How to avoid extreme Temperature Strands in a Chimney

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1. Introduction

In many cases two or more flue gas flows were injected into a single steel liner of a chimney stack. In general temperature strands follow up the liner wall if there is no mixing device. If the temperature difference of these flue gas strands are large, temperature induced stresses may occur in the liner, which may lead to cracks or buckling. Another effect can be a strong bending of the liner, while the deformation is prevented by the support points. Therefore it is appropriate to avoid these strands by intelligent design of the inflow situation. Some examples are presented in this paper how to avoid or how to minimize this thermal effect.

2. Central Injection

One solution is the central injection. **Fig. 1** shows an example. A hot gas is injected in the centre of the main flow. The vertical part of the hot gas duct must be long enough in order to avoid cross flow components. The elongation must be 2 times of the duct diameter as a minimum.

The hot centre jet stream remains in the middle of the liner and spreads slowly into the direction of the wall while a mixing occurs with the main flow. Single temperature strands at the liner wall are avoided by this design.

Furthermore, if the velocity of the hot central jet is significantly higher than the velocity of the main flow, an injector effect can be taken into account which reduces the pressure loss of the main flow.

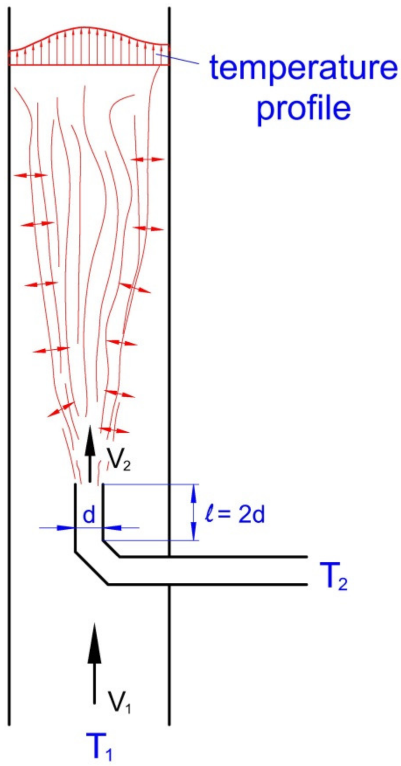

Fig. 1: Central injection into a stack liner

3. Vortex induced Mixer

The vortex induced mixer is based on the leading edge vortex system, which is generated at a delta shaped plate or at a circular plate. It is a stationary vortex system, which exists not only at the generating plate but also downstream of it. **Fig 2.a and Fig. 2.b** present the principle of such a vortex system.

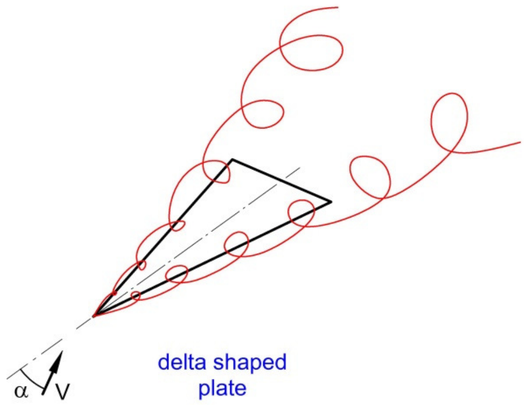

Fig. 2a: Principle of the leading edge vortex system at a delta shaped plate

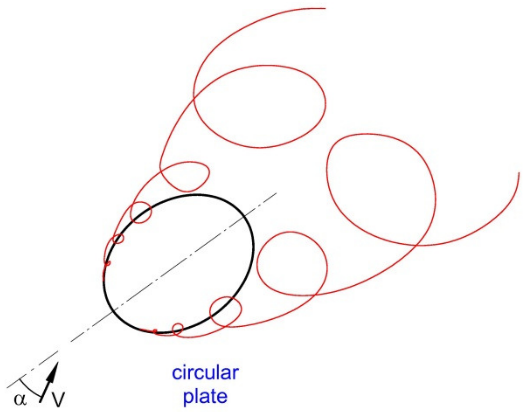

Fig. 2b: Principle of the leading edge vortex system at a circular plate

This vortex system can be used for the mixing of different gas flows. **Fig. 3.a to Fig. 3.c** show three typical applications in a stack. The optimum arrangement of the mixer plates depends on the flow amounts of the different gas flows and on the geometry of the stack and the connection ducts.

