Noise pollution and its control in textile industry

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High noise level causes psychological effects and physical damage, including irritability, loss of concentration, anxiety and increased pulse rate. A one minute exposure to a sound level over 100dBA can cause permanent hearing loss. The studies show that a large number of textile workers, especially weavers, suffer from occupational hearing loss. The machinery manufacturers made considerable efforts in keeping the noise emission as low as possible while improving the speed of their machines, but the measures are not adequate to protect the textile workers from occupational hearing loss.

Keywords: A-weighted scale, Active noise control, Air-jet weaving machine, Projectile weaving machine, Rapier weaving machine, Water-jet weaving machine

1 Introduction

Noise is an unwanted sound that interferes with the function in a given space. It is subjective because what is disturbing and unacceptable to one may be acceptable to another. It is difficult to give a very clear definition of an irritating noise. Generally, noise is a disturbing sound, regardless of its intensity or duration.

In recent years, even a developing country like India has taken positive steps against excessive noise. Like air and water pollution, noise pollution has been accepted as a major threat to human beings. Much discussion and legislation have been evolved in an attempt to recognize and combat the problem of noise pollution. It has been recognized that noise of sufficient intensity can damage hearing.

The problem of noise pollution can be combated when there are means of measuring noise levels and a system of classification. The decibel is a dimensionless number, which relates sound intensity or sound pressure levels to some reference point. When most people use the term decibel or discuss noise levels in decibels, they refer to decibels as related to the A-weighted scale (dBA). The A-weighted scale parallels the sensitivity of the human ear and uses the lowest audible sound that the human ear can detect as the reference point for determining the decibel level of a noise. The human ear is able to hear 1 - 130 decibels.

Any noise rating above 80 dBA produces physiological effects and any long exposure at above 90-100 decibels will produce permanent damage to a person's hearing. An increase of 10 dBA is a doubling of loudness with respect to the human ear.

Noise generally consists of many tones with varying rates of vibration or frequency. The frequency, expressed in cycles per sound and referred to as cps or Hertz (Hz), is usually in the range of 20 - 20,000 cycles per second. The ear is not very responsive to very low or very high tones as it is selective to the tones of medium frequency. As mentioned earlier, the dBA scale matches the response of the ear and is, therefore, well suited for evaluating noise as it relates to human beings.

This paper highlights the noise in the textile industry, its effects on the workers and the measures taken by machine manufacturers to reduce the noise emission.

2 Noise in Textile Industry

Ahmedabad Textile Industry's Research Association (ATIRA) conducted noise pollution surveys in the Indian textile mills over a period of 15 years. The results (Table 1) indicate that the noise level in spinning department is between 80 dBA and 90 dBA, of which the lowest is in blow room and the highest in ring spinning. Noise level in weaving preparatory is low. Excessive noise level of 94 - 99 dBA is in loom shed, depending upon the design, type, erection and number of looms used, condition of machines, fabric structure, building type, building size, etc.

Talukdar evaluated quantitatively the noise level of conventional automatic looms and observed that the noise during weaving is mostly impulsive and...
Table 1 — Noise level in different departments of a textile mill

<table>
<thead>
<tr>
<th>Section</th>
<th>Noise level, dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blow room</td>
<td>80 - 83</td>
</tr>
<tr>
<td>Carding</td>
<td>84 - 89</td>
</tr>
<tr>
<td>Draw frames</td>
<td>84 - 88</td>
</tr>
<tr>
<td>Inter frames</td>
<td>82 - 86</td>
</tr>
<tr>
<td>Ring frames</td>
<td>86 - 90</td>
</tr>
<tr>
<td>Winding</td>
<td>82 - 86</td>
</tr>
<tr>
<td>Warping</td>
<td>80 - 86</td>
</tr>
<tr>
<td>Sizing</td>
<td>73 - 86</td>
</tr>
<tr>
<td>Loom shed (Non-auto)</td>
<td>94 - 99</td>
</tr>
<tr>
<td>Loom shed (Auto)</td>
<td>95 - 97</td>
</tr>
</tbody>
</table>

Table 2 — Damage risk criteria

<table>
<thead>
<tr>
<th>Equivalent control sound level, dBA</th>
<th>Risk percentage⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>10⁰</td>
<td>20⁰</td>
</tr>
<tr>
<td>85</td>
<td>3</td>
</tr>
<tr>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>95</td>
<td>17</td>
</tr>
<tr>
<td>100</td>
<td>29</td>
</tr>
</tbody>
</table>

³A 40-hour week with 50 weeks per year
⁴Years of exposure = Age – 18 years

periodic in character. When the loom is run with a shuttle, noise level increases by about 1.5 – 2.0 dBA. The maximum noise level is observed at the front of the machine because of the movement of sley, which causes air turbulence. As the loom speed increases, the noise level also increases significantly due to the higher impact forces acting on the different parts of a loom. Spectrum analysis shows that the peak noise level occurs at the frequencies between 1.4 kHz and 5.0 kHz and is mainly due to the impact between different parts of the picking and checking mechanisms.

