Ignition of a cloud of wood dust in a manufacturing facility

May 11th,2004

Allouville-Bellefosse – [Seine Maritime] France

Panels
Press
Inappropriate intervention
Lack of procedures
Banalizing of the risk
Cleaning
Training
Death
Serious burns

THE INSTALLATIONS IN QUESTION

The company is specialized in the manufacture of panels made of chipboard or flax shive.

The installations, whose capacity had been increased in 2003, are subject to prefectoral authorisation with regard to the installed power (50 MW of heat drying, 4.5 MW for the shredding of wood and nearly 2 MW of electricity for sawing and sanding). The industrial site produces 500,000 m³ of chipboard panels per year. It operates around the clock and shuts down only twice a year, in August and December.

The flow chart of the manufacturing process is provided below :

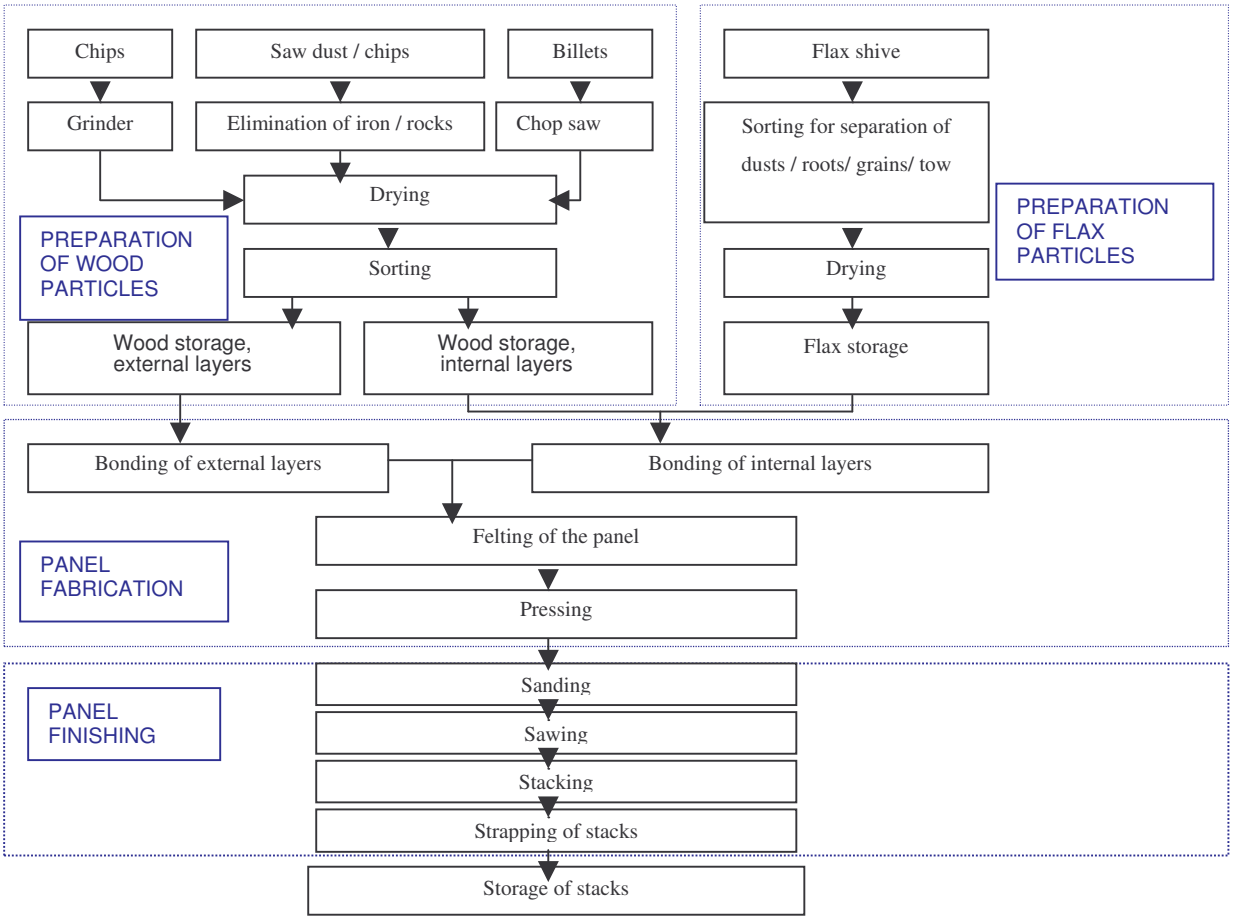

Figure 1: Flow chart of the chipboard panel manufacturing process

The panel manufacturing process can be broken down into three steps:

- gluing of particles with a urea-formaldehyde adhesive,
- felting which consists in spreading out the material to form a uniform mat on metal screens,
- pressing during which the mat is placed in a heated hydraulic press to ensure polymerisation of the adhesive.

