AN EXPLOSION CAUSED BY MICROBIAL HYDROGEN FORMATION

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SUMMARY

A gas phase explosion in a storage tower with semichemical pulp at a paper mill has possibly been caused by combustion of a mixture of hydrogen and air. The hydrogen was formed by microorganisms in the pulp. Ignition may be due to electric sparks in connection with an electric field in the mist above the pulp.

ACCIDENT AT A NORWEGIAN PAPER MILL

A gas phase explosion which took place in a 1300 m$^3$ storage tower for semichemical (NSSC) pulp at a Norwegian paper mill will be described. The storage tower was 21 m high and equipped with an agitator at the bottom and by a pumping arrangement the pulp was circulated from bottom to the top through external pipes connected with the mill (Fig. 1).

In connection with celebration of the Norwegian National Day the production was stopped at a time when the storage tower was loaded with 1000 m$^3$ pulp at a temperature of 60-65°C and a pH of 5.5-6.0. Simultaneous with production stop the circulation pump was stopped whereas the stirrer at the bottom was kept going. After 24 hours' stop the mill production was started and pulp pumped from the tower to the mill and from the bottom to the top of the tower. About 3 hours after production start a violent explosion took place in the tower, blowing out the cover over the manhole and deforming the top of the tower into a spherical shape. At the moment of explosion the tower contained approximately 600 m$^3$ of pulp and recordings from the load cell showed momentarily full scale deflection. Large amounts of steam mixed with droplets of pulp were spread over a wide area. There was a distinct smell of SO$_2$ at the top of the tower and also smell of H$_2$S from samples of pulp from the bottom.
LABORATORY TESTS

Due to the smell of SO$_2$ and H$_2$S at the time of explosion it was decided to analyze pulp samples for H$_2$S and CH$_4$. Samples taken from the storage tower before and after the explosion were analyzed but only traces of H$_2$S were found.

Microbiological examinations, however, showed that pulp samples from the paper mill were heavily contaminated by microorganisms. In order to check the possibility of gas formation by these organisms a number of pulp samples from the paper mill were collected in 6 l flasks equipped for gas collecting. One of the flasks was inoculated with pulp taken from the tower just before the explosion. All samples were incubated at 60°C. Within 24 hours gas was produced in all flasks, about 300 ml in each.

Gas chromatography and mass spectrometry showed about half of the gas to be H$_2$, the other half being a mixture of CO$_2$ and N$_2$ in equal amounts. H$_2$S and CH$_4$ were not detected, but analysis taken few weeks later showed small amounts of H$_2$S (50 ppm) in the gas phase.

DISCUSSION

Today it is possible to control and utilize complicated microbial processes. This also applies to processes based on substrates or products consisting of combustible or explosive gases as for instance production of Single Cell Protein (SCP) from mixtures of CH$_4$ and O$_2$ (Hamer et al., 1967)