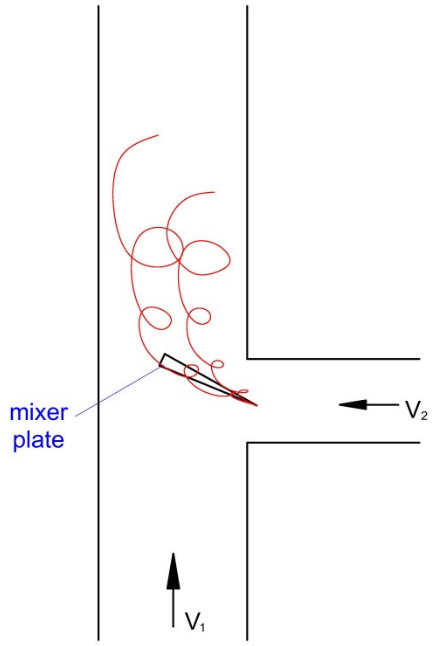

Fig. 3.a: Examples of vortex induced mixing systems in a stack
Type 1

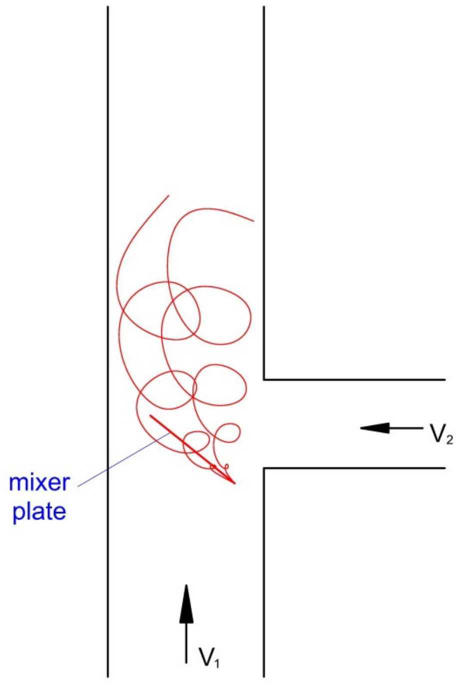

Fig. 3.b: Examples of vortex induced mixing systems in a stack
Type 2

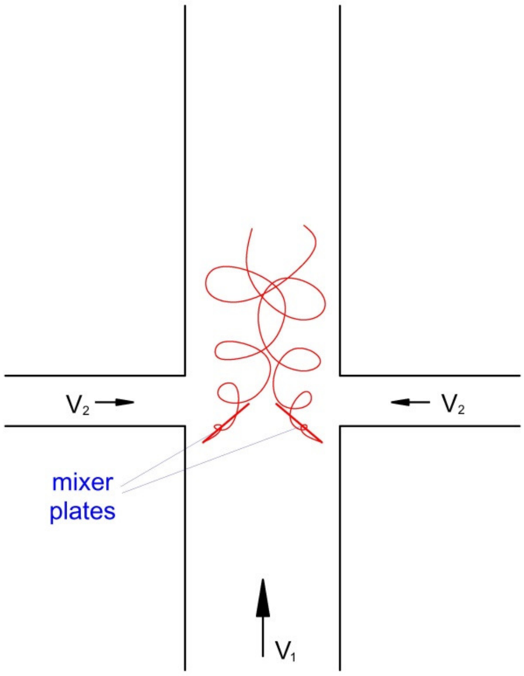

Fig. 3.c: Examples of vortex induced mixing systems in a stack
Type 3

Model tests have demonstrated the effectiveness of such a mixing system. **Fig 4.a and Fig. 4.b** present a flow model with a mixing device of type 2. The hot gas (500 °C) is visualized by injecting fog. Without the mixing device the hot gas strand is immediately at the wall, while the cold gas (100°C) is on the opposite site of the liner. A strong temperature gradient exists at the wall of the liner in the transition zone between the hot gas and the cold gas. With the mixing device the hot gas is proper mixed with the cold gas and the temperature gradient at the wall is reduced respectively (**Fig. 4.2**).