Of the shuttleless weaving machines, noise level of water-jet weaving machine is the lowest (85 dBA) followed by that of air-jet and rapier weaving machines (91 dBA) and projectile weaving machine (92 dBA).

3 Effect of Noise on Human Beings

The effect of noise on human health has been a subject of research for some time. Nevertheless, in India, no systematic study has been conducted so far. Damage risk criteria³ of workers exposed to sound level of ≥ 85 dBA at the frequencies 500, 1000 and 1500 Hz are given in Table 2.

Balachew and Berhane⁴ carried out a detailed study in a textile factory of Ethiopia during October-December 1994. They found the prevalence of, and risk factors for, noise-induced hearing loss (NIHL) in the textile mill. A sample of 630 from 5900 workers was selected from the factory rosters by means of systematic sampling technique. Data were collected through interview, otology examination and pure tone audiogram measurement. Environmental noise survey and personal dosimeter data were also collected to determine noise exposure levels at every section of the mill. The highest noise level in area samples was observed in the weaving section (99.5±3.2 dBA). History of hearing loss was reported by 51 (8.1%) participants, while 57 (9.0%) reported a history of ear-related diseases. More than one third (34.3%) complained of current ear problems, and 186 (29.5%) complained of ear pain. On physical examination, 154 (24.4%) were found to have detectable ear problems, of which 66 (42.9%) had otitis, while the remainder had ceremonious occlusion of the auditory canal. There was no significant difference by gender in the prevalence of detectable ear problems.

Audiometric tests, carried out at a frequency of 4000 Hz, revealed a 34% overall prevalence of NIHL (hearing threshold level exceeding 25 dBA) with the highest prevalence of 71.1% observed among the weavers. Preventive measures were generally absent, with no employee reporting use of personal protective devices (PPDs). Textile factories⁵ are among the many occupational settings that pose the risk of noise-induced hearing loss.

Apart from damage to hearing, there is evidence that noise also affects the people in the following other ways:

- Reduced performance, e.g. reduced ability to concentrate.
- Disturbance of sleep.
- Annoyance (oral communication is difficult or impossible), which manifests itself primarily in emotional responses.
- Excitement (activation) of the central and vegetative nervous system, e.g. increased blood pressure, higher heart frequency, and effect on metabolism.

4 Methods of Reducing Noise and Vibration

In approaching the possibilities of reducing noise and vibration, a fundamental distinction must be drawn between the active and passive measures. Active measures are all primary measures, which prevent noise and vibration to occur in the first place. Passive measures are all secondary actions aimed at reducing the radiation of existing noise and vibration.
4.1 Active Measures

Despite the enormous increase in speed of the textile machines, the machinery manufacturers have succeeded in keeping the noise level reasonably low. For example, the speed of the projectile weaving machines has gone up from 550 m/min to 1500 m/min during the last two decades, but the sound level of the machine on the emission side (effect on human beings) reduced from 92 dBA to 86 dBA (ref. 6).

Some of the active measures taken by the textile machine manufacturers, especially weaving, to control noise and vibration are briefly discussed below:

4.1.1 Reducing Inertia Forces

Inertia forces that are produced in a machine are responsible for noise and vibration. If noise and vibration are to be reduced, this presupposes a reduction in the inertia forces. Reducing the mass and/or reducing the acceleration can achieve this. With this in mind, the textile machinery manufacturers have repeatedly optimized the most important components of the textile machinery, especially in weaving and, therefore, there is very little scope to reduce the mass further. However, the reduction in mass can also be achieved through substitution with another material like carbon. Some progress has been made in this direction. Since the introduction of new material usually means redesigning of entire section of the system, the modifications of this kind are generally not transferable to older machines. They are, therefore, restricted to newer generation machines. The simplest method of reducing acceleration is to reduce the rotational speed and/or to increase the distance, but both are not feasible for well-known reasons.

