Environmental and health hazards in spinning industry and their control

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Various aspects of environmental and health hazards in cotton spinning industries have been discussed and the measures to reduce the risk of health hazards, to a great extent, in cotton textile mills are suggested.

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1 Introduction

Cotton textile production normally takes place in several steps, beginning with ginning and ending with finishing. Each step has health and safety risks which are distinct and unique to that step. Depending on the amount of environmental pollution generated by an industry, the Govt. of India has classified the industries into three categories, viz. red, orange and green. Industries under red category are identified as the most heavily polluting followed by those in orange category and green category respectively. According to this classification, cotton spinning and weaving industries fall in the orange category which means these industries are prone to produce environmental pollution at an alarming level.

Although textile industry is an old and traditional one, not much attention was paid to the environmental hazards produced by this industry. However, with the increasing awareness towards environmental issues and labour welfare, a good amount of seriousness has been aroused and attention is being paid to this issue by employers, machinery manufacturers and technologists. Legal and statutory measures have also been enforced to control the hazards. As far as spinning mill is concerned, the hazards are confined mainly at the work place, i.e. inside the mill, and not much outdoor pollution is generated by the spinning. The environmental and health hazards at the work place in a spinning mill can be classified in two main categories, namely environmental hazards and physical hazards.

Cotton dust and noise are the two main environmental hazards which cause health risk in a spinning mill. Out of these two, the cotton dust and fly, released in the spinning room environment, contribute maximum to the health hazards of the workers.

The physical hazards are mainly the chances of accidents, involving physical damage to the workers, and process hazards such as fire. With proper precaution, process design, training of labours and safety gadgets, the physical hazards can be minimized or almost eliminated. However, the cotton dust is a continual and persistent problem. Researchers and machinery manufacturers have succeeded in reducing the intensity of the problem to a great extent and hence today's spinning room environment is much a safer work place. However, constant attention towards maintenance and upkeep of machines, proper work procedures and worker training are required to keep the level of this problem under control. The various aspects of environmental and health hazards in spinning industry have been discussed in this paper.

2 Dust Problem in Cotton Spinning

Cotton dust in the work place is a major problem in cotton textile industry. This problem is more severe in spinning section. Dust consists of small and microscopic particles of various substances which are present as suspended particles in air and sink slowly so that they can be transported in air over substantial distances. In accordance with a classification system established by the International Committee for Cotton Testing Methods, the particles present in the cotton dust can be distinguished on the bases of particle size, such as: trash (> 500 μm), dust (50-500 μm), micro-dust (15-50 μm) and fine dust or breathable dust (< 15 μm).

Dust in cotton spinning mills is a mixture of technical dust (bits of fibre and fragments from the
fibre surface) and organic and inorganic natural dust. The micro and fine dust comprises 50-80% of fibre fragments, leaf and husk fragments, 10-25% sand and 10-25% water-soluble materials. The high proportion of fibre fragments indicates that a large part of the micro and fine dust arises during the course of processing. It has been observed that 40% of the micro and fine dust is free between the fibres and flocks, 20-30% is loosely bound and the remaining 20-30% is firmly bound to the fibres. The dust mixture is set free by processing. The principal factors giving rise to it are the working cycle, machine inventory adopted and the room air conditions. Organic components originate typically from leaves, stalk or seed bolls of the cotton plant. Inorganic natural dust of mineral origin is swirled up by sand storms or during harvesting and adhere to the fibres. The amount of natural dust accompanying the raw cotton bought into the mill depends mainly on the (a) cultivation region, (b) fibre maturity, and (c) method of harvesting. Dust particles have a low velocity of fall. They can, therefore, remain over longer periods in the air borne state and be transported over considerable distance, depending on the air movement. According to Leifeld1, the problems created by the dust can be listed as given below:

- Additional stress on personnel
  - dust is unpleasant, e.g. for eyes and nose.
  - it can induce allergies.
  - it can induce respiratory disease (Byssinosis).
- Environmental problems
  - dust deposits.
  - dust accumulations which can fall into the machines.
  - loading of the air conditioning equipment.
- Effect on product
  - quality deterioration directly or indirectly through machine faults.
- Stressing of the machines
  - dust accumulations lead to operational disturbances.
  - jamming and running out of true.
  - increased yarn unevenness.
  - rapid wear of machine components (e.g. rotors).

