SATE
Systems & Advanced Technologies Engineering S.r.l.

Cut-off of acoustic pulsations in a CO fuelled Boiler

2009, October – SATE solved a severe vibration problem in a refinery boiler combustor

Overwiew

***PROBLEM**:*

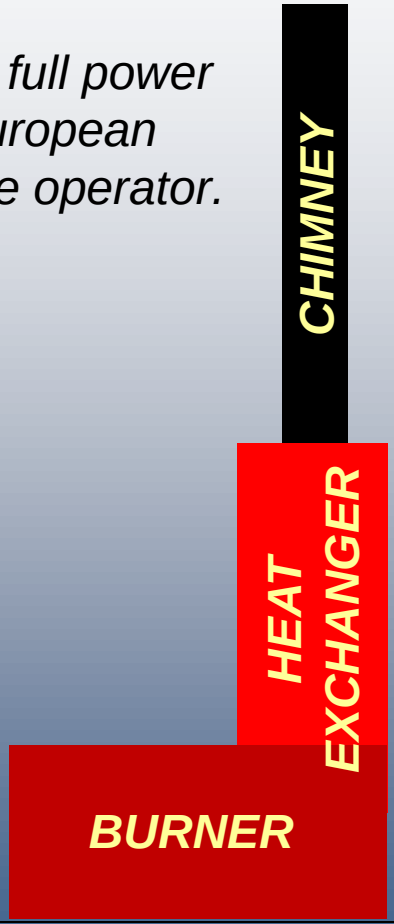
a severe low frequency vibration onset was preventing the full power utilization of a large gas fuelled steam generator, in a European refinery, causing a high production and economic loss to the operator.

Elements of the steam generator:

1. Burner

2. Vertical heat exchanger, consisting of several crossflow tube banks

3. Chimney, to exhaust gases to atmosphere



Experimental evidence

PLANT EVIDENCE

Longitudinal mechanical vibrations of high amplitude on steam generator;
Vibrations amplitude is increasing with the exhaust flow rate.

PROBLEM ANALYSIS

After having studied the internal layout of the heat exchanger ,SATE argues that longitudinal acoustic resonances is excited by vortexes detaching at certain heat exchangers pipe bundles.

Physical phenomena

Physical process leading to mechanical vibrations

Flow conditions:
The exaust gases flow through the heat exchanger bundles

↓ Bundle geometry

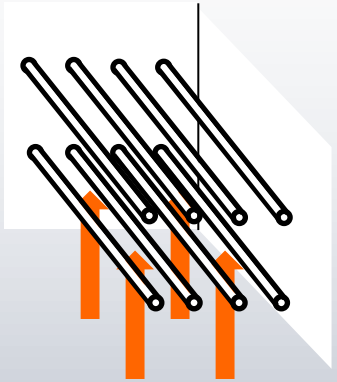
Vortex shedding
The vortexes, detaching from the bundles, are the pulsation source at calculated shedding frequency

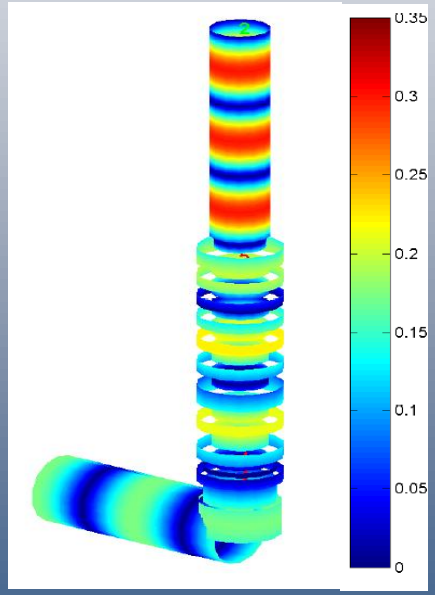
↓ *Acoustic Transfer Function* (longitudinal acoustic mode near the shedding frequency)

Acoustic Response
Mass flow rate and pressure pulsations in the boiler

↓ *Mechanical Transfer Function*

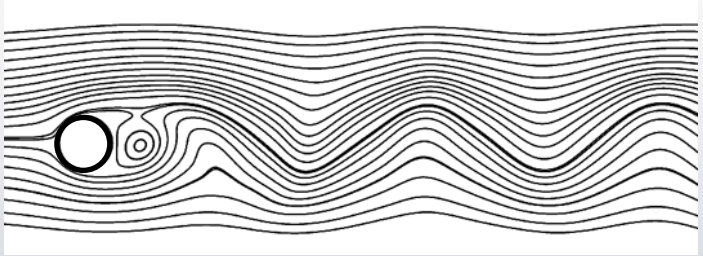
Mechanical Response
Mechanical longitudinal vibration at measured frequency, near the shedding frequency