A reduction of 10% in speed of a weaving machine, for example, would give a noise reduction of 2 dBA. Another possibility of reducing noise is the optimum design of the sequence of motion at a given speed and a given stroke. Today, cam gears are replaced by crank gears since the former give acoustic and vibration problems which arise from the choice of long standstill times and discontinuous transmission functions, while the latter give harmonious transmission functions, resulting in a steep drop in the excitation spectrum of forces to give acoustically problem free machine.

General machine components (toothed gears, motor, fans, etc.) are also a major source of noise on all machines. Noise control is extremely important, for example, in toothed gears. Faulty gear teeth cause uneven transmission and bumpy loading of the teeth. Mass balancing is another way of reducing noise. Effect of noise reduction measures of individual functional groups in the projectile weaving machine is shown in Fig. 1.

4.1.2 Active Noise Control

Active noise control (ANC) is the state-of-the-art technique which is most successfully demonstrated for controlling noise in enclosed spaces such as ducts, vehicle cabins, exhaust pipes and headphones. However, the most demonstrations have not yet made the transition into successful commercial products, probably due to the high capital cost. In 1998, Vigone undertook a project to use active noise control technique on weaving machines. Initial laboratory study indicated that newly designed active noise control is able to work in reverberant field as the looms’ hall. The basic principle of ANC technique is outlined as follows:

ANC is sound field modifications, particularly sound field cancellation, by electro-acoustical means. In simplest form, a control system drives a speaker to produce a sound field that is an exact mirror image of the offending sound (disturbance). The speaker thus cancels the disturbance and the net result is no sound at all. In practice, of course, active control is somewhat more complicated. The idea of active noise control was actually conceived in the 1930’s and more developments were done in the 1950’s. However, it was not until the advent of modern digital computers that active control became truly practical. ANC works best when the wavelength is long compared to the dimensions of its surroundings, i.e. low frequencies.

The four major parts of an active control system are:
- The plant is the physical system to be controlled;
typical examples are a headphone and the air inside it and the air traveling through an air-conditioning duct.

- Sensors are the microphones, accelerometers or other devices that sense the disturbance and monitor how well the control system is performing.
- Actuators are the devices that physically do the work of altering the plant response; usually they are electromechanical devices such as speakers or vibration generators.
- The controller is a signal processor (usually digital) that tells the actuators what to do; the controller bases its commands on sensor signals and, usually, on some knowledge of how the plant responds to the actuators.

4.2 Passive Measures

These measures should be looked at keeping following three basic solutions in mind:
- Blocking airborne sound.
- Absorption of airborne sound.
- Vibration damping.

For most applications, a solution will consist of one to all of these categories.

4.2.1 Blocking Airborne Sound

Individual ear protectors are by far the most effective and cheapest means of reducing airborne noise emissions. They are available virtually everywhere in any forms. However, they must be worn and, therefore, require the exercise of a minimum of discipline.

Normally, all machines including textiles have enclosures. The enclosure is basically made up of a metal or plastic sheet and its primary function is for cosmetic purposes or as a safety feature to protect the work force from a possible hazard. Whatever the case may be, it is convenient when an enclosure, of any sort, can be utilized for noise abatement.

At frequencies from 250 Hz to 750 Hz, a barrier can be extremely effective if a complete enclosure exists. The major stumbling block associated with barrier materials is that they are best utilized with complete enclosures. A small amount of open area, even 1%, will significantly reduce the barrier's performance. In general, a complete enclosure gives substantial noise reduction, but the method has considerable drawbacks in respect of space requirements, monitoring, accessibility, operation and maintenance, material flow, cleaning and cost. Partial enclosure has rather fewer disadvantages as regards space requirements, monitoring and accessibility. However, the effect achieved is much less compared to that achieved with a total enclosure.

When the absorber is coupled with a barrier, significant reduction can be realized. The acoustical energy, which is not dissipated by the absorber, is reflected, in part, by the barrier and is again dissipated by the absorber. The total energy within the enclosure is reduced, which minimizes the problem of acoustical energy that escapes out of the open area of partial enclosures.

4.2.2 Absorption of Airborne Sound

If the major noise problem lies in the medium frequency range (500 Hz - 4,000 Hz), the acoustical absorption can be a good starting point.

