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SPONTANEOUS HEATING AND IGNITION IN HEAPS OF SAWDUST

by

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Summary

This note reviews available information on spontaneous heating and ignition in heaps of sawdust and wood waste. Some possible ways are considered of reducing the likelihood that heating in large heaps will proceed to ignition.

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Introduction

The Joint Fire Research Organization occasionally receives enquiries on the occurrence of spontaneous heating and ignition in heaps of sawdust and wood waste. This note reviews available information on the subject and considers some possible ways of reducing the likelihood that heating in large heaps will proceed to ignition.

The note is concerned more with relatively green sawdust and wood waste, than with sawdust from seasoned wood.

Review

Spontaneous heating and ignition in sawdust and similar wood waste appear to have been studied only in the United States and Sweden where large quantities of wood waste are stored for use as fuel.

Describing experience in Oregon, United States of America, Boals (1) states that fresh green sawdust and hog fuel* begin to heat as soon as they are piled. "In small piles the temperatures rarely if ever approach a danger point, but where hundreds or thousands of 200-cubic-foot units are stored outdoors hot spots appear and fires are common". Of the examples given by Boals, the smallest heap in which ignition occurred was an experimental one (1, 2) consisting of 130 units of Douglas fir hog fuel and 90 units of the sawdust piled side-by-side in the open to a height of 25 ft; the ignition occurred after about nine months. Temperatures observed at a series of points in the hog fuel section reached maxima of 130-185°F (55-85°C) in 30-45 days, and then decreased to between 120 and 150°F until shortly before the outbreak of fire about 7½ months later. In the sawdust section the rate of heating was less than in the hog fuel and temperatures rose to maxima of 145-180°F (63-82°C) in 120-160 days. Fire first occurred in the hog fuel section at a point remote from the points at which temperature observations were made; it is not clear whether or not the fire was confined to this section.

Three separate examples of spontaneous ignition occurred in heaps of sawdust and sawmill waste, cut to short lengths, at Swedish pulp mills in 1928. Describing these incidents Bergstromm (3) states that spontaneous ignition rarely occurs in wood fuel heaps, and he attributes the incidents to the abnormally large size of the heaps concerned (about 25,000 units) and to the fact that the weather at the time was unusually warm and rainy. He suggests that in a tropical, damp, climate spontaneous ignition would be frequent and would occur in smaller heaps.

Studies of the temperature rise in green sawdust have been reported by Jenkins and Guernsey (4). The quantities of sawdust varied from 4 to 8 units, stored in bins, to 750 units in open storage. The highest temperatures observed were 152-164°F in the largest heap, at 16 ft from the surface in a section of the heap that was 4-6 months old.

Available evidence (1, 3, 5) indicates that the spontaneous heating and ignition of sawdust is due to oxidation. Biological agencies play a large part in the early stages of the oxidation and their activity is promoted by the presence of moisture. However, the maximum temperature at which the organisms responsible for the biological oxidation can function is about 167°F (75°C). Heating from this temperature up to

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* Hog fuel is wood waste that has been reduced to small chips in a hogging machine for use as fuel.

ignition must be due to non-living, i.e. chemical, oxidation. Green sawdust oxidizes more rapidly than sawdust from seasoned timber [5] and, hence, is more likely to undergo spontaneous heating and ignition.

In general the maximum temperature attainable in a heap of sawdust will depend on the balance between the rate of heat production due to oxidation and the rate of heat loss. This heat balance will in turn depend mainly on the size of the heap, the degree of ventilation existing in it, and on the external atmospheric temperature. Since the organisms responsible for the biological oxidation can either die or multiply and, in effect, adjust the heat balance in their own favour, it may be expected that the biological oxidation will tend to produce a fiarly constant maximum temperature for a wide variety of conditions; but the possibility of heating to ignition, due to the non-living oxidation, may be expected to depend rather critically on the size of the heap and on the ventilation.

The ventilation in a heap of sawdust will depend on the coarseness of the sawdust, on the density at which it is packed, and on the proportion and distribution of coarser material, such as off-cuts, present. The fact that fires have not been reported in heaps consisting entirely of fine sawdust, but only in sawdust mixed with hog fuel or with coarse sawmill waste, may mean merely that such heaps are not built to any extent. It is, however, possible that the ventilation in a heap consisting entirely of sawdust may be inadequate for spontaneous heating to ignition. For the purposes of this note it will be assumed that sawdust heaps always contain an appreciable proportion of coarser material and that, in general, ventilation is adequate for ignition.

It is not possible to say what temperature should be regarded as the danger signal for ignition in a heap of sawdust that is undergoing spontaneous heating. Boals [1] reports that temperatures of up to 135°F (57°C) have been observed consistently in an indoor store of sawdust and hog fuel, over a period of more than three years, with no sign of a fire developing elsewhere in the store. Temperatures of this order may therefore perhaps be regarded as harmless. But the behaviour of the experimental heap (above) indicates that temperatures of about 180°F (82°C) are likely to be followed eventually by ignition, even though such temperatures are followed by a decrease for a time.

