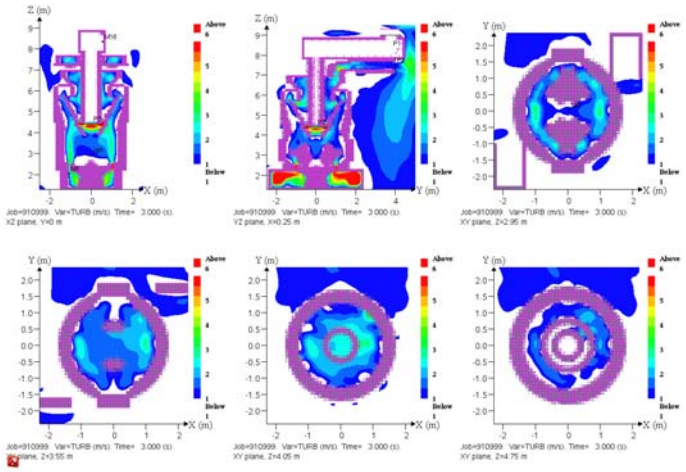
DESC simulations: geometry



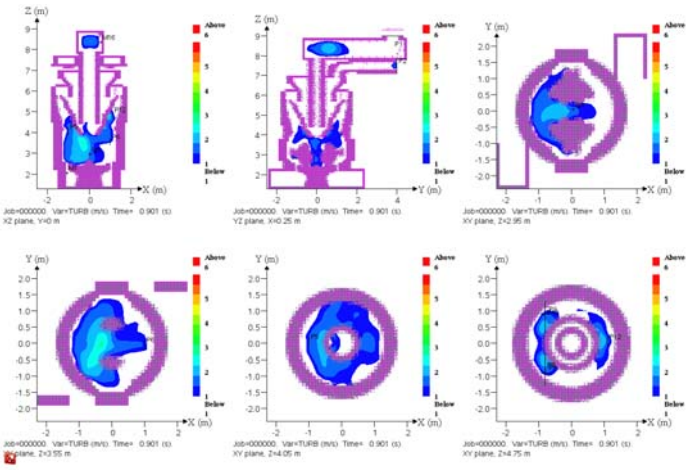
Aim: obtaining turbulence conditions as when mill is used under maximum load conditions

- Total air flow rate of 70,000 m^3/hr through the mill
- Production of 36 tons/hr of fine coal dust

Simulation of maximum load process conditions (flow only)



Simulation of flow conditions in mill after dust injection from bottles (delay time 900 ms)



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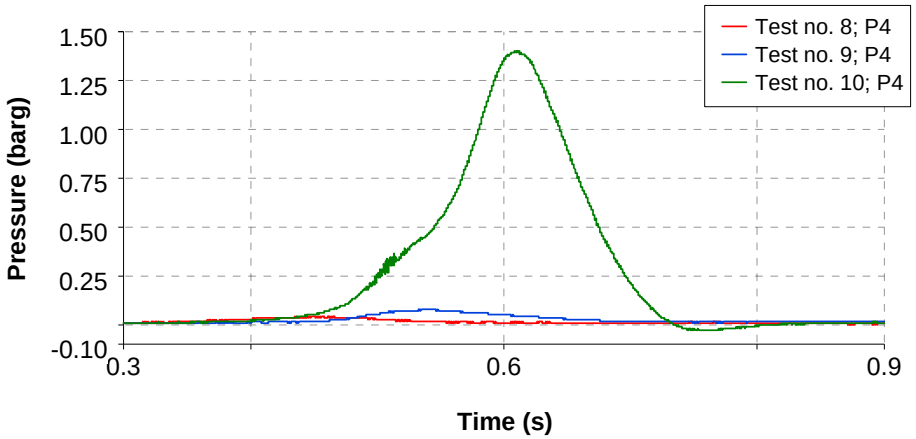
Experimental results: general observations

- Experiments at maximum load conditions concentration wise (~500 g/m^3) were avoided due to (minor) damage to mill at lower (less reactive) concentrations
- Big differences between coal dust and wood dust most likely due to different dispersion properties
- Big variations in wood dust samples (K_{St}-value determined for dust used in every single test)