By lining the interior walls of the enclosure with an absorber, a significant amount of the acoustical energy incident on the walls can be absorbed and dissipated. Particulars of a typical acoustic absorbent fabric are given in Table 3. This fabric utilizes controlled permeability to optimize the absorption characteristics. Another advantage of membrane is the impervious film facings available that prevent absorption of dirt, oil, grease and moisture, which will degrade the sound attenuating properties and shorten the life of the foam. Since the most industrial applications have somewhat of an adverse environment, a film facing is a necessity.

As sound waves, which are pressure waves traveling in air, pass through a porous open cell of membranes, the movement of the air molecules through the openings across the strands and membranes generates heat through friction which takes energy away from the sound wave. The most significant attribute affecting an absorber's acoustical performance is the permeability performance of the product.

Rakshit et al. studied the noise absorption of 300 gsm needle-punched nonwoven fabrics using a number of blend compositions of wool and polypropylene. They concluded that wool waste/polypropylene blend could be used effectively for noise reduction. Sound absorbing covers as well as machine and accessory components made of special materials or with special coatings may be used in modern spinning and weaving machines. These along with other measures can reduce the sound power level of these machines. For example, the sound level of projectile weaving machines at maximum rotational speed is reduced from 105 dBA to 102 dBA. This corresponds on the emission side (effect on human beings) to a reduction of the sound pressure level...
Table 3—Properties of acoustical membrane fabrics

<table>
<thead>
<tr>
<th>Property</th>
<th>Fabric I</th>
<th>Fabric II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coated fabric weight, gsm</td>
<td>475 (nominal)</td>
<td>290 (nominal)</td>
</tr>
<tr>
<td>Thickness, mm</td>
<td>0.35 (nominal)</td>
<td>0.35 (nominal)</td>
</tr>
<tr>
<td>Strip tensile, N/m (Strain rate: 50 mm/minute)</td>
<td>62 (min)</td>
<td>37 (min)</td>
</tr>
<tr>
<td>Warp</td>
<td>50 (min)</td>
<td>32 (min)</td>
</tr>
<tr>
<td>Weft</td>
<td>5.3 (min)</td>
<td>3.0 (min)</td>
</tr>
<tr>
<td>Trapezoidal tear, N/m</td>
<td>3.5 (min)</td>
<td>3.2 (min)</td>
</tr>
<tr>
<td>Warp</td>
<td>23 (nominal)</td>
<td>27 (nominal)</td>
</tr>
<tr>
<td>Weft</td>
<td>68 (nominal)</td>
<td>65 (nominal)</td>
</tr>
<tr>
<td>Solar transmission (ASTM E-424), %</td>
<td>0 (max)</td>
<td>5 (max)</td>
</tr>
<tr>
<td>Solar reflectance (ASTM E-424), %</td>
<td>0 (max)</td>
<td>15 (max)</td>
</tr>
<tr>
<td>Burning characteristics</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Flame spread (ASTM E-84)</td>
<td>0.70</td>
<td>0.55</td>
</tr>
</tbody>
</table>
| Smoke generation (Tunnel test)   | 10% increase in speed means a 20% increase in forces). Damping pads are used to dissipate mechanical vibration. For high speed weaving machines, plastic spring elements were used to reduce vibration emission. Subsequently, air spring absorbers were developed to enhance the performance of vibration isolation. Today, steel spring/laminated base plate elements are replacing air spring absorbers since the former is just effective as the latter as regards isolation effect, but it is virtually maintenance free. These elements can be retrofitted.

4.3 Weaving Machine Widths

Increased output on a weaving machine can be achieved by increasing the speed or by using greater machine widths. The noise level for a 10% increase in weft insertion rate thus changes as follows:

- With a 10% increase in rotational speed and unchanged machine width, the noise level rises by about 2 dBA.
- With a 10% increase in width and the same speed, the noise level rises by only 0.5 - 0.7 dBA.

Wide weaving machines thus record lower noise
levels than the narrow weaving machines at the same weft insertion rate.

5 Conclusion

Reduction of noise is important and above all a demanding task. Machinery manufacturers have attempted to keep the noise emission as low as possible, but what would have been achieved in lowering down the noise level has been cancelled out by the continuous increase in speed. Further progress in this field is foreseeable with the aid of computer-aided online control.

In Indian textile mills, the noise level is high and it is high time that the mills must recognize this as an environmental problem with an impact on occupational environment and take steps to reduce it.

Reference
6 Sulzer Textil, Private Communication.