Dust Explosion Simulations in a Filter Using DESC

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Abstract: Dust explosion is dangerous hazard. There are basically two ways to study dust explosions and their dangers. One is to use different devices in laboratories and real equipment from industry in large scale test sites to carry out small and large dust explosion tests. Another one is to use computational fluid dynamics (CFD) methods to simulate dust explosions. Both have advantages and short comings. CFD can be useful for theoretical studies which in some cases could not be carried out under real industrial conditions. In this paper a CFD program, Dust Explosion Simulation Code (DESC), is used to simulate dust explosion and flam propagation in a bag filter. Some simulation results are presented.

Keywords: Filter, Dust explosion, Simulation, DESC, CFD

Introduction

Dust explosion is a kind of very dangerous hazard and can happen anywhere, where dust is produced either as main products, or intermediate products, or by-products. In order to prevent dust explosion from happening it is necessary to study dust combustion behaviours and its potential dangers. There are two ways to do the work. One is to do practical dust explosion tests in laboratories and in large scale, near-industrial process test sites. Another one is to theoretically use CFD methods to simulate dust combustion process and dust explosion behaviour. The former one has a lot of advantages to obtain real test results under real conditions. It has, however, also many limitations. For example, tests can not be carried out unlimitedly which depend on different parameters, such as personal, test materials, time, cost, and sometimes in large scale test site even on the weather. In one word practical condition itself is the limitation. The later one has advantages to get computational results by changing initial and boundary conditions, geometries, and other parameters systematically. Detectors can be positioned anywhere to monitor dust explosion pressure, pressure rise, oxygen consuming, concentration of CO and CO_2, turbulence and any other concentrated parameters. CFD methods can model an explosion happened before to back trace the development of the explosion, to analyse the possible causes and further more to prevent the similar explosions from happening again. It is useful for risk management. The disadvantage is also obvious -its reliability. Real conditions can not be one hundred percent simulated by using CFD methods and they have their limitations too. The modelling results, no mater how they are closed to real test results, should be thought as an assessing tool to figure out and to predict what could happen under real conditions.

Some researchers did numerical modelling of dust explosion using different CFD methods. Bielert etc did numerical simulation in pneumatic conveyors[1]. Zhong etc modelled vented maize starch explosions in a silo[2]. DESC is a new CFD method to model dust explosions with new challenges.

Dust Explosion Simulation Code, in short DESC from GexCon AS situated in Bergen, Norway, is a dust simulator based on FLACS, a gas simulator, which was originally developed by its parent company Christian Michelsen Research (CMR) in 1980s. The first version of DESC was developed in a project sponsored by the European Commission. Apart from GexCon, there were 10 institutions, companies and universities from European countries having been participated the DESC project, which involved extensive experimental work, measurements in real process plants, modelling, and validation. As a member of the project FSA did the work of turbulence measurement[3-7].

DESC can handle not only simple geometries but also complicated geometries as well. Giving enough power to a computer, DESC can simulate a workshop and even a whole factory. Skjold, the key developer of DESC did some dust explosion simulations with his colleagues[8,9].

1. Filter layout and simulation conditions

Fig.1 shows the diagram of the filter. There are sixteen bags inside in the filter which are positioned on the upper part of it. A venting window is on one side of the filter near its top (Fig.1 on the right side). Fig.2 shows the filter connected with pipelines and a cyclone. Cornstarch was selected as test dust which has the following combustible characteristics:

Dust concentration: 750 g/m^3;

K_{St} value: 144 bar·m/s;

Maximum explosion pressure: 7.4 bar;

