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PARAMETERIZED SUB-SYSTEMS OF HVAC PIPING SYSTEM

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Abstract

The goal of this paper is to introduce the proposed parameterized sub-systems of HVAC piping system (HVAC = heating, ventilation, air conditioning). Parameterized 3D models of piping sub-systems and supports of piping system were created. Using control parameters we can control not only the size of pipes and supports, but with logical parameters (0/1) and conditions, we can change the sub-system type, or show and hide individual parts of the sub-system. This spectrum of parameterized models enables quick and efficient design of HVAC piping system.

Keywords: parameterized 3D model; HVAC; piping system; optimization.

1. Introduction

At our workplace we deal with design and optimization of HVAC piping system (HVAC = heating, ventilation, air conditioning). Most often, these are pipelines for combustion plants and heating plants [7]. In such plants, these are mainly large diameter pipes (most often in the range of 300 - 1000 mm). Pipes of such large dimensions must be securely fastened to the structure. We deal with design, optimization and structural [1] and temperature [2], [3], [4], [10] numerical simulations of piping systems and supports. The design takes into account the resulting functionality and efficiency, manufacturability, assembly and safety during production and operation. In case of a failure [8], [9] we also deal with the analysis of the problem, such as in the publication [1], where excessive load and failure of supports and piping are solved.

The motivation to create parameterized sub-models was born because identical or similar elements are often repeated on the piping system. Simple and fast modifiable models can save a great deal of time.

In the CAD system - Siemens NX 12.0 parameterized 3D models and drawings are created. Finite element models and simulations are created also in Siemens NX 12.0.

2. Piping system and supports of piping system

Figure 1 shows a part of the piping system (in this case it is specifically the recirculation circuit of the combustion plant). The piping system consists of purchased pipes, pipes made of sheets and supports.

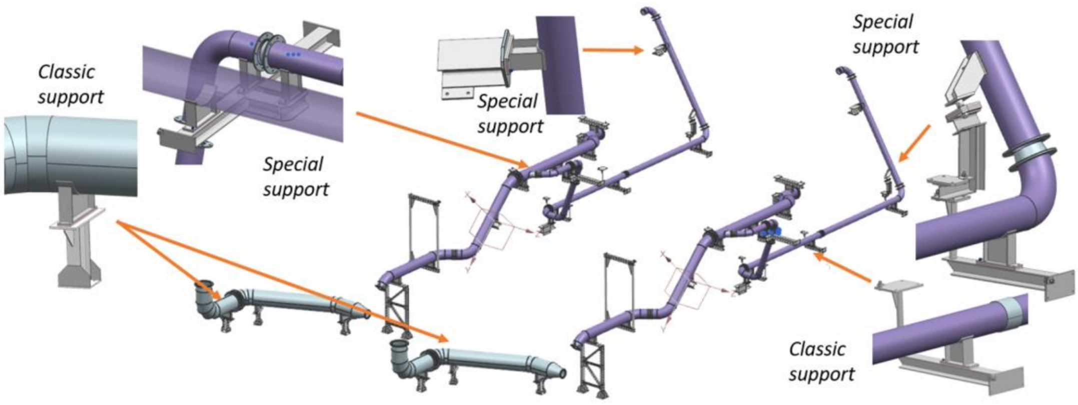

Fig. 1. Sample recirculation circuit combustion plants

3. Parameterized piping system

Fully parametric 3D models of pipes, pipe elbows and pipe transition parts have been created to optimize the pipeline design process. Thanks to fully parametric 3D models, simply by rewriting several parameter values in the table, the 3D model of the given segment is completely changed, which are then assembled into a pipe line.

Figure 2 below shows 3D models of pipes and elbows with their control parameters. In addition to the pipe dimensions, the radius and angle of the knee and the cutting of the ends at the desired angles can be controlled by means of the parameters. The 3D model is designed so that the tubes can be directly unfolded on a sheet metal flat pattern (for laser) to create a drawing of the part with the basic dimensions.

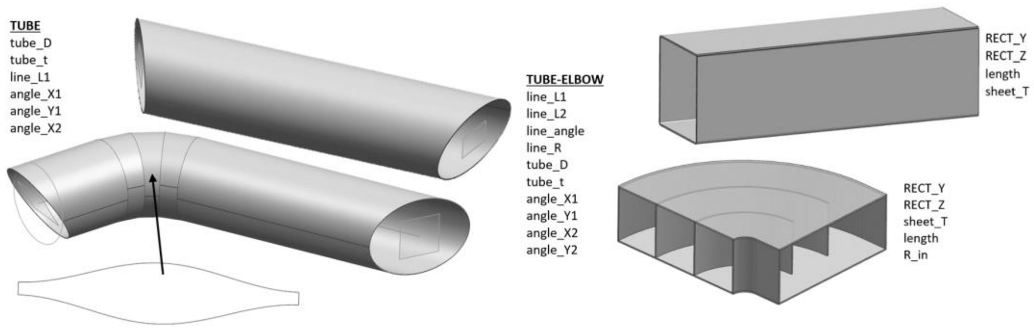

Fig. 2. Parametrized model of a tube and an elbow and control parameters and demonstration of flat-pattern of one sheet

Different transition elements are used when changing the pipe cross-section. Examples of transition elements are shown in Fig. 3 below. The control parameters are the dimensions of both ends, the total length and the offset of the centers of both ends relative to each other. All these transitions are made from one piece of sheet metal and the flat pattern is automatically generated.