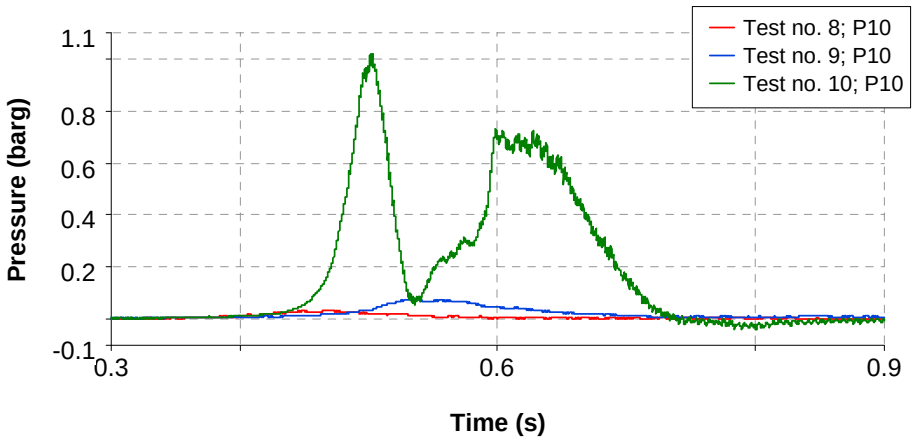
Effect of dust cloud location: only in milling part (coal dust)

Effect of dust cloud location: in entire mill and in coal feeder (coal dust)

Effect of dust cloud location (coal dust), measurements in mill



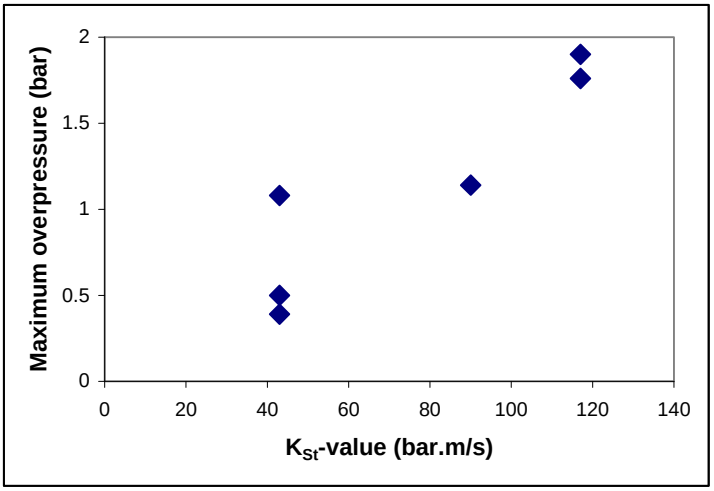
Effect of dust cloud location (coal dust), measurements in coal feeder



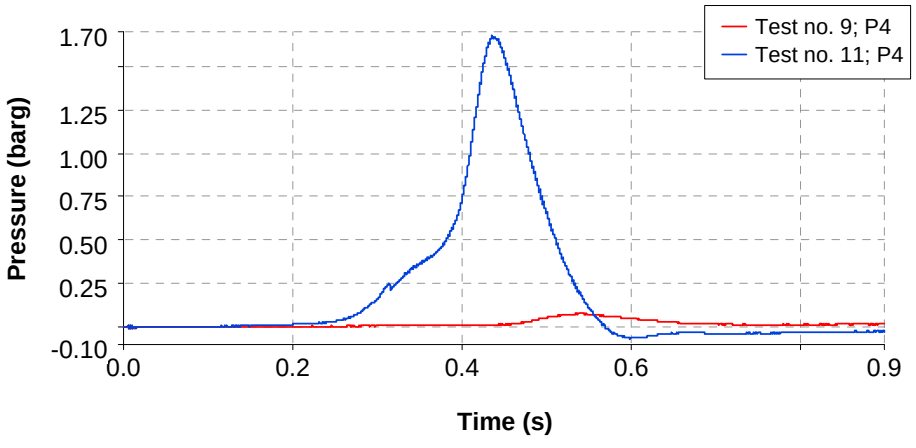
Effect of dust reactivity (dust cloud in mill only) (Wood dust K_{St} = 31-55 bar.m/s)

Effect of dust reactivity (dust cloud in mill only) (Wood dust K_{St} = 88-92 bar.m/s)

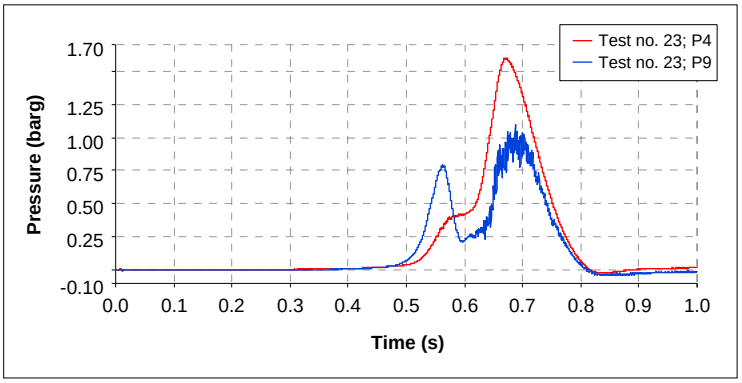
Effect of dust reactivity (wood dust ~250 g/m^3, cloud filling mill only)