About vortex shedding

HYPOTHESIS about VIBRATION ONSET



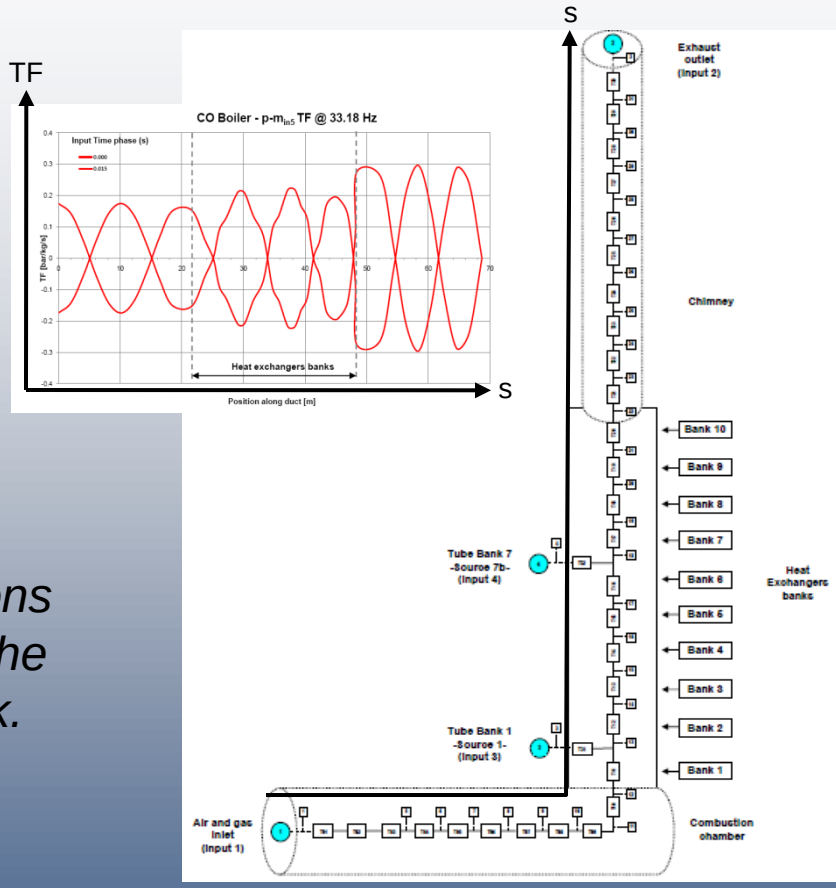
Frequency of vortex shedding
near to
Frequency of acoustic resonance

Bundles banks become sources of potential high amplitude pressure pulsations.
These banks are treated as the acoustic inputs to the equivalent simulated acoustic system

Modelling of the acoustic system

PLANT MODELLING

*SATE models the whole steam generator, calculating acoustical eigenvalues and transfer functions from inputs (selected bundles banks) with **ACUSYS** ©.*



RESULTS

The simulations confirm the hypothesis: the frequency of observed mechanical vibrations is closed to the acoustic frequency for which the transfer function has relevant amplitude peak.

Mechanical vibrations are consequential to these acoustical flow induced pulsations

Remedial

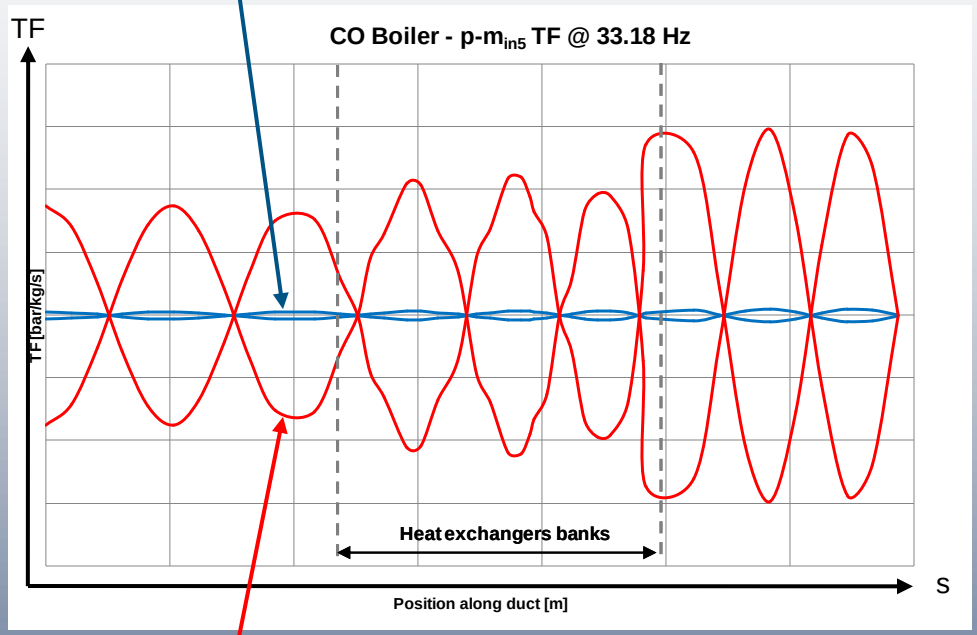
PROPOSAL OF REMEDIAL DEFINITION

To reduce the pulsation amplitude a remedial device has been placed along the exhaust flow path.

VERIFICATION OF REMEDIAL DEVICE

Simulations of the modified system show a great reduction of the transfer function amplitude in the range of frequencies near to the observed mechanical vibration frequency.

AFTER REMEDIAL ADDITION



BEFORE REMEDIA L ADDITION

Plant Remedial Realization and Operator Feedback

After modification the operator restarted the plant.

Immediately he confirmed that:

I. **vibrations were reduced** to less than one tenth of the original level, for the same boiler heat rate;

II. **the plant could reach without problems the full power condition.**