Fig. 4.a: Model test without mixer

Fig. 4.b: Model test with mixer

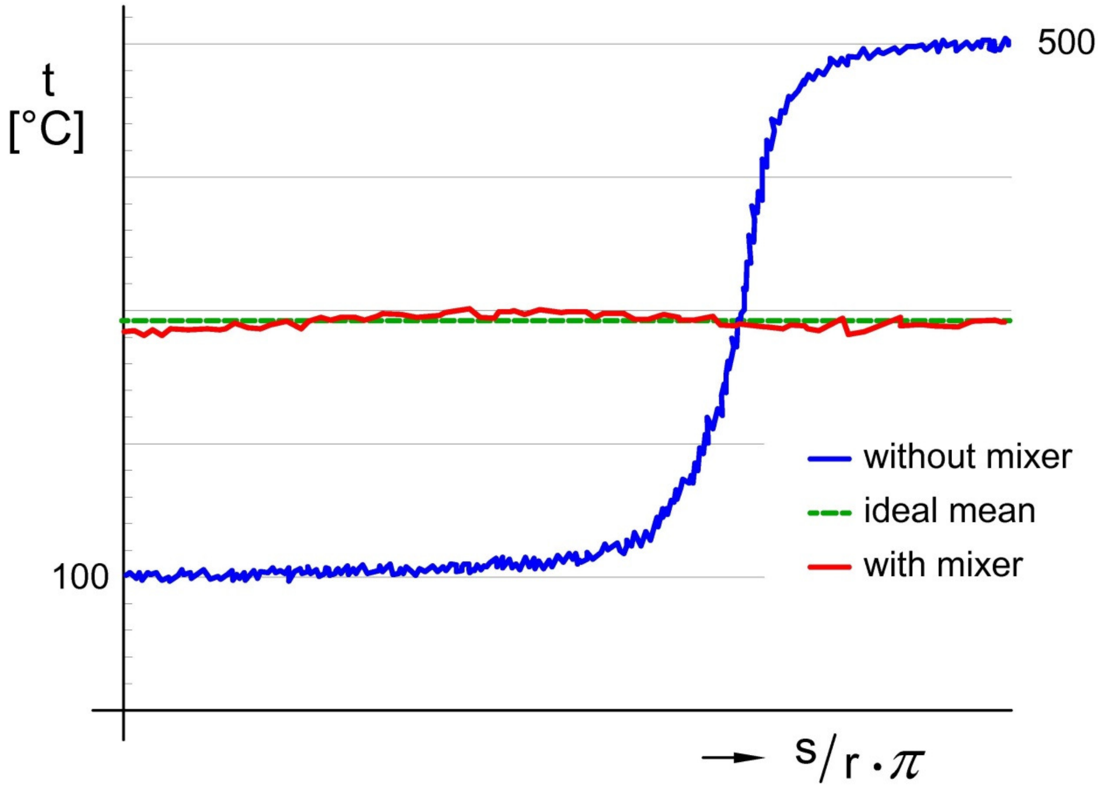

Fig. 4.2: Temperature distribution at the wall of the liner without and with mixer
The abscissa represents the half circumference of the liner

Another application of the mixing device in a stack can be found, if a silencer, a reactor or a heat exchanger follows the hot gas injection. It is often required, that the temperature at these elements must be equal distributed respectively the deviation from the ideal temperature must be a minimum. In such a case the vortex induced mixer type is a very successful measure to satisfy the specification. **Fig. 5** presents an example for a DeNOx reactor. Without mixer the temperature distribution is unacceptable, while with the vortex induced mixer the deviation is in the range of ± 15 K, which is acceptable for the reactor.

Fig.5: Mixing upstream of a DeNOx reactor.

Another example is given in **Fig. 6**. The gas from a gas turbine is partly guided through a heat exchanger and finally connected again with hot gas of the bypass flow entering through a silencer into the steel stack liner. Because there was no mixing between both flows, a high thermal stress occurred in the steel wall of the liner and cracks were observed.

Two mixer plates of type “vortex-induced-mixer” solved the problem.

Fig. 6: Mixing of a hot strand after a silencer at the base of the chimney liner

4. Wet Gas at a Brick Liner

Another application of flow control is shown in Fig. 7. Wet gas flow from a desulphurisation plant enters the chimney stack with brick liner. The momentum of the inflow is high enough in order to generate an overpressure at the brick liner. Wet and corrosive parts of the flue gas penetrate through the brick liner and cause corrosion problems and the back side of the liner.

By adding a turning vane and a mixer plate the overpressure at the brick liner could be changed into an under pressure which avoids the penetration of the wet gas through the liner. No corrosion problems have been observed anymore.

