Tube Bundle Vibration and Acoustic Resonance Check

Vortex-shedding and acoustic frequencies of a tube bundle in cross-flow, compared with the tube natural frequency by Ganapathy's 20 % separation rule.

Method: Ganapathy; Steam Plant Calculations Manual; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Tube natural frequency	18.200	Hz
Tube outer diameter	50.800	mm
Gas velocity in the gap	6.4000	m/s
Strouhal number Ganapathy Fig. 4.22: about 0.2–0.33 for common pitches.	0.33000	
Duct width across the gas flow and tubes	3.5660	m
Gas temperature	103.72	°C
Gas molar mass	29.000	kg/kmol
Ratio of specific heats	1.4000	
Acoustic mode	1.0000	

Calculated results

Parameter	Value	Unit
Vortex-shedding frequency	41.575	Hz
Speed of sound	388.94	m/s
Acoustic frequency	54.534	Hz
Vortex / natural frequency	2.2843	
Acoustic / vortex frequency	1.3117	

Notes for this case

- All three frequencies are at least 20 % apart in this mode; check other modes too.

Formula and method

$$f_v = \frac{S V}{d_o}, \quad c = \sqrt{\frac{\gamma R T}{M}}, \quad f_a = \frac{n\, c}{2 W}$$

Variables

f_n	Tube natural frequency	1/s
d_o	Tube outer diameter	m
V	Gas velocity in the gap	m/s
S	Strouhal number	-
W	Duct width across the gas flow and tubes	m
T	Gas temperature	K
M	Gas molar mass	kg/kmol
γ	Ratio of specific heats	-
n	Acoustic mode	-
f_v	Vortex-shedding frequency	1/s
c	Speed of sound	m/s

f_a	Acoustic frequency	1/s
f_v/f_n	Vortex / natural frequency	-
f_a/f_v	Acoustic / vortex frequency	-

Method and standards

Ganapathy's checks with the ideal-gas speed of sound.

Assumptions and limits

- The tube natural frequency f_n is an input: compute it from the tube span, end fixity, stiffness EI and mass per length (Ganapathy Q4.59 shows how) or take it from the maker.
- One acoustic mode is checked at a time; repeat for modes 2, 3 … and compare each f_a with f_v. A direct comparison of f_a with f_n is not part of Ganapathy's check.
- Strouhal number from charts for the pitch.

References

- Ganapathy
- Steam Plant Calculations Manual
- 2nd ed. (Marcel Dekker, 1993)
- Q4.59a–e (natural, vortex-shedding and acoustic frequencies; 20 % separation)

Report details

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Release checks	2 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/heat-transfer/tube-bundle-vibration-check

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.