In conventional spinning mills, the areas like mixing room, blowroom, carding and combing departments are usually full of dust and dirt in the working environment. The cotton dust in these areas of conventional mills varies between 40 mg/m³ and 50 mg/m³ of air. The cotton dust is also present in other departments but the concentration varies between 1 mg/m³ and 8 mg/m³.

2.1 Health Aspects

2.1.1 Occupational Disease

Byssinosis is recognized today as an occupational disease in cotton spinning. It is characterized by shortness of breath, cough and chest tightness on the first day a worker returns to work after time off (the Monday morning syndrome)2.

Byssinosis is a progressive respiratory disorder due to long exposure to cotton dust. The onset is slow but it progresses to incapacitate completely in due course. Mainly, the workers in carding, spinning, weaving and winding departments are more affected from this disease. Due to progressive incapacitative nature, byssinosis has drawn the attention of occupational health scientists all over the world and many studies have been conducted so far. The incidence of byssinosis was found to be very low in India as compared to other countries3. It was observed that in certain countries having cold and damp climatic conditions, the incidence of byssinosis was more. Out of all the departments of a conventional textile mill, the preparatory room contributes maximum cases of byssinosis, followed by spinning and winding departments. The maximum numbers of cases were recorded for the age group of 51-60 years. The disease was observed to be related to the length of service and the intensity of dust at the work place. The development and severity of this disease directly depend on the technological situation at the particular work place. Most of the data available is on investigations made between 1960s and early 70s. Enormous technical improvements have taken place since then. Today, the byssinosis is very much on decline and the cases reported are less frequent than those reported for other industrial diseases.

It has been observed that prolonged byssinosis in an irreversible third stage leads to a chronic lung disease. A study by CINKOTAI in 10 spinning mills revealed a correlation with the frequency of byssinosis only for smaller fractions of dust (1-2 μm and 2-4 μm). This agrees well with the deposition of the dust in the lung, which is maximum in this range. There is a very good correlation between the mean diameter of dust and the byssinosis frequency. It is clearly evident that the finer dust causes more byssinosis.
2.1.2 Breathability of Dust

The part of the dust which tends to be retained in lungs (breathable dust) is dangerous to health\textsuperscript{1}. The deposits in lungs are related to the particle size, and it is observed that for dust particles of <4 μm, the deposition is maximum.

2.1.3 Trash in Cotton and Cotton Dust

There is a significant correlation between the trash content in cotton and the airborne dust generated by mechanical processing in spinning. The airborne dust content increases with the increase in trash content of raw cotton. However, the ratio of dust to trash content decreases with the increase in trash content and approaches a constant value at the higher trash levels.

2.1.4 Total and Fine Dust

On the analysis of the room air conditions at work place for medical reasons, a distinction is made between total dust and fine dust (defined as breathable dust and fraction entering the lung). The total dust contains many fibre constituents which are not primarily responsible for the health hazard. The fine dust suspended in the room air is not discernible in its details to the naked eye. Only in higher concentrations, it becomes visible as mist. This fine breathable dust is most dangerous.

2.1.5 Humidification and Health Hazard

Additional humidification is unavoidable for any modern spinning plant. The humidification plants help in making the work place more comfortable due to the air changes they bring about. However, these humidification plants cause health hazards\textsuperscript{3}.