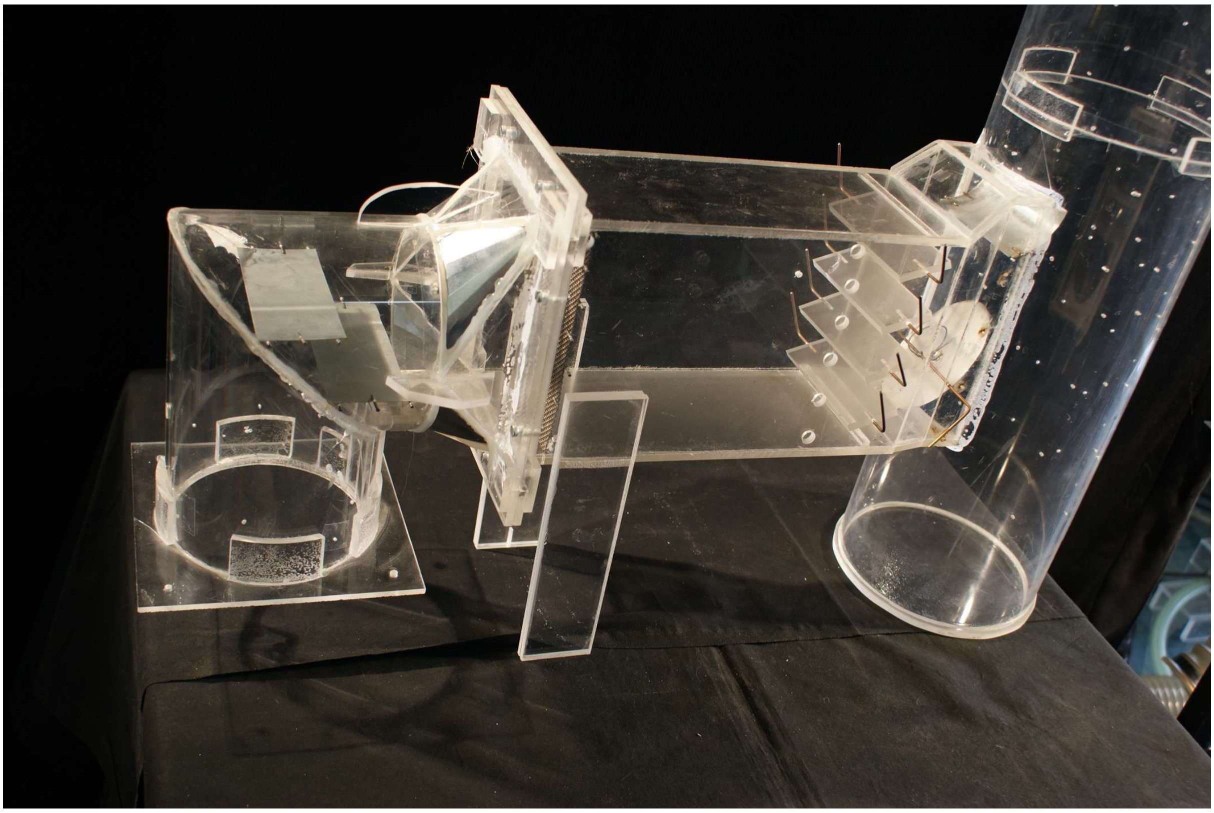

Fig. 7: Wet gas causing over pressure at the brick liner and flow devices to avoid this over pressure.

6. Summary and Conclusion

Flow devices and mixer applications are presented for avoiding hot gas strands in a chimney liner. This measure shall avoid high temperature gradients in the stack wall or to avoid over pressure at a brick liner with an aggressive flue gas.

One solution may be to inject the hot gas in the centre of the stack into vertical direction.

A very successful device is the installation of a static mixer of type “vortex-inducing-mixer”. It consists of delta-shaped or circular flat plates, which generate a stationary vortex system. With this mixer an intensive mixing of different flue gas streams can be achieved. It should be mentioned, that this vortex system has a stationary character and do not induce regular vortices, i.e. no vibration is excited.

The pressure loss of such a mixing system depends on the flow ratio of the different gas flows and on the mixing quality which must be achieved. Practical values of the pressure loss coefficient, the k-value, are in the range of $-0{,}5 < k < 1{,}5$. A negative pressure loss is possible for the injected gas flow.