Introduction to Machinery Vibration Sheet Answer

1.
    1. imposed motions related to the function - e.g. slider crank and earn
    2. inadequate design - e.g. resonance
    3. manufacturing processes - e.g. fluid flow, metal cutting
    4. installation, misalignment and soft foot
    5. wear and abuse
    6. operational maintenance - improper repair

2. harmonic, periodic, impulsive, pulsating, and random
3. material moving, stress relief
4. vibration induced process error- machining, printing, imaging

5.
    1. acceptance testing for purchase of equipment
    2. predictive maintenance for repair scheduling
    3. manufacturing processes - conveying
    4. determination of dynamic properties

6.
    1. used to initiate data acquisition
    2. provides an angular relationship between a reference mark on a shaft and the shaft vibration

7. Vibration levels and frequencies are an indicator of machine faults and condition.

8. <u>trending</u> of vibration levels is used to determine when the condition of a machine has changed; <u>alarm levels</u> are used to indicate different states of condition

9.

$$\frac{400\ \text{mv} - \text{pk to pk}}{200\ \text{mv/mil}} = 2\ \text{mils pk} - \text{pk}$$

10. Period (τ) = 32.8 mSec/cycle

$\tau = \frac{32.8\ \text{mSec}}{1000\ \text{mSec/sec}}$ = 0.0328 sec/ cycle

Frequency (f) = $\frac{1}{\text{period}\ (\tau)}$

Then

$f = \frac{1}{\tau} = \frac{1}{0.0328 \text{ sec/cycle}}$ = 30.49 Hz(cycles/sec)

f = 30.49 Hz x 60 sec/min = 1,829 cycles/minute (CPM)

11. A vibration displacement of 5 mils-pk to pk at a frequency of 100 Hz becomes

D= 5/2000 = 0.0025 inches-peak.

V = 2 x πx 100 x 0.0025 in/sec-peak.

V = 1.57 IPS-pk.
A = 2 x πx 100 x 1.57/386.1 = 2.55 gs-peak.

12. A vibration displacement of 6.4 mils-pk to pk at a frequency of 10 Hz becomes

D= 6.4/2000 = 0.0032 inches-peak.

V = 2 x πx 10 x 0.0032 in/sec-peak.

V = 0.2 IPS-pk.
A = 2 x πx 10 x 0.2/386.1 = 0.03 gs-peak.

13. A vibration acceleration of 3.2 gs-peak at a frequency of 1000 Hz becomes

A= 3.2 gs-peak=3.2*386.1= 1235.2 in/sec^2

V = 3.2/(2 x πx 1000) in/sec-peak.

V = 0.19 IPS-pk.
D = 2 x 0.19/(2 x πx 1000) = 0.032 mils-pk.
D = 2 x 0.032 = 0.064 mils-pk to pk.

14. displacement - mils pk to pk
acceleration - gs-peak or RMS

15. volts
16. The period is the time required to make one cycle of vibration - seconds per cycle.
The frequency of vibration is the number of cycles per unit of time - cycles per

second.

17. milli seconds (mSec)

18. Major divisions are 400 mSec/l0 = 40 mSec/div. Minor divisions are 40 mSec/div/10 = 4 mSec/div.
The period is 16 minor div
Period = $\frac{16\text{ div}}{\text{cycle}} \times \frac{4\text{ mSec}}{\text{div}} = \frac{64\text{ mSec}}{\text{cycle}} = 0.064$ sec /cycle

19. f = $\frac{1}{\text{T}} = \frac{1}{0.064\text{ sec/cycle}} = 15.625$ cycles/sec (Hz)

20. major divisions 1.25 mils/div
minor division 0.3125 mils/div
amplitude = 14 minor divisions
amplitude =14 div $\times \frac{0.3125\text{ mils}}{\text{div}}$
amplitude = 4.375 mils-pk to pk

21. A spectrum is a plot of amplitude versus frequency. For a harmonic (spectral) component - RMS = 0.707 x peak

22. the frequency of operating speed

23. Forcing frequencies are generally related to shaft speed and line frequency.

24. A frequency of the machine governed by design where energy is easily absorbed.

25. Resonance is amplified vibration at frequencies around the natural frequency. A critical speed is the rotor speed that matches a natural frequency.

26. peak acceleration = 4.25 minor div peak
minor div = $\frac{10\text{ gs}}{8\text{ div}} = \frac{1.25\text{ gs}}{\text{div}}$
acceleration = $\frac{1.25\text{ gs}}{\text{div}} \times 4.25$ div = 5.3 gs peak

If 0.707 X peak is used the RMS = 3.47 gs. The actual RMS is equal to 2.44. It shows that the multiplier does not work for non-harmonic signals.

27. 1. physical observations

2. periodic collection of vibration data, oil samples and thermograms

3. continuous vibration monitoring

4. process data acquisition

5. design and installation drawings and procedure

6. maintenance records

28. accelerometers are usually mounted near a bearing so the magnet is firm and does not rock

29. type of measurement, frequencies in the data to be acquired, space, environmental conditions

30. load zone measurement is important to obtain good signal transmission

31. $f_l = 54.375$ Hz

$f_2 = 59.375$ Hz

32. The difference in spectral frequencies is 54.375 Hz minus 59.375 Hz or 5 Hz. The beat period is 1/5 or 0.2 see/cycle

from the waveform $f = \frac{1}{0.18} = 5.55$ Hz

33.
- operating speed oriented sources
- installation sources
- flow induced vibrations due to inefficient operation - operational sources, Gearmeshing forces, flow induced vibrations and blading vibrations, and electrically induced force.

34. process forces from stamping, drawing, turning, cutting, and grinding materials

35. meters, oscilloscopes, and data collectors

36. store, analyze, and trend data

37. compromises the amplitude of the data and may yield unnecessarily noisy data

38. machine frequencies

39. Amplitude = 0.55 IPS-peak

Period = $\frac{196.26 - 149.75}{1000}$ = 0.0465 sec/cycle

Frequency = $\frac{1}{\text{period}} = \frac{1 \text{ cycle}}{0.0465 \text{ sec}}$ = 21.5 Hz

40. pulses indicate impact = broken or chipped gear tooth

41. operating speed

42. rotor bar passing frequencies

a. number of poles times slip frequency

b. two times line frequency and multiples

c. slot passing frequencies

43. vane/blade pass

44. The most probable fault is mass unbalance - 1x.

45. The most probable fault is misalignment - lx and 2x.

46. recirculation - there is high back pressure

47. amplitude and frequency

48. Speed = 1,793 RPM

Frequency = 29.88 Hz

Amplitude = 0.39 IPS-peak

Condition = surveillance

49. RMS = 0.316 - unsuitable for operation