Igniter position: lower middle center

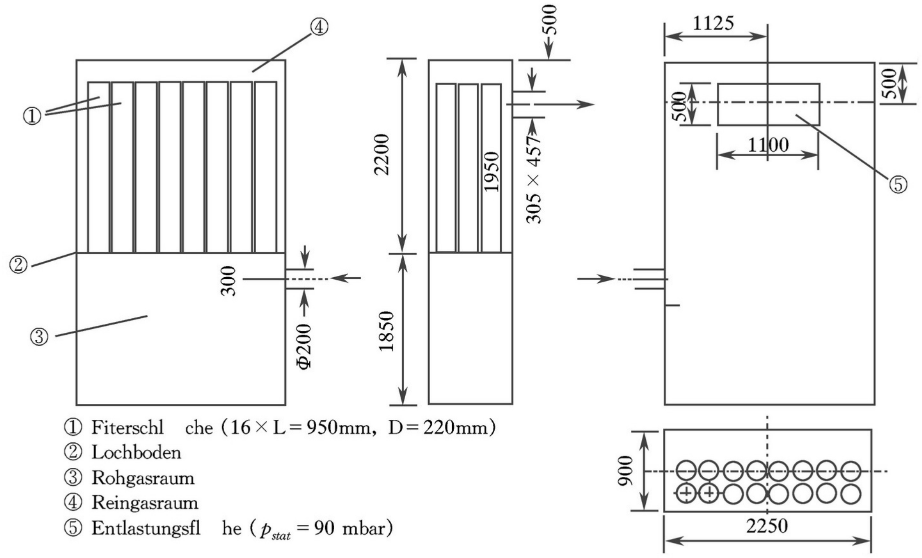


Fig.1 Diagram of the filter

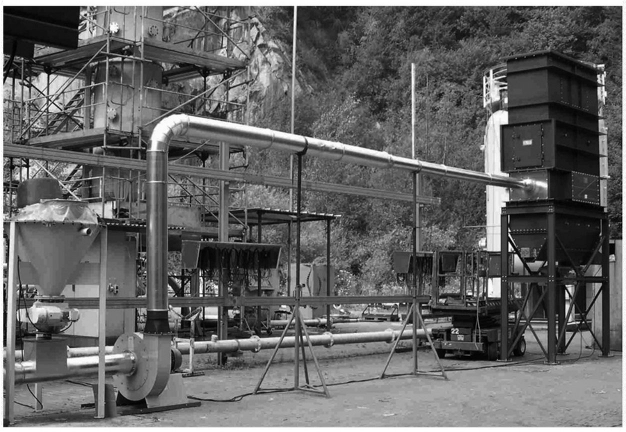


Fig.2 The filter in the test site Kappelrodeck

DESC program to simulate dust explosions in a certain set of objects or a system has typically three main steps:

(1) Preprocessing, which includes

- Creating geometry
- Setting grid
- Setting parameters such as initial boundary conditions, monitoring point locations, composition, and ignition location.

(2) Numerical computation -simulation

(3) Postprocessing, which includes

- Analyzing results data
- Plotting curves, contour and vector plots as pictures, animations and videos.

Of course this procedure can be repeated by changing different parameters to get different results.

In this paper DSEC 1.0 run under Linux was used for simulations.

2. Simulation Results

Fig.3 to Fig.9 show the development of dust explosion in the filter.

