UNIT -5

Noise Engineering

INTRODUCTION: - As with any occupational hazard, control technology should aim at reducing noise to acceptable levels by action on the work environment. Such action involves the implementation of any measure that will reduce noise being generated, and/or will reduce the noise transmission through the air or through the structure of the workplace. Such measures include modifications of the machinery, the workplace operations, and the layout of the workroom. In fact, the best approach for noise hazard control in the work environment, is to eliminate or reduce the hazard at its source of generation, either by direct action on the source or by its confinement. Practical considerations must not be overlooked; it is often unfeasible to implement a global control program all at once. The most urgent problems have to be solved first; priorities have to be set up. In certain cases, the solution may be found in a combination of measures which by themselves would not be enough; for example, to achieve part of the required reduction through environmental measures and to complement them with personal measures (e.g. wearing hearing protection for only 2-3 hours), bearing in mind that it is extremely difficult to make sure that hearing protection is properly fitted and properly worn. This chapter presents the principles of engineering control of noise, specific control measures and some examples. Reading of chapter 1 is indispensable for the understanding of this chapter. Note that many of the specific noise control measures described are intended as a rough guide only. Further information on the subject can be found in ISO 11690 and in the specialized literature. Also suppliers of equipment and noise control hardware can often provide helpful noise control advice.

CONTROL OF NOISE AT THE SOURCE

To fully understand noise control, fundamental knowledge of acoustics is required. To control noise at the source, it is first necessary to determine the cause of the noise and secondly to decide on what can be done to reduce it. Modification of the energy source toreduce the noise generated often provides the best means of noise control. For example, whereimpacts are involved, as in punch presses, any reduction of the peak impact force (even at theexpense of a longer time period over which the force acts) will dramatically reduce the noisegenerated.Generally, when a choice of mechanical processes is possible to accomplish a given task, thebest choice, from the point of view of minimum noise, will be the process which minimizes thetime rate of change of force or jerk (time rate of change of acceleration). Alternatively, whenthe process is aerodynamic a similar principle applies; that is, the process which minimizes pressure gradients will produce minimum noise. In general, whether a process is mechanical orfluid mechanical, minimum rate of change of force is associated with minimum noise.Among the physical phenomena which can give origin to noise, the following can bementioned:

1. Mechanical shock between solids,
2. Unbalanced rotating equipment
3. Friction between metal parts,

4. Vibration of large plates
5. Irregular fluid flow,

Control of noise at the source may be done either indirectly,i.e.generally, or directly,i.e. related To the design process addressing one of the causes cited above. In noise control by design the terms direct and indirect sometimes are used for the pathof sound from the generation to propagation in the air. So airborne sound in a fan is radiateddirectly but solid borne sound in a gear is transmitted to the wall of the casing and radiated asairborne sound indirectly.

GENERAL SOURCE NOISE CONTROL CAN INVOLVE:

Maintenance:

1. Replacement or adjustment of worn or loose parts;
2. Balancing of unbalanced equipment;
3. Lubrication of moving parts;
4. Use of properly shaped and sharpened cutting tools.

Substitution of materials (e.g., plastic for metal), a good example being the replacementof steel sprockets in chain drives with sprockets made from flexible polyamide plastics.

Substitution of equipment:

1. Electric for pneumatic (e.g. hand tools);
2. Stepped dies rather than single-operation dies;
3. Rotating shears rather than square shears;
4. Hydraulic rather than mechanical presses;
5. Presses rather than hammers; roller conveyors
6. Belt conveyors rather than

Substitution of parts of equipment:

1. Modification of gear teeth, by replacing spur gears with helical gears – generally resulting in 10 dB of noise reduction).
2. Replace straight edged cutters with spiral cutters (e.g. wood working machines 10 dB(A) reduction)
3. Replace gear drives with belt drives;
4. Replace metal gears with plastic gears (beware of additional maintenance problems);
5. Replace steel or solid wheels with pneumatic tires.