In this case, the hydraulic press, installed 8 years ago, had been modified in 2002 in order to increase the production capacity (11 stages instead of 8). The heat is provided by mineral oil heated to 250 °C and distributed by a control circuit from 140 to 210 °C.

In essence, the process generates wood dust. For example, 60 tonnes of dust are produced on daily basis by the panel finishing operation alone.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident:

On Tuesday, May 11, 2004, a cloud of dust ignited at 6.45am above the press while two operators were attempting to extinguish a smouldering fire with a dry chemical extinguisher.

The consequences:

This accident had dramatic consequences. One operator died and another was very severely burned. At the time this report was being drawn up, the latter, who had been hospitalised for several months, had not yet returned to work.

There was limited property damage: Overpressure did not occur as the accident took place in a relatively open area. The fire was quickly brought under control by the automatic fire-extinguishing network (sprinklers). As the emergency response centre is located just a few kilometres way, firefighters were able to respond quickly on a part of the roofing. Part of the bituminous roofing material had been damaged.

Operating losses were significant (production was stopped for 10 days). Resumption of operations is contingent upon submittal of assessments prescribed by a draft order outlining "emergency measures".

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterised by the following 4 indices, based on the information available.

The unfortunate death of an employee explains the level 2 classification attained by the human and social consequences under the terms of parameter H4. In addition, as the operator had not yet indicated the actual amount of property damage and operating losses (parameters €15 and €16), the classification relative to the economic consequences could not be characterised.

The parameters, which comprise these indices and the corresponding rating method, are indicated in the appendix hereto and are available at the following address: http://www.aria.ecologie.gouv.fr

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

Given the severity of the accident, an analysis of the accident's circumstances and the definition of the corrective and preventive actions to be implemented were requested. The company has contacted an engineering firm specialised in dust explosions to conduct an expert evaluation.

Circumstances:

On the eve of the accident, the crew working the 9pm to 5am shift detected a burnt odour in the workshop without being able to locate where it was coming from. The morning crew (5am to 1pm) located the smouldering fire on top of the press around 6am.

Using an aerial basket, a mechanic and an electrician discovered embers on the upper "counter-heating platform" of the press. After informing the foreman, the decision was made to empty the press and shut down the line prior to intervention.

The production supervisor was informed. The foreman and the electrician, wearing neoprene masks equipped with a P3 cartridge and face shield climbed to the level of the embers with a 50 kg dry chemical extinguisher. A scraper was brought in order to recover the burning material. Beforehand, one or two attempts to smother the embers were made with the extinguisher. At that moment, around 6.45am, the dust ignited immediately causing a flashover above the press. The mechanic, at ground level next to lifting device whose basket had been moved and blocked in the press' upper structure, was able to rescue the foreman, who was able to climb down by himself despite his burns. The electrician was found dead in the lift.

Origin and causes of the accident:

The eleven stages of the press, which measures approximately 9.50 m x 5.50 m are subject to high stresses in terms of both temperature and pressure. In order to compensate the possible deformation of the highest platforms, the manufacturer had installed a "counter-heating platform" above and below the press, divided into three lengthwise control zones.

When adjusting the press, the company had worked on the temperatures in these heating zones. Experience had shown that above 165 °C dust had caught on fire locally. A maximum setpoint of 140 °C had been adopted.

Transformations of the press

During the backfitting of the press (from 8 to 11 stages), the last platform was brought closer to the "counter-heating platform". For production reasons and throughout the entire adjustment period (July 2002 to January 2003), the temperature of the platforms was dropped from 190-215°C to 170-190°C.

