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Inherent hazards, poor reporting and limited learning in the solid biomass energy sector: A case study of a wheel loader igniting wood dust, leading to fatal explosion at wood pellet manufacturer

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ABSTRACT

Large loaders are commonly used when handling solid biomass fuels. A preventable accident took place in 2010, where the malfunction of a front-end wheel loader led to a dust explosion which killed the driver and destroyed the building. The case offers an opportunity to examine the hazards of solid biomass, the accident investigation and any learning that subsequently took place.

The paper argues that learning opportunities were missed repeatedly. Significant root causes were not identified; principles of inherent safety in design were ignored; the hazardous area classification was based on flawed reasoning; the ATEX assessment was inadequate as it dealt only with electrical installations, ignoring work operations; and powered industrial trucks had not been recognized as a source of ignition. Perhaps most importantly, guidelines for hazardous area classification for combustible dust are insufficiently developed and give ample room for potentially erroneous subjective individual judgment. It is a contributing factor that combustible dust, although with great hazard potential, is not classified as a dangerous substance. Accidents therefore fall outside the scope of systems designed to disseminate lessons learned and prevent future accidents.

More attention to safety is needed for the renewable energy and environmentally friendly biomass pellet industry also to become sustainable from a worker safety perspective.

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1. Introduction

1.1. *Background and purpose*

A layer of dust from solid biomass is a significant fire hazard and when fine dust particles become airborne in sufficient quantity they represent a serious explosion hazard. A series of recent incidents have shaken the confidence of the biomass industry in the handling of these new fuels [1]. Insurance companies have warned the wood pellet industry that its performance must improve or else pellet plants will no longer be insurable [2].

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Table 1 – Selected hazard metrics for some wood type dusts.

	Hazard metric					
	For dust cloud				For dust layer	
	Deflagration index, K_{st} (–)	Maximum explosive overpressure P_{max} (MPa)	Minimum ignition energy, MIE (mJ)	Minimum explosible concentration, MEC (kg m^{-3})	Hot surface ignition temperature, 5 mm dust (°C)	Hot surface ignition temperature 19 mm dust (°C)
Dust from wood pellets produced in British Columbia (Canada)[a]	146	0.81	17	0.070	300	260
Dust from wood pellets produced in Nova Scotia (Canada)[a]	162	0.84	17	0.070	310	250
Dust from wood pellets produced in USA, southern yellow pine[a]	98	0.77	20	0.025	320	270
Cellulose[b]	66	0.93	250	0.060		
Wood dust, chipboard[b]	102	0.92		0.060		
Lignin dust[b]	208	0.87		0.015		
Peat, 15% moisture[b]	157	1.04		0.060		

[a] Source: Melin [27].
[b] Source: Eckhoff [28], appendix A.1.

Hedlund and Astad [3] argued that while wood dust hazards may have been grandfathered as tolerable risks in traditional operations such as saw mills, the large-scale use of solid biomass as a renewable and carbon dioxide neutral energy source presents new challenges. The complexities that come with intensification, scale-up and handling of unprecedented quantities of solid biomass fuels call for increased attention. The authors presented a list of recent major fires and serious explosions involving wood pellets and argued that the accident record indicates that wood pellets represent an emerging risk for which proper control strategies have yet to be developed. They also argued that information sharing schemes are absent or deficient – that accident investigations, if carried out, often are kept internal and lessons learnt to prevent recurrence are not shared widely. The authors observed that this is a familiar and age old problem across industries. It may be that market participants for commercial reasons, reputation, cost or otherwise find information sharing unattractive. Some sort of regulatory intervention is probably required to translate the seemingly straightforward ideal of sharing lessons learned into something workable in practice.

This paper presents a case that would appear to confirm each of the concerns raised above. In Denmark, a new facility started production in 2001 to manufacture environmentally friendly wood pellets for the domestic stoker market. The paper argues that the wood dust hazards were not adequately controlled, seemingly because the hazards were not fully understood. It may have been a contributing factor that wood dust is not classified as a dangerous substance. After less than one year the facility experienced a very serious explosion. Only due to sheer luck, nobody was injured. The accident was insufficiently investigated and root causes were not identified. No attempt was made to share information; in fact, the event has vanished from open sources. Eight years later the facility exploded again, this time fatally injuring one employee. Again, the accident was insufficiently investigated, root causes not identified and no information shared. The case offers a text book example of the truism that if accidents are not investigated, and root causes not identified, accidents recur. Had the company chosen to rebuild the facility, which this time they did not, a future repeat explosion would be likely.

1.2. *Hazards of wood dust*

Dust explosions have traditionally been difficult to deal with in industry. Part of the problem lies with the limited general understanding of the complex mechanism of dust explosions among plant operating personnel as well as corporate management. Abbasi and Abbasi [4] note that dust explosions pose the most serious and widespread of explosion hazards in the process industry alongside vapour cloud explosions (VCE) and boiling liquid expanding vapour explosions (BLEVE). Dust explosions almost always lead to serious financial losses in terms of damage to facilities and down time. They also often cause serious injuries to personnel, and fatalities.

Dust explosions can either be primary or secondary. A primary dust explosion occurs when a dust suspension within a container, room, or piece of equipment is ignited and explodes. A secondary explosion occurs when dust, which has been allowed to settle and accumulate on floors or other surfaces, is made airborne by the pressure wave of primary explosion and subsequently ignited by the slower moving flame front. Depending on the extent of the dust deposits, a weak primary explosion may cause very powerful and catastrophic secondary dust explosions.

Dust explosibility hazard metrics are determined experimentally. A frequent categorization is based on the dust deflagration index K_{st}, which represents the measured maximum rate of pressure rise in a standardized vessel; in other words the 'dust explosion violence' [4]. Other commonly measured hazard metrics are shown in Table 1.

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