Introduction to Machinery Vibration Sheet Answer

Chapter 1: Vibrations Sources and Uses

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. Mechanical vibrations are one indication of machine quality and condition.
8. Vibration levels and frequencies are an indicator of machine faults and condition.
9. trending of vibration levels is used to determine when the condition of a machine has changed; alarm levels are used to indicate different states of condition

Chapter 2: Basic Machinery Vibration

10. oscillation of shafts and structures in a pattern determined by forces and machine design

11. The amount and frequency of vibration are governed by forces, design of the machine, speed, damping.

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

13. volts

14. 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.

15. milli seconds (mSec)

16. 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

$$\text{Period} = \frac{16\ \text{div}}{\text{cycle}} \times \frac{4\ \text{mSec}}{\text{div}} = \frac{64\ \text{mSec}}{\text{cycle}} = 0.064\ \text{sec/cycle}$$

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

18. major divisions 1.25 mils/div
minor division 0.3125 mils/div
amplitude = 14 minor divisions

$$\text{amplitude} = 14\ \text{div} \times \frac{0.3125\ \text{mils}}{\text{div}}$$

amplitude = 4.375 mils-pk to pk

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

20. Excitation is the force that causes vibrations.

21. the frequency of operating speed

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

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

24. Resonance is amplified vibration at frequencies around the natural frequency.

A critical speed is the rotor speed that matches a natural frequency.

25. peak acceleration = 4.25 minor div peak

minor div = $\frac{10\ \text{gs}}{8\ \text{div}} = \frac{1.25\ \text{gs}}{\text{div}}$

acceleration = $\frac{1.25\ \text{gs}}{\text{div}} \times 4.25\ \text{div} = 5.3\ \text{gs peak}$

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.

Chapter 3: Data Collection and Analysis

26. 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

27. the range of frequencies where vibration occurs
28. machine frequencies
29. seismic sensors are usually mounted near a bearing so the magnet is firm and does not rock
30. type of measurement, frequencies in the data to be acquired, space, environmental conditions
31. load zone measurement is important to obtain good signal transmission
32. $\frac{100\ \text{Hz}}{400\ \text{lines}} = 0.25\ \text{Hz}$
33. low frequency ski slope error occurs in the spectrum
34. $f_1 = 54.375\ \text{Hz}$

    $f_2 = 59.375\ \text{Hz}$
35. 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 $f = \frac{1}{0.18} = 5.55\ \text{Hz}$

Chapter 4: Machine Characteristics

36. Machine knowledge of mechanisms provides the information required to identify forcing and natural frequencies. Knowledge of force levels and damping help in amplitude estimation

37. Through the rotation of the journal the fluid film bearing generates an oil wedge that supports the journal.

38. The function of a centrifugal pumps is to transfer fluids from one location to another usually involving a change in elevation.
A rotating impeller with vanes imparts energy to the fluid by moving it through the impeller at high speed from the inlet (suction) to the discharge (volute or diffuser) in the form of higher pressure and velocity. The volutes or diffuser changes some of the velocity energy developed by centrifugal acceleration to static pressure.

39.
- 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.

40. An induction motor uses alternating current in the rotor which cause the rotor to rotate at a speed slightly slower than the line current frequency divided by the pole pairs.

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

Chapter 5: Vibration Instruments

42. meters, oscilloscopes, and data collectors

43. store, analyze, and trend data

Chapter 6: Vibration Testing

44. efficient movement of the data collector from point to point - an efficient program with minimal data collection points

45. 1. mount the sensor after examination of the surface
    2. clean the surface if necessary
    3. test its stability by attempting to rock it
    4. reposition it if it rocks by twisting it

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

47. Machine mounting review, sensor selection and location, data processing procedure operational testing details - loads, speeds, and any special conditions, reporting

48. The acceptance test is used to determine whether or not new or repaired equipment meets the purchase specification. Sometimes the data are used as baseline signatures.

Chapter 7: Basic Analysis

49. machine frequencies

50. 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

51. pulses indicate impact = broken or chipped gear tooth

52. the ability to distinguish closely spaced frequencies

53. operating speed

54. when motors, generators, and variable frequency drives are being analyzed

55. rotor bar passing frequencies

    a. number of poles times slip frequency

    b. two times line frequency and multiples

    c. slot passing frequencies

56. vane/blade pass

57. random vibration

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

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

60. recirculation - there is high back pressure

Chapter 8.: Vibration Severity

61. amplitude and frequency

62. Speed = 1,793 RPM

Frequency = 29.88 Hz

Amplitude = 0.39 IPS-peak

Condition = surveillance

63. RMS = 0.316 - unsuitable for operation