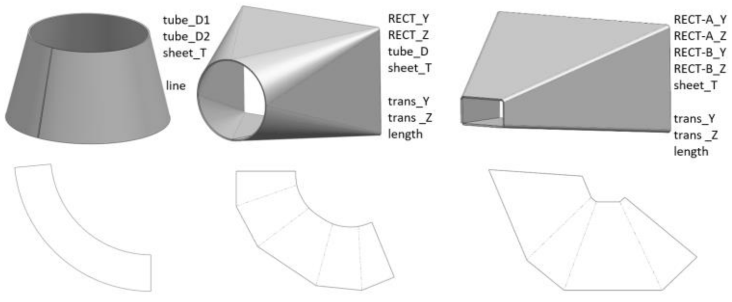

Fig. 3. Transition elements

Fans, preheaters [4], [5], compensators and control valves are often part of the HVAC piping system. All these elements are fixed into the pipeline by means of flanges. Fig. 4 shows parametric models of flanges and deflectors that are part of compensators. The flanges are controlled by only one (circular flanges) or two (rectangular flanges) parameters that control the pipe dimension (internal flange dimension). All remaining dimensions depend on the pipe diameter. The flanges have a uniform thickness of 10 mm. The number and pitch of holes is calculated from the condition that the hole pitch must be between 100 and 150 mm and the number of holes for bolts is always even.

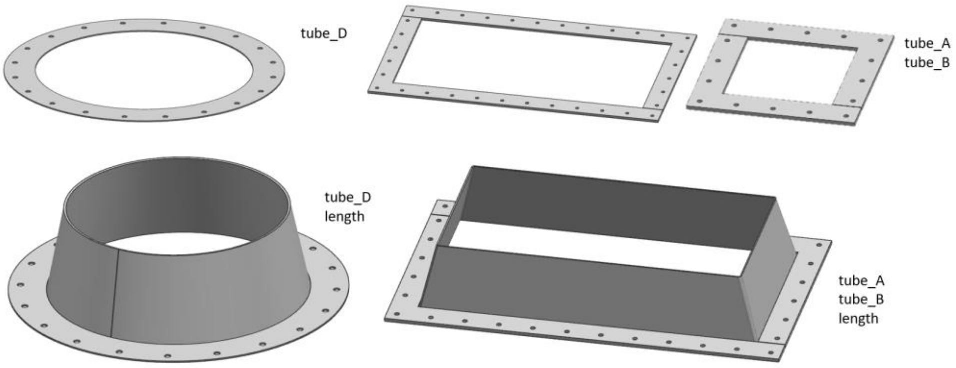

Fig. 4. Flanges and deflectors

4. Parameterized supports of piping system

Most supports are made of sheets and profiles. Therefore, scalable models of HEA, IPE and UPE profiles were created. Figure 5 shows an example of a scalable HEA profile. It is possible to choose from several standardized dimensions, but also to control the parameters of holes and cut the ends of the profile. These profiles serve as the basic building element for further support.

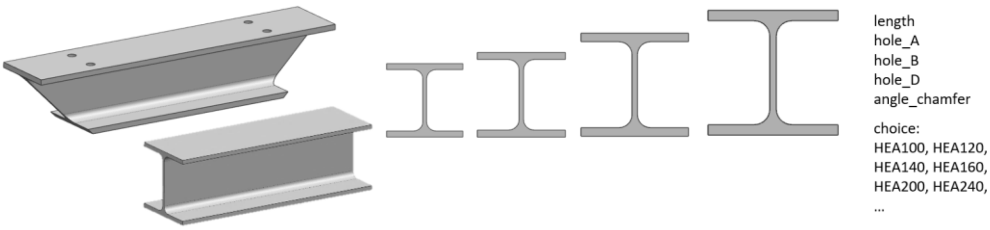

Fig. 5. Scalable model of HEA profile

Figure 6 shows a 3D model of a classic two-point hinge, which is very versatile. In addition to the dimensions, it is possible to switch between the symmetrical and asymmetrical design of the mounting foot and the tubes independently. Individual components can also be suppressed/displayed. All supports are mounted to the supporting structure using lindapters [11], which is basically a clamping connection.

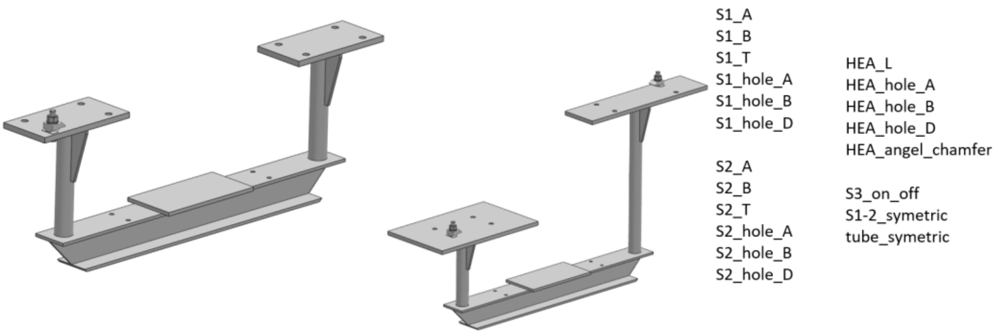

Fig. 6. Two-point hinge

Another frequently occurring support is the beam on two feet (Fig. 7). Here, again, it is possible to set the symmetrical/asymmetrical design, to suppress components, but also to control the position of the feet whether they are on the side or top surface of the profile with one logical parameter.

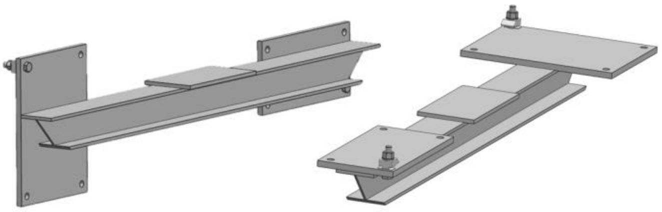

Fig. 7. Beam on two feet

Similarly, a 3D model of additional support is constructed in Fig. 8, wherein the feet are located on the faces of the profiles. This type of support has the same options as the previous model, and it is also possible to rotate the profile to the feet at any angle.

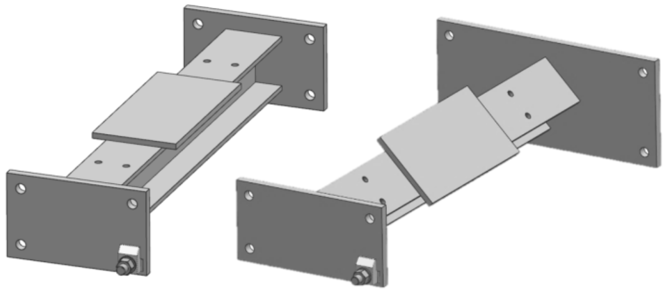

Fig. 8. Beam on two feet – front feet

For anchoring to the floor or foundations, the single-leg support (Fig. 9) is often used, where it is possible to change the dimensions and to choose between sliding or fixing bonding.

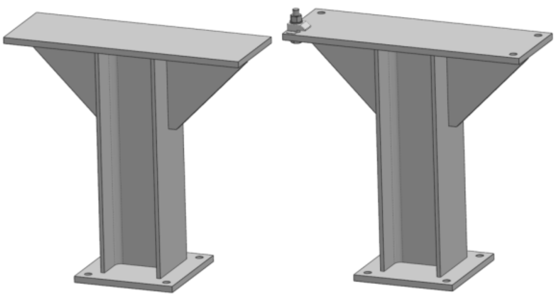

Fig. 9. Simple leg - floor mounting

On the above-mentioned type of support it is possible to place the bottom support (Fig. 10), where it is possible to choose between fixed and sliding bonding.

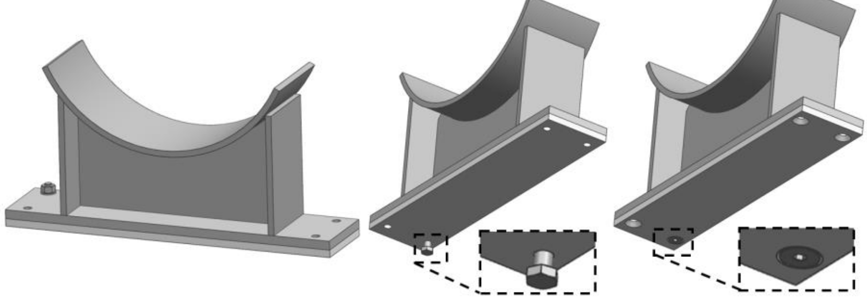

Fig. 10. Bottom support – fixed (b) and sliding version (c)

When mounting into the floor or foundation, where the pipe is at a higher height, the higher leg is shown, as shown in Fig. 11 below.

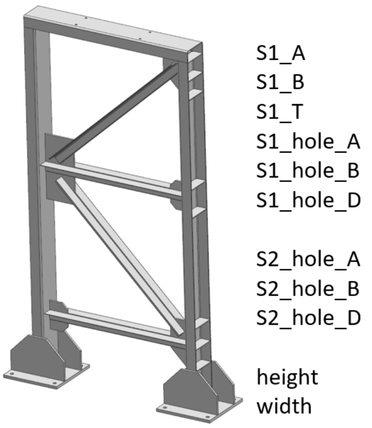

Fig. 11. Higher leg

An insulating layer must always be placed between the pipe and the supporting structure. Usually it is a plastic plate that is