So far as is known spontaneous ignition is unlikely to occur in sawdust heaps that do not exceed about 150 units (30,000 ft^3) in volume. By analogy with the bahaviour of coal (in which spontaneous ignition is due to oxidation), the most important single dimension affecting the tendency of a heap to heat to ignition is likely to be the height of the heap. If the height is kept below a certain limit the area covered by the heap can be increased almost indefinitely without risk. Unfortunately the limiting height for sawdust is not known; but all the fires due to spontaneous ignition, of which accounts have been published, occurred in heaps exceeding 20 ft. in height.

When ignition occurs in a heap of sawdust and wood waste combustion consists mainly of carbonization with loss of volatiles and without appreciable change of volume. The combustion tends to spread through the heap along tracks of fairly small cross-section, and in directions that are to some extent dictated by local variations in the density at which the sawdust and wood waste have been packed. In places where the air supply is favourable combustion proceeds to ash and cavities are formed which may ultimately collapse [1, 3].

Finally it must be pointed out that sawdust, at least when reasonably dry, is easily ignited by a small source such as a cigarette end. Studies of smouldering carried out at the Joint Fire Research Organization [6] indicate that once a heap of sawdust is ignited it may be expected to continue to smoulder until it is consumed. A heap ignited in the interior will smoulder for a considerable period, possibly for some weeks, before there is clear evidence that the heap

is on fire. The combustion may be expected to follow a course similar to that described above. In general, therefore, there is likely to be some difficulty in deciding whether a fire in a sawdust heap is due to spontaneous ignition or to accidental ignition during construction of the heap, unless the early stages of the spontaneous heating have been followed.

Methods of reducing the risk of spontaneous ignition

From the above review it is clear that no precise recommendations can be made for the prevention of spontaneous ignition in large sawdust heaps. The best guide to the risk of spontaneous ignition, and the need for counter measures, attached to piling a given type of sawdust in a given locality is a study of existing heaps in that locality.

If sawdust is being piled for the first time in a given locality, or if it is desired to build heaps larger than hitherto, it is suggested that the height should be restricted at first to, say, 15 feet and a careful watch should be kept on the behaviour of the first 50,000 ft^3 or so. For this purpose temperatures should be determined by a method such as inserting thermometers into iron pipes driven into the heap at intervals over the surface and to varying depths; this procedure is used for coal piles and details will be found in references 7 and 8. Temperatures should be recorded until it is quite clear that the stack is cooling down. It is recommended that the nearer the maximum temperature at any point approaches 180°F the longer should be the time for which the cooling is followed. It may be necessary to follow the temperature of the heap for as long as a year, perhaps more, but meanwhile the heap can be extended in area. If it eventually becomes clear that a height of 15 feet is safe, the height of piling may be increased to, say, 20 feet and a further watch kept.

It may be possible to reduce the risk of ignition in a large sawdust heap by adopting certain of the measures that have been found successful for the control of heating in large coal heaps and colliery waste tips. These measures are aimed at reducing the air supply to the interior of the heap, i.e. the ventilation, as far as possible.

Assuming such measures are both practicable and economic for sawdust, the heap should be built up in a series of shallow layers of large area and each layer should be compacted by means of a road roller or tracked bulldozer. If coarse sawmill waste is included in the heap it should be well mixed with the sawdust and should not be distributed in layers through which air would gain easy access.

The general plan should be the formation of a heap with a flattened top and gently sloping sides. It is not possible to prescribe a definite limit to the height of the heap but it could probably be higher than a heap that has not been compacted. It is probable, however, that the height to which a compacted heap can be built will be severely limited by considerations of safety in operating the roller or bulldozer, since it may not be possible to make the heap very firm.

Great care must be taken to avoid ignition of the sawdust by sparks, hot ashes, cigarette ends etc. both during construction of the heap and afterwards. If the sawdust is dry and easily raised as a dust cloud it may be impossible to prevent deposits forming, and becoming ignited, on engine exhausts etc.; in which case mechanical compacting will be ruled out.

A layer of earth over a completed heap would doubtless reduce the ventilation, provided the earth were fine, well compacted, and maintained intact. If the earth layer were not compacted its porosity might well be of the same order as, or even greater than, that of the sawdust itself and the reduction in ventilation would be negligible. An earth layer will, however, help to protect the heap from accidental ignition.

Although a heap of sawdust will rot down over a period of years it may be expected to remain combustible and, therefore, a fire hazard practically indefinitely.

American experience (1) indicates that, when fire breaks out in a heap of sawdust and wood waste, the injection of steam is more effective than water for controlling the fire. Digging out appears to be the only means of ensuring complete extinction.

It is suggested that, if no manufacturing use can be made of it, sawdust and other sawmill waste should preferably be burnt as it is produced, either as furnace fuel or in incinerators. If no furnaces or incinerators capable of burning sawdust are available it will still be an advantage to burn the large size sawmill waste rather than include it in the sawdust heap.

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