NATURAL DRAFT EXHAUST STACK

This case study demonstrates the use of Flownex® to model a natural draft exhaust stack such as those typically used in natural gas combustion processes. A basic stack compound component has been developed to assist and simplify the modeling process.

OIL AND GAS INDUSTRY

Challenge:

The main challenge is the application of Flownex® to create a compound component to simplify the modeling of a natural draft exhaust stack to be used in combustion and other related processes.

Benefits:

Although Flownex® is capable of modeling natural draft processes out of the box, it is convenient to have a dedicated natural draft exhaust stack component available which may be added to any applicable process. Furthermore, this basic component may be used in conjunction with other combustion compound components to simplify the process flow diagram.

Solution:

Flownex® could effectively be used to model a natural draft exhaust stack.

"The most important and powerful use of compound components is that it creates reusable "networks". Once a tested and reliable compound component has been developed, the Flownex user may simply copy it to any future network and reuse it without any further effort. Flownex® offers the user the ability to develop extensive libraries of dedicated components for any specific application. These libraries may also be made available to other users in the organisation or elsewhere with obvious benefits. This ability sets Flownex® apart from other tools in the industry."

Hannes van der Walt
Principal Thermal Engineer

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Introduction

Natural draft processes rely on buoyancy effects to generate draft. However, when modeling an exhaust stack, the stack height also implies a small but significant pressure drop due to elevation. These two effects combine to drive the natural draft flow.

Additionally, the exhaust stack compound component implements convenient mechanisms to specify stack geometry and losses such as the elbow between the vertical stack and the horizontal piping feeding into the stack. It allows for a unity exit loss as well as an additional loss factor that could be used for any additional losses in the stack design such as a velocity seal, a silencer or a spark arrestor.

> "Even though it is relatively simple to develop compound components, it is a very powerful facility available to the Flownex® user. It may assist in simplifying otherwise complicated and "messy" flow diagrams by packaging related sections of a network into a single component that is far easier to understand and interact with."

Model

Figure 1 shows the stack compound component used in a simple example network. The stack component has a single fibre (link) that is connected to an upstream element. In this example, however, the link is simply connected to a boundary where the pressure and temperature are specified. Stack specific inputs (in the blue rectangles) and outputs (under the blue rectangles) are also shown on the canvas. The user may enter all inputs directly on the canvas except the stack diameter and the stack flue gas (fluid). The compound component input and result property grids are shown in Figure 2 and Figure 3 respectively.

The stack compound component internal elements are shown in Figure 4. It contains a single pipe element, an elbow and a restrictor with loss coefficient as flow elements. It also contains three scripts to assist with calculations. The *Stack Elbow Radius Script* aims to provide realistic elbow bend radii used in industry. The *Diameter Transfer Script* reads the stack pipe element diameter, specified either via a schedule or via a direct diameter, and then assigns the actual inside diameter to the elbow and restrictor elements. The *Stack Pressure Script* calculates the stack exit pressure which is slightly less than atmospheric due to elevation. It also collects the stack draft and stack loss values and displays these to the user.