In January 2004, when the temperature of the platforms was raised. Even in the absence of heating of the central zone of the "counter-heating platform", the temperature reached 165°C. As outbreaks of fire were again noted (these incidents, considered minor and of no consequence, were not reported to the Classified Installations Inspectorate), the company decided that the central zone would be cooled instead of heated, as the platform was supplied with coolant from the heat sink. All of the equipment (pumps, piping…) was operational during the month of April. The centre zone was set at 140 °C.

Felting line and press

Initiator

An incident was reported in the report of the crew's electrician. On the eve of the accident, at roughly 10am, the control room operator noticed excessive temperature in the "counter-heating platform" (temperature above 200 °C). The electrician and the mechanic reported that the temperature regulator was operating correctly but not the 3-way valve which remained partly open on the hot reservoir. The thus manually closed the 3-way valve and, for safety reasons, a manual valve and the zone's circulating pump.

The temperature dropped regularly. At around 4.30 pm, it is known that the temperature was around 150°C.

An expert evaluation of the 3-way value conducted later showed that its blockage may be the result of a hard spot, as the servomotor used to drive it is low-power.

An incandescent layer of dust

The press is stopped and cleaned only one or two times per year (the platform is difficult to access and the extreme temperature does not allow intervention while it is in operation). At the time of the accident of May 11th, the layer of wood dust was probably between ten and fifteen centimetres. The blast from the extinguisher blew the dust into suspension thus increasing the explosibility conditions with the presence of incandescent particles.

ACTION TAKEN

During the week following the accident, the company performed repairs and verifications of the damage equipment. It also proposed to implement temporary monitoring measures, mainly consisting of a reading with a paper printout of fluid temperatures and a procedure to be followed to handle any new rise in temperature.

As the accident had claimed victims, the Classified Installations Inspectorate acted jointly with the labour inspectorate and the CRAM ("Caisse Régionale d'Assurance Maladie", regional sickness insurance fund). The latter were able to testify regarding the difficulties encountered in how the company takes occupational hazards into account. This report limited the scope of the procedures proposed by the company for restarting the activity.

an emergency shutdown order was proposed to the Prefect, making the continuance of the activity contingent on in-depth investigations. The scope of the study concerned the press and its utilities, although the company was also asked to implement a study program bearing on the entire site. The company contracted an expert organisation, specialised in dust explosions.

Immediate measures prior to installation restart

Several pre-restart measures were defined jointly with the organisation in order to allow the installations to resume production:

✓ Temperature control:

Concerning the "counter-heating" control zone, the external zones not needing to be heated, and the heating systems were shut down.

Three temperature probes were added in a fail-safe configuration, each having indicators on the fluid and 2 alarm thresholds (1st threshold at 142 °C to indicate an anomaly and a 2nd threshold at 160 °C which stops the boiler burner).

✓ Dust limitation

In its analysis report, the expert organisation shows that, in terms of a dust deposit's self-ignition characteristics, there is a relationship that links the thickness of a dust deposit and the temperature in contact with this deposit.

In this particular case, a fire may break out at 240 °C (temperature of the coolant leaving the boiler) for a 5mm layer. This thickness is increased to 7cm at 160°C, a temperature that the operator's fail-safe temperature measurement system should prevent.

However, markers were placed at 5cm from the surface of the last platform as a preventive measure and are checked two times per week. The readings are then recorded. The press is shut down and cleaned by a vacuum system as soon as the thickness is reached (every 10 to 15 days of operation).

It is important to mention that the expert organisation stipulates that the dust thickness limits are provided only as a general indication (products need to be known better) and bears only on controlling smouldering fires. Such dust thicknesses are sufficient enough to propagate an explosion when the dust is put into suspension.

✓ Definition of procedures to be followed

According to the operator, several fires had already occurred on the installation since its commissioning. These were the result of errors of the fixed setpoint temperature on the platforms at issue. These outbreaks of fire occurred on the hot parts (lighting…), the incandescent portion had been collected with a broom or scraper and the incidents were of little consequence. Owing to a lack of written instructions regarding the procedure to be followed in the case of fire, on May 11, 2004 the employees attempted to put the fire out with a fire extinguisher.

Following this dramatic accident, written procedures were drawn up and explained to the personnel regarding what actions are to be taken in different circumstances. Namely :

- the procedure to be followed when an abnormal increase in temperature is noted,
- what actions are to be taken when a burnt odour is detected,
- the press cleaning procedure,
- the intervention procedure on smouldering fires.