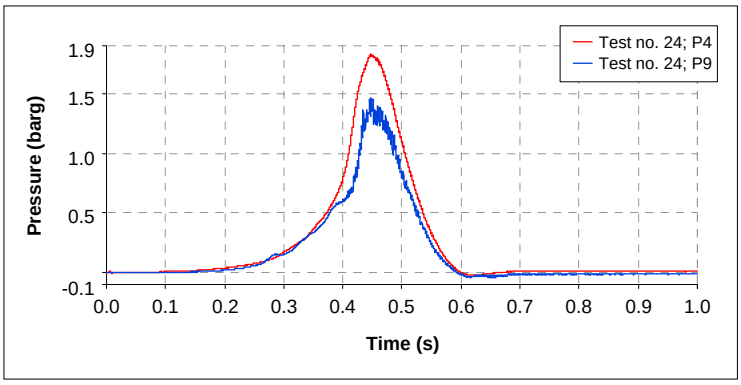
Effect of dust type (test 9 coal; test 11 wood; K-value at 250 g/m^3: 61 and 38 bar.m/s resp.)



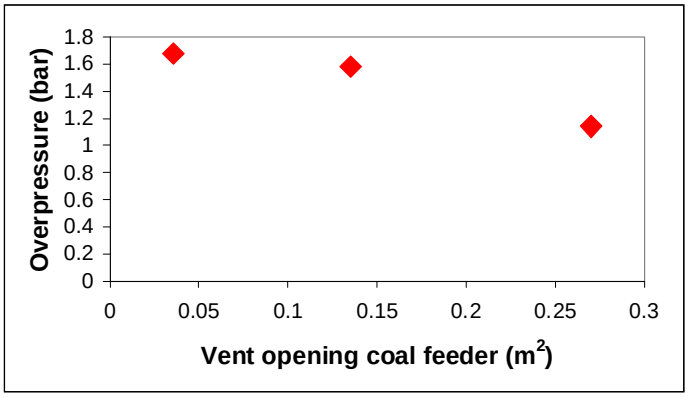
Coal dust explosion (dust in entire geometry; concentration ~ 250 g/m^3)



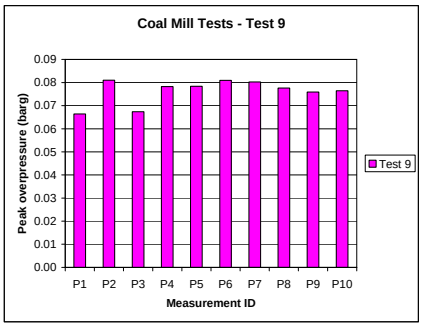
Wood dust explosion (dust in entire geometry; concentration ~ 250 g/m^3)

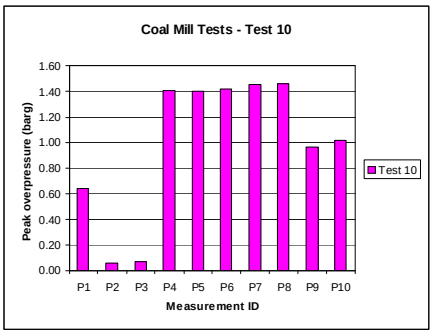


Effect of vent opening size in coal feeder on pressure in mill; dust cloud in mill only; wood dust (K_{St}-value 88-92 bar.m/s)



Pressure distribution in mill for weak and strong explosions (coal dust in mill only vs coal dust in mill and coal feeder)





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Conclusions

- Pressures generated by wood dust explosions (K_{St}-value ~120 bar.m/s) occurring in a roller mill operated under conditions approaching maximum load conditions exceed 1.9 bar
- Similar for coal dust explosions (K_{St}-value ~130 bar.m/s) exceed 1.65 bar
- Important factors affecting the maximum pressure load include venting possibilities, cloud size, dust reactivity and dust dispersion properties

Explosion wood dust (K_{St}-value ~120 bar.m/s)

Acknowledgement

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Thank you very much for your attention!!

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