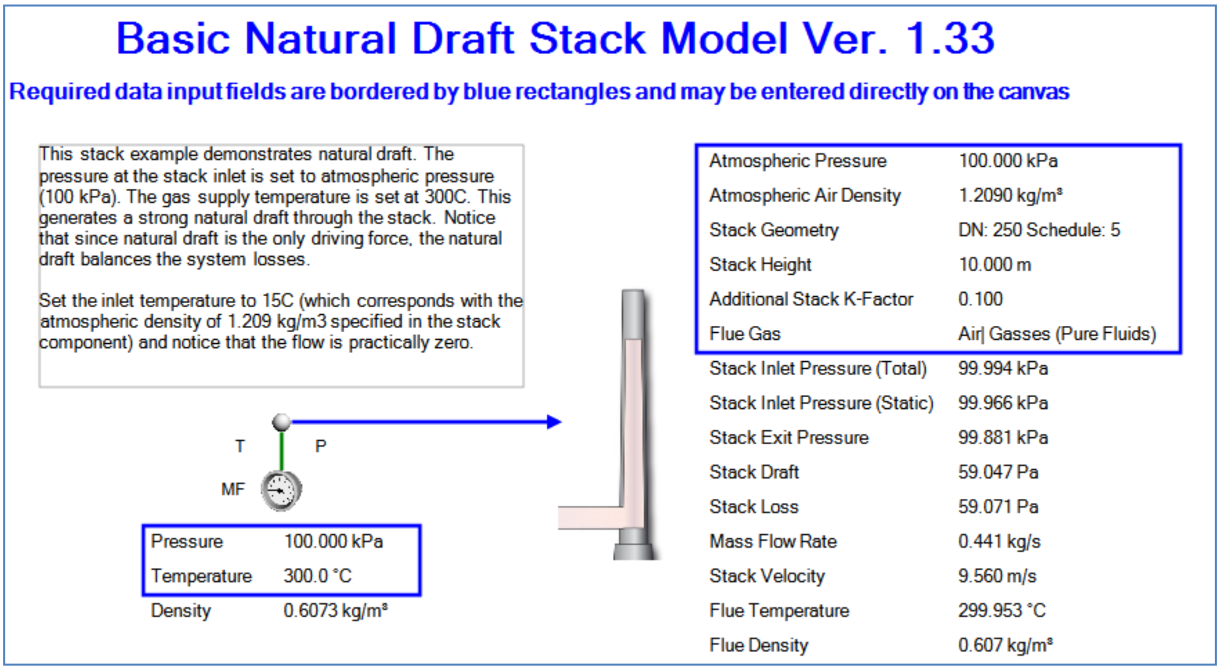

Figure 1: Flownex® Model using a Basic Natural Draft Exhaust Stack Compound Component.

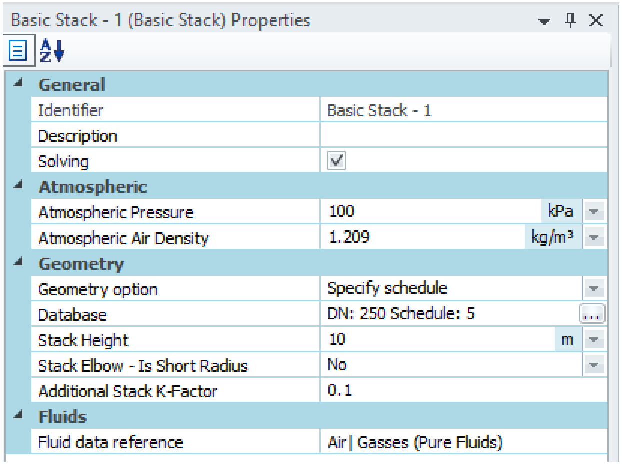

Figure 2: Inputs Property Grid.

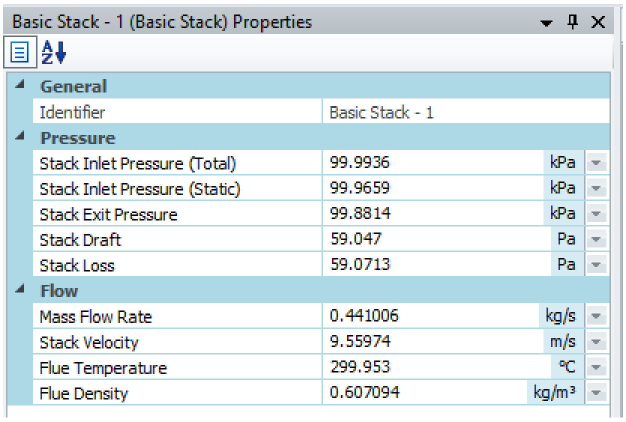

Figure 3: Results Property Grid.