✓ Prevention and protection measures on the press

Heat lagging was installed on the top of the press to insulate the hot surface from dust deposits. Should fire break out on the top of the press not protected by the sprinkler network, spray booms are installed to ensure cooling and extinguishing from the floor level.

✓ Training of personnel

Fifteen individuals were trained in the handling of fire extinguishers (i.e. 3 people per crew). This was the first time that such a training program had been given.

✓ Management's commitments

The company committed to the following points: the continuation of the studies stipulated by the expert organisation in order to define Potentially Explosive Atmospheres (ATEX), the search for collection solutions at the source of dusts and centralised cleaning by a vacuum system, the hazard training of personnel and the implementation of specific documentation (labour regulations).

Additional requirements reinforcing site safety

As a result of the measures taken, operations were resumed in the afternoon of May 22, 2004, following a fire extinguisher training for the employees. The shutdown over a period of approximately ten days was economically destabilising for the company as well as about twenty scutching operations and multiple customers upstream and downstream of the production facility (500 jobs).

The Classified Installations Inspectorate also proposed a complementary order intended to reiterate all of the palliative measures retained for resuming activities. This order, also prepared in close collaboration with the labour inspectorate and the CRAM, requires that additional studies be carried out encompassing the entire site. They aim to reduce the source of hazards presented by the installations according to the following four axes:

- identify the dust emission sources and, as required, the dust prevention measures that would reduce these emissions in the ambient air and closed spaces,
- analyse the pertinence of the cleaning procedures and methods, the means implemented (suction equipment, equipment and operator protection devices, secure access to the areas to be cleaned, human resources...) and personnel training,
- define all explosive atmospheres, identify the associated equipment and establish the adequacy program as per Directive No. 1999/92/CE (ATEX directive) transposed into French law,

Mechanical transport with decoupling by screw

- dimension and define the protective means against the effect of a possible overpressure (vents, explosion suppressor…) and accident response means.

The installations have now been modified so that dust is no longer deposited on the press. The cleaning of the facilities has been facilitated by the installation of a centralized vacuum system.

The danger study defined several modifications that should be undertaken, including moving a dust silo and resizing of overpressure vents. It also stresses the hazards presented by the sawdust transport installations via pneumatic means. The slow mechanical transport which enables an uncoupling system to be implemented must be given special consideration as it limits the effects in the event of an explosion.

It should be noted that the installations have been equipped with the risk of explosion since the beginning. In particular, spray booms slaved to spark detectors are installed along a large portion of the system. These devices record an average of 400 detections per month. This number certainly contributes to banalization of the phenomenon within the company.

A search of the accidentology in the ARIA database relative to similar installations provided to be rich in information: of the 100 accidents reported between 1999 and 2004, the main hazards identified concern fire (70 cases) and explosion (20 cases). In particular, 9 accidents involve driers, 5 cases involve silos and 4 cases concern dust connection systems.

The study relative to the adequacy of the equipment, per the requirements of the "ATEX" directive, culminates on an extensive program of additional investigations and replacements which cannot be completed prior to 2007. A difficulty arises from the fact that the manufacturers cannot commit on the compliance of the equipment sold without an expert assessment of the equipment on site and with the installation shut down. Complete replacement of the installations must sometimes be considered.

In terms of installation operation, roughly thirty procedures and instructions are implemented. Unfortunately, the inspections conducted since then show that the updating of these procedures are not in line with the modifications made to the installations. As the personnel's "risk" culture is not developed, it appears as though these tools have not been successfully adopted. This is the reason why a training program seems essential.

Finally, the company hired a safety manager.

Drier

LESSONS LEARNED

The following elements can be retained from the feedback:

✓ although exposed to dust explosion and fire hazards, the particle board manufacturing industry in the Seine-Maritime department does not appear to be prepared for the application of texts relative to the "ATEX" directive. The Classified Installations Inspectorate reiterated these requirements to all of the flax scutching plants in the department, which are subject to requirements of the same type,

✓ the measures consisting in reducing dust emissions at the source and to avoid the accumulation of dust are essential in the prevention of fire and explosion hazards. In addition, as of June 30, 2005, the concentration in the ambient air at the workstation is limited to 1 mg/m^3.

✓ changes in the behaviour of the personnel, such as the assimilation of written procedures, are difficult to obtain without appropriate training. In this respect, cooperation with the CRAM and the Labour Inspectorate allows complementarities to be found.