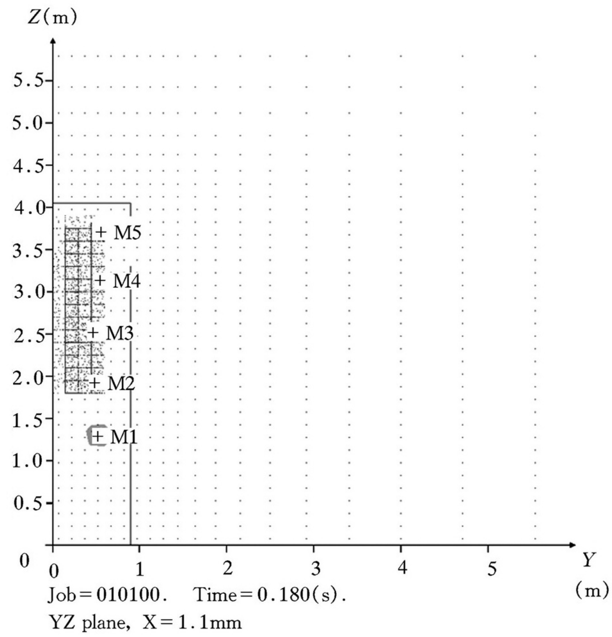


Fig.3 Beginning phase of ignition

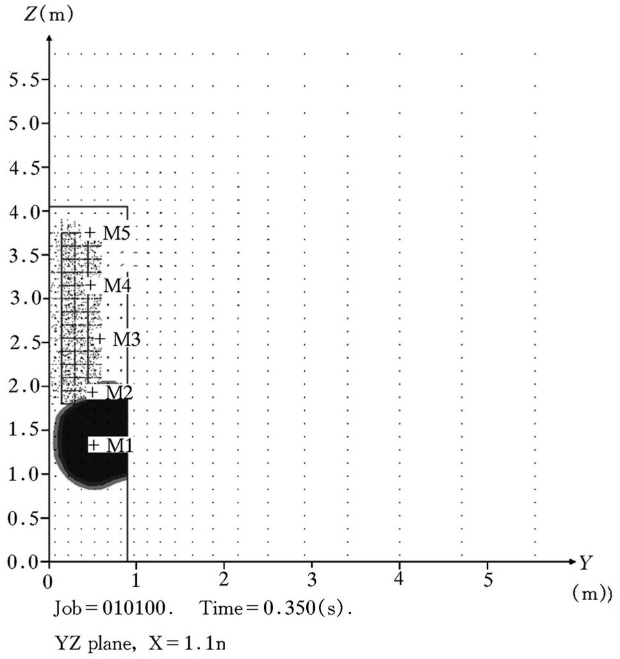


Fig.4 Flame ball reached the filter wall

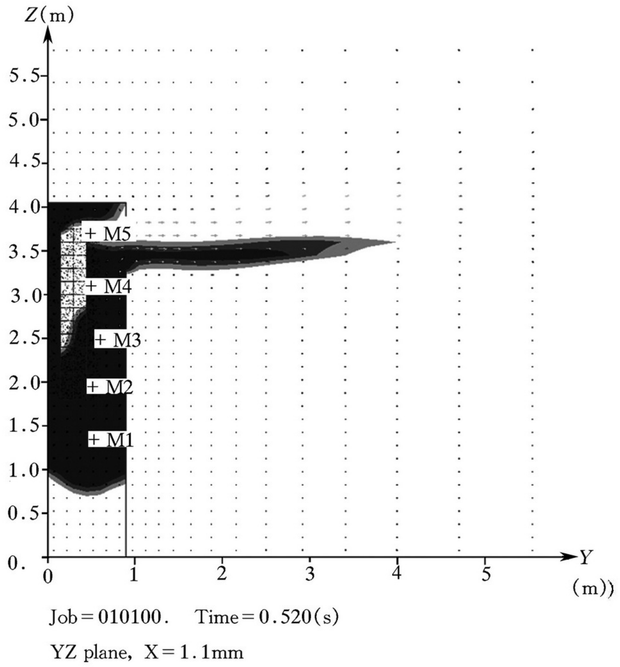


Fig.6 More flame went through the venting window

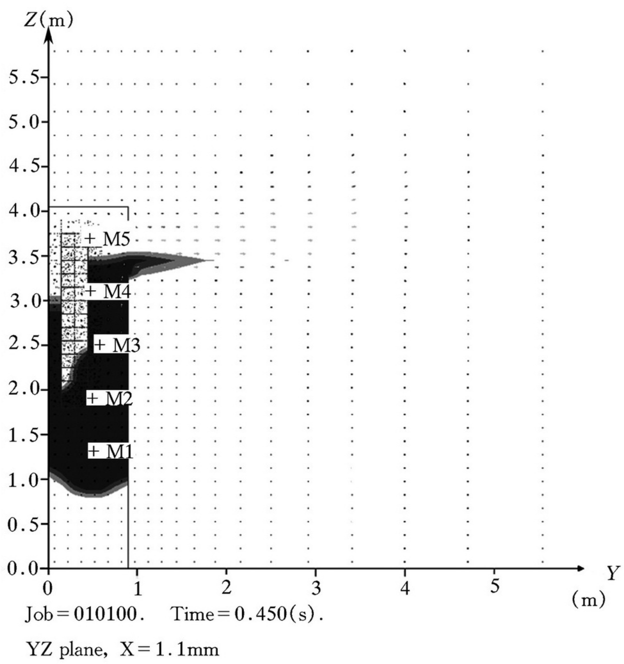


Fig.5 The flame went through the vent window

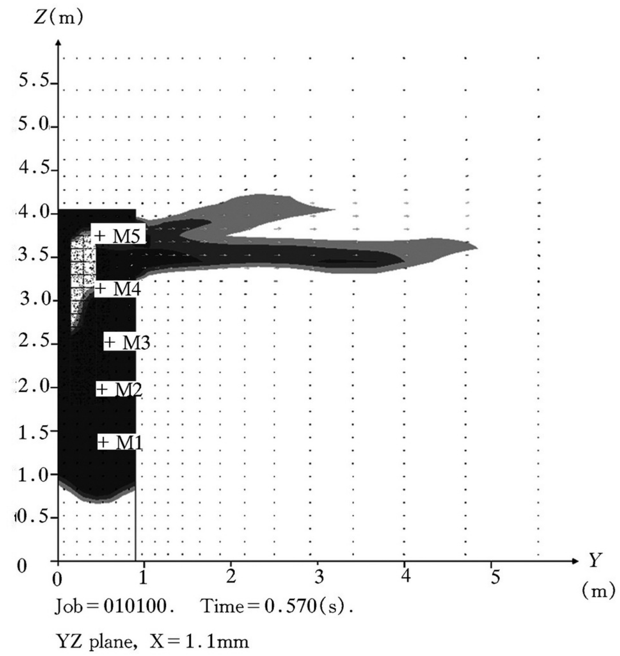


Fig.7 The room without combustion inside getting smaller

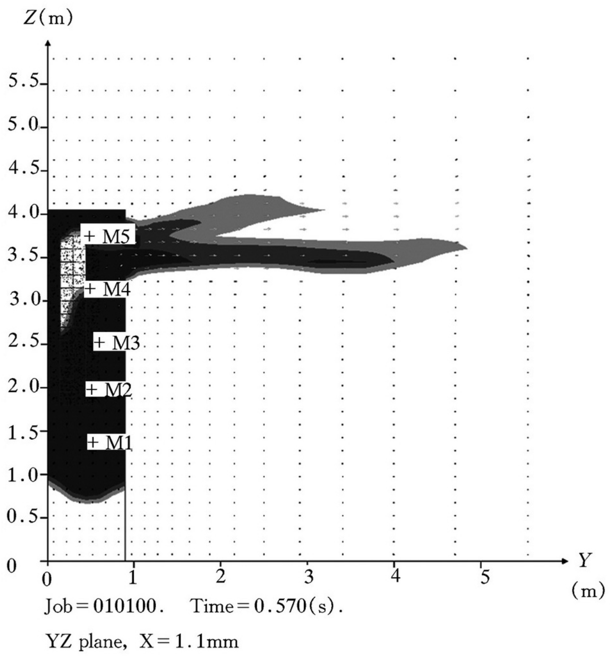


Fig.8 The flame developed further

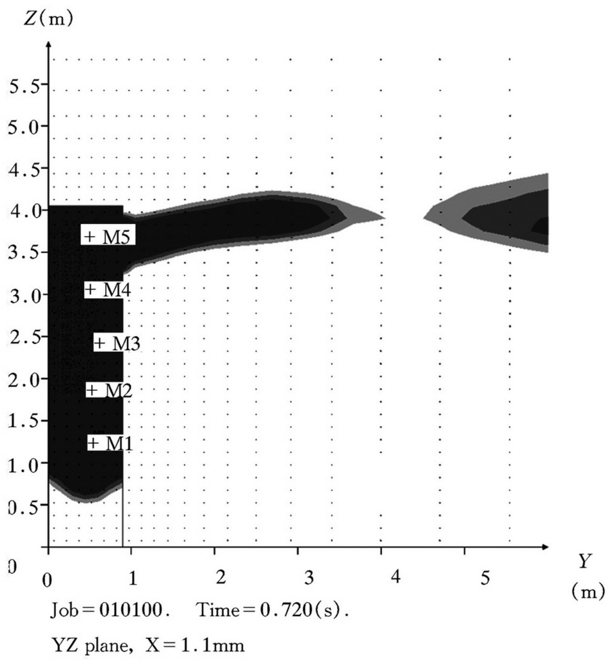