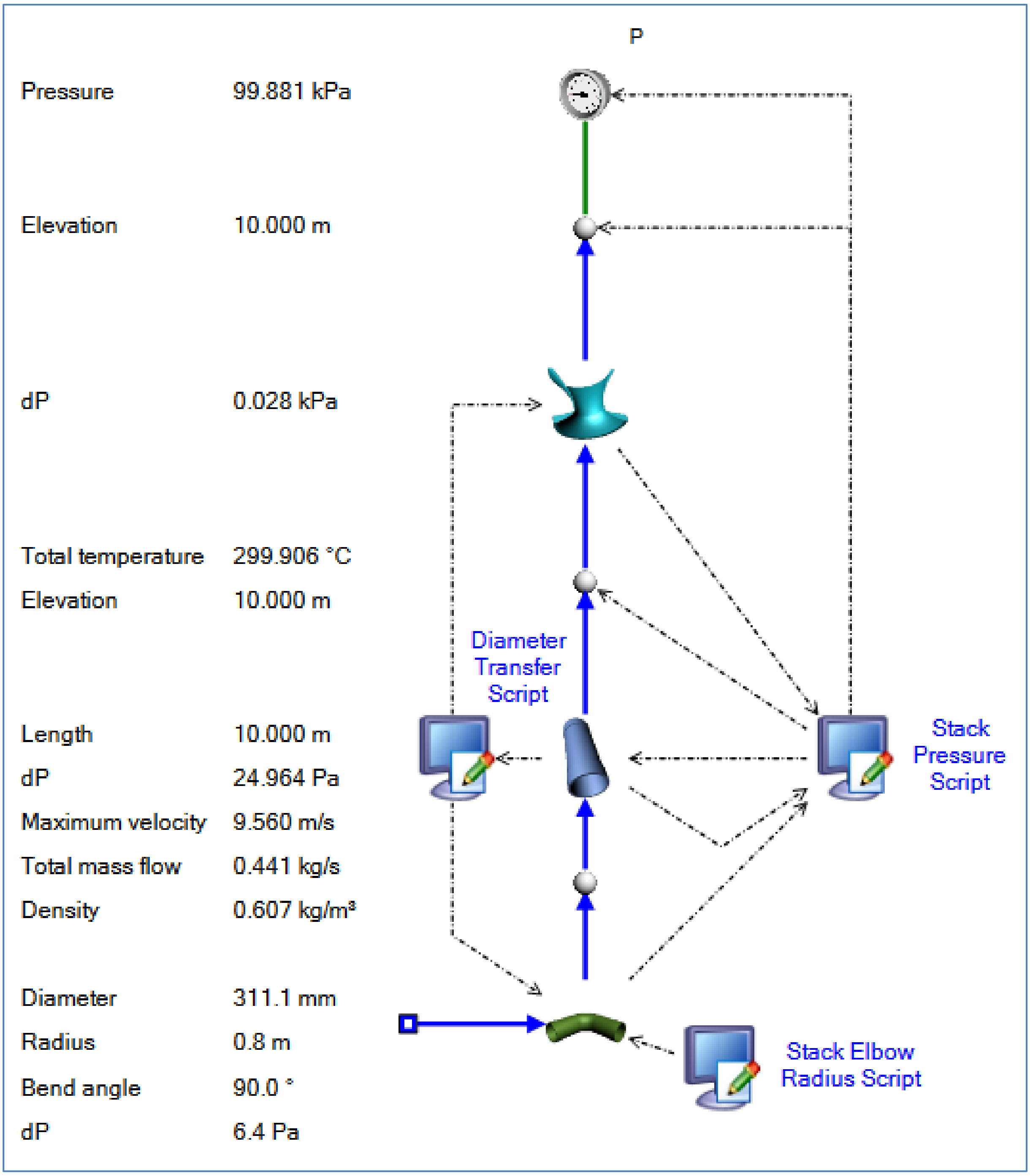

Figure 4: Basic Natural Draft Exhaust Stack Compound Component Inner Elements.

Case Study

As an example, air is assigned as the "flue gas" to the stack component as shown in Figure 2 above. The stack diameter is DN 250 and it is 10 m high. Assuming an atmospheric pressure of 100 kPa and temperature of 15 °C, a density of 1.209 kg/m^3 is calculated and assigned to the stack component for buoyancy calculations. At the inlet boundary, a "flue gas" temperature of 300 °C is assigned with a pressure equal to the atmospheric pressure so that a pressure driving force exists.