In spinning plants, mainly air washers and water sprays are used for humidifying the air. The air normally is passed through a duct system in the production hall, and then filtered, heated, cooled and humidified in a central unit. Considering the structure of such a humidification plant, the following risks are involved: (a) when air is taken from outside, there is a fundamental danger of contamination, and (b) the next source of health hazards is the actual air humidifier in the form of a sprayer or an air washer. The bacteria and other micro-organisms find very favourable growth conditions in the humidifier water, in the condensate on moist surfaces, and above all, in the bio-film often found. The spraying operation can lead to the formation of particles containing bacteria and legionellae. The aerosol particles formed in this way, very often, have the ideal diameter of 1-5 μm for entering in to the lung. It is known that these germs are widely spread in nature, particularly in water, and can survive at 6°-50°C. The ideal range of temperature for multiplication of bacteria and germs is 20°-45°C. However, above 50°C, they decrease and finally die at > 60°C. Depending upon the filter class used and the duration when filters are changed, very fine dust particles enter the air washer or sprayer with the air and thus form an ideal nutrient medium for bacteria and germs. Peter Iselt investigated that the germs and bacteria divide after every 20-30 min, precisely at water temperature of > 20°C, and in this way lead to a considerable health risk because of the disproportionate increase in the germ counts. The germ concentrations as high as 1.5-10 million germs/m\textsuperscript{3} of water have been observed. Maximum germ count limits of 10,000 have been specified as safe where people can work without any health risk. There are examples of people who have suffered long-term damage due to high germ counts in air washers.

To avoid such incidences, air washer and sprayers must be cleaned and disinfected very frequently. Use of jet humidifier, which is directly connected to the mains and does not require water reservoir, reduces this type of problem to a great extent.

2.1.6 Legislation on Air Hygiene at the Work Place

To reduce the risk of health hazard to employees in cotton textiles, it was necessary to lay down guidelines by law. The first guidelines were laid down in Britain in Factory Act of 1937 and became law in 1942. In 1964, American Conference of Governmental Industrial Hygienists included cotton dust in its list of substances harmful to health. In 1968, in the USA an upper admissible limit for dust in the work place environment was set as 1 mg/m\textsuperscript{3}. In 1973, the British Occupational Hygienic Society recommended an air having a dust concentration of 0.5 mg/m\textsuperscript{3} as dust free.

On 23rd June 1978, the Occupational Safety and Health Administration (OSHA) published a new law, which was enforced from 4th September 1982, stating the upper limit for dust in cotton industry environment as 0.2 mg/m\textsuperscript{3}. The term cotton dust covers, among other things, the vegetable matter, fibres, bacteria, fungi, pesticides, non-fibrous matter and other impurities picked up during harvesting and at subsequent processes and storage. The OSHA regulations are today followed all over the world.
2.2 Actions by Employers

To fulfil the stringent statutory obligation, the employers must take following actions:

- To maintain the dust at admissible level, appropriate production processes and working regulations must be introduced. The air conditioning system must be modified accordingly.
- Wherever it is difficult to maintain the required conditions, the persons involved must wear respirators and masks.
- Cleaning of machines by blowing compressed air must be avoided. Wherever it is not possible to avoid this, respirators must be given to employees.
- Cleaning of floor must be done with vacuum cleaners.
- Regular medical inspection of every employee must be done.
- Every employer must lay down in writing the methods used to ensure lowest possible dust levels in different parts of the work levels.
- Maintain proper humidity in each of spinning sections.
- Dust suppressing lubricants, which have also been found beneficial, should be used.

In many advanced countries, great attention is paid to this problem by both employers and government. However, in countries like India, this aspect of human safety is not been taken very seriously so far.

2.3 Action by Machinery Manufacturers

Research work done by many organizations lead to a clear cut conclusion that there is a linear relationship between dust concentration and personal sickness. It was observed that in spinning preparatory, dust concentrations of 0.1, 0.2 and 0.5 mg/m$^3$ give rise to 7%, 13% and 26% byssinosis cases respectively. Carding is found to associate with highest dust concentration levels. Machinery manufacturers have been working to find out the solutions for the problem of dust for quite a long time. There are following two routes open to them: (i) completely enclosing the machines to facilitate thorough cleaning of fibres being processed and segregation of the cotton being processed from the work place environment and employing special machines for deducting the cotton before it goes to carding and subsequent processes, and (ii) equip the air conditioning system with appropriate equipment to extract fibres and dust from the return air.