Change of work methods

1. In building demolition, replace use of ball machine with selective demolition;
2. Replace pneumatic tools by changing manufacturing methods, such as moulding holes in
3. Concrete rather than cutting after production of concrete component;
4. Use remote control of noisy equipment such as pneumatic tools;
5. Separate noisy workers in time, but keep noisy operations in the same area, separated
6. From non-noisy processes;
7. Select slowest machine speed appropriate for a job - also select large, slow machines
8. Rather than smaller faster ones;
9. Minimize width of tools in contact with workpiece (2 dB(A) reduction for each halving of tool width)
10. Woodchip transport air for woodworking equipment should move in the same direction.
11. Minimize protruding parts of cutting tools.

Noise vibration measurement terminology:

- **Peak value:** Indicates the maximum response of a vibrating part. It also places a limitation on the "rattle space" requirement.
- **Average value :** Indicates a steady or static value (somewhat like the DC level of an electrical current) and it is defined as

$$\bar{x} = \lim_{T\to\infty}(1/T)\int_0^T x(t)dt$$

- where $x(t)$ is the displacement, and T is the time span (for example time period)

Example:-

- For a complete cycle of sine wave,

$$x(t) = A\sin\omega t : \bar{x} = \frac{1}{2\pi}\int_0^{2\pi} A\sin\omega t dt = \frac{A}{2\pi}\left[\frac{\cos\omega t}{\omega}\right]_0^{2\pi} = \frac{A}{2\pi\omega}[1.0 - 1.0] = 0$$

For half cycle of the sine wave:

$$\bar{x} = 1/\pi\int_0^{\pi} A\sin\omega t dt = \frac{A}{\pi}\left[\frac{\cos\omega t}{\omega}\right]_0^{\pi} = \frac{A}{\pi\omega}[1-(-1)] = 2A/\pi = 0.637A$$

Where A is the amplitude of the displacement.

Mean square value:
Square of the displacement generally is associated with the energy of the vibration for which the mean square value is a measure and is defined as

$$\langle x^2 \rangle = \lim_{T\to\infty}(1/T)\int_0^T x^2(t)dt$$

Root mean square value (rms): This is the square root of the mean square value.

For example: for a complete sine wave

$$x_{rms} = \left[\langle x^2 \rangle\right]^{\frac{1}{2}} = \left[\frac{A}{2}\right]^{\frac{1}{2}} = 0.707A$$

Decibel (D_b) : It is a unit of the relative measurement of the vibration and sound. It is defined in terms of a power ratio:

$$D_b = 10\log_{10}(p_1/p_2)$$

Where *p* is the power, since power is proportion to square of amplitude of vibrations or voltages, which is easily measurable, hence

$$D_b = 10\log_{10}(A_1/A_2)^2 = 20\log_{10}(A_1/A_2)$$

Where *A* is the amplitude. For amplitude gain of 5, the decibel has a gain of

$$D_b = +20\log_{10} 5 = +14$$

In vibrations *decibel* is used to express relative measured values of displacements, velocities and accelerations.

$$D_b = 20\log_{10}(z/z_0)$$

Where *z* is the quantity under consideration (e.g. displacement, velocity or acceleration), z_0 is the reference value (e.g. for velocity $v_0 = 10^{-8}\ m/\sec$ and acceleration $a_0 = 9.81\times10^{-6}\ m/\sec^2$

For example $D_b = 20$ means 10 times the reference value $D_b = 20 = 20\log_{10} 10$), and $40D_b$ means 100 times the reference value (i.e. $D_b = 40\log_{10} 10 = 20\log_{10} 10^2$)

Octave: The octave is used for the relative measurement of the frequency. If two frequencies have ratio 2:1, the frequency span is one octave.

$$\text{Octave} = \log_2 (f_{max}/f_{min})$$

For example:

f_{max}	f_{min}	Octave
20	10	$\log_2(2) = 1$
30	10	$\log_2(3) = \frac{\log_{10} 3}{\log_{10} 2} = \frac{0.4771}{0.3010} = 1.585$

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