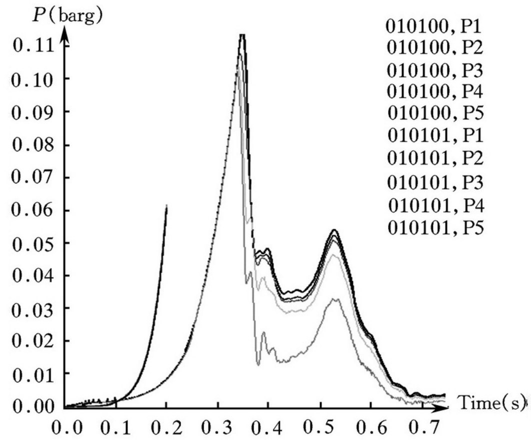


Fig.9 The combustion inside fully developed

3. Conclusion

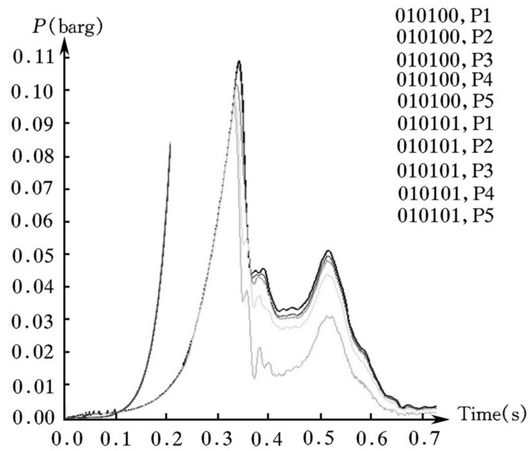
In this paper simulation results using a CFD program DESC are presented. It should be pointed out that this is a very first approach to model dust explosion in a filter with simple tries. Further work needs to be done. As we mentioned above CDF methods to simulate explosions are good accessing tools to help us to better figure out what could happen in real industrial process. The