For the first approach, a number of variations are offered. There are two consequences on new machines: (i) intensive suctioning of machine chambers in which the tufts swirl up, and (ii) loose transport of the fibre tufts onto the cages, where the formation of dense fibre mat is strictly avoided – a contrast to the older concept.

Dedusting begins at the automatic bale openers or the blending hopper openers and continues up to carding and draw frame. Extensive suction points of the new cards help tremendously to reduce the dust levels with their air flow, vacuums and suction surfaces. In existing plants, a conversion, a redimensioning of the card suction system and replacement of the condensers, is often sufficient to secure a very good result with modest investments.

Modern draw frames are increasingly being designed so that the dust is extracted at the point of its generation, i.e. during drafting.

For the second approach, a number of specialist firms in industrial ventilation and dedusting offer many products and systems ranging up to the most sophisticated concepts. If the return air is filtered and cleaned thoroughly, dust afterwards is a relatively minor problem. However, as the quality composition and size of dust released by different departments vary, the air conditioning systems need to be designed optimally for each department.

On conventional machines, the waste taken out by machine, e.g. flat strips and droppings, is removed manually. During this manual operation, a good amount of dust is released to the atmosphere. Modern machinery manufacturers provide for automatic waste removal and cleaning and compacting the waste. This technique has also helped in reducing the dust release to the atmosphere.

Travelling cleaners employed at speed frames, ring frames and automatic winding systems also help in removing fibre fly and dust from the machine parts and air.

3 Noise

Noise is another environmental pollutant generated in an industry and the spinning industry is no exception to this. The workers, exposed to industrial noise of potentially damaging quality and intensity, suffer from impairment of hearing capacity of several degrees and other physiological disorders or stresses apart from adversely affecting their job performance.
Prolonged exposure to a noise level of > 90 dB may cause hearing disorders. Studies conducted in various Bombay mills showed that the noise level in spinning department has been around 96.5 dBA which is quite high. Maximum permissible noise levels for 8 h exposure is fixed at 90 dBA. Precautions are required to be taken in a spinning mill to control the noise below the prescribed level. Noise can be controlled in following ways:

- Noise control by location — Noisy machines can be segregated (e.g. compressors) and machines having equal level of noise can be clubbed together.
- Noise reduction by layout — segregation of areas or dividing areas by thick walls, avoiding permanent openings, etc.
- Proper maintenance.
- Using sound absorbers or silencers.
- Design of machinery and equipments — The machinery manufacturers have been constantly working on reducing the noise levels generated by their machines. Incorporation of individual spindle drive in place of belt drive, use of improved bearings, reduction in vibrating parts, elimination of cams, use of electronic controls in place of mechanical controls and damping the noise wherever possible are some of the examples of efforts to reduce noise in modern spinning machines.

4 Physical Hazards

There are following two types of physical hazards for workers in a spinning mill:

4.1 Accidents

Accidents in the conventional spinning mills used to be a regular feature in past. Right from opening of bales, during material handling and operation of the machines, the workers were exposed to the risk of accidents. However, with the advent of modern machines, modern material handling systems, modern equipments and tools, the incidences of accidents have been reduced. Particularly, the dangerous machines have all parts properly encased. They have been also fitted with necessary fastening and bolts on doors or covers. Appropriate safety stop motions have also been provided. Automation in transportation of the material has also helped in reducing the accidents. Pneumatic material transport in blow room and cards, automatic transport of cans, speed frame packages, ring cops and cones, automatic package monitoring, palletting and packing have been also introduced.

4.2 Fire

Cotton is an inflammable material and hence prone to fire. It is prone to fire more in blow room and cards. Any spark generated at these places can not only generate the fire but also the same can propagate to other machines through cotton conveying system. Many modern equipments are available, such as smoke detectors and CO₂ flooding, to prevent the spreading of fire in spinning.

References