A strong flow of 0.441 kg/s and a stack velocity of 9.56 m/s through the stack are calculated. It is also shown that the calculated stack draft is balanced by the total stack losses as there are no other driving forces.

Since the assigned atmospheric density of 1.209 kg/m^3 relates to an atmospheric pressure of 100 kPa and 15°C, the stack draft should be tested at 15°C. As shown in Figure 5, the flow through the stack is now essentially zero.

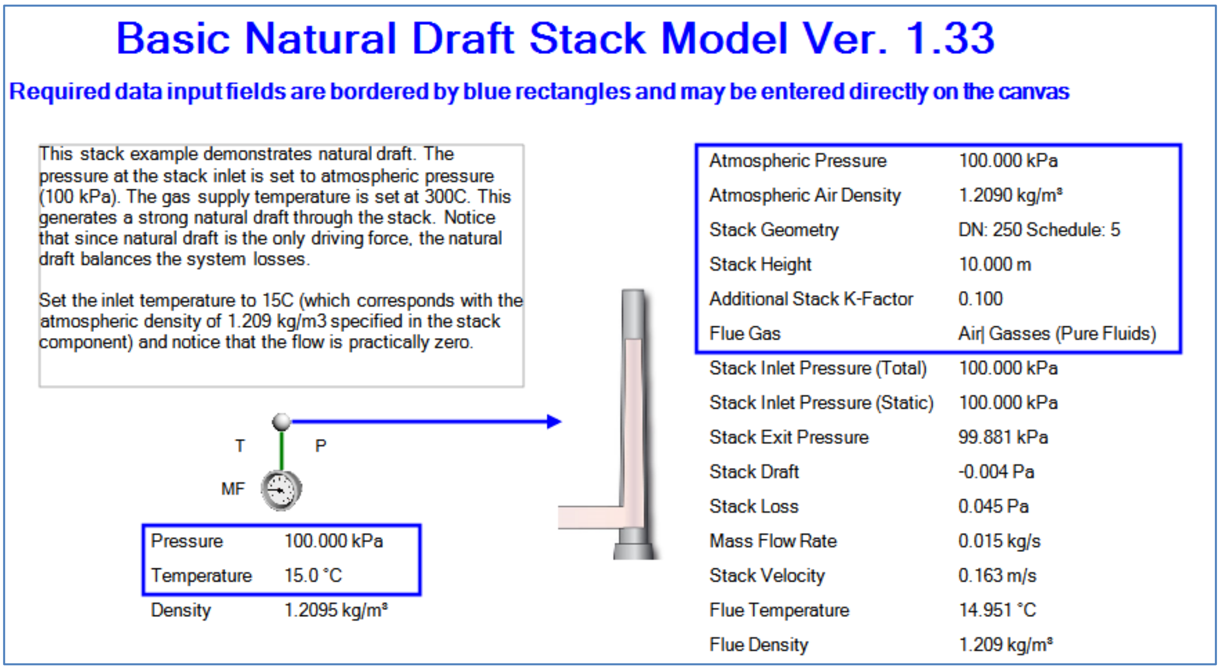

Figure 5: Basic Exhaust Stack Component with Atmospheric Pressure and Temperature at the Entry.

Summary

Even though it is relatively simple to develop compound components, it is a very powerful facility available to the Flownex® user. It may assist in simplifying otherwise complicated and "messy" flow diagrams by packaging related sections of a network into a single component that is far easier to understand and interact with.

However, the most important and powerful use of compound components is that it creates reusable "networks". Once a tested and reliable compound component has been developed, the Flownex® user may simply copy it to any future network and reuse it without any further effort. This is of course true of any compound component.

Flownex® offers the user the ability to develop extensive libraries of dedicated components for any specific application. These libraries may also be made available to other users in the organisation or elsewhere with obvious benefits. This ability sets Flownex® apart from other tools in the industry.

Case Study Flownex Model Availability

The Flownex model discussed in this case study is available in the user project downloads area located at:

http://www.flownex.com/projectlibrary