results can indicate and demonstrate the tendency what could happen before real upcoming tests will be carried out.

Fig.10 (a) ~ (c) shows the pressure-time history of two simulations with rough grid (job 010100) and fine grid (job 010101).



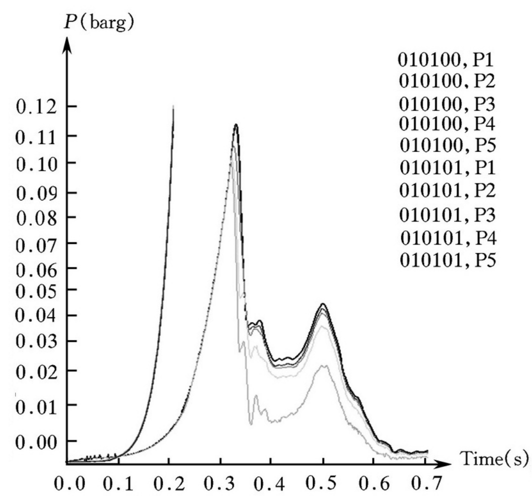
(a) the pressure-time history

Fig.10 (a) The pressure-time history



(a) the pressure-time history

Fig.10 (b) The pressure-time history



(c) the pressure-time history

Fig.10 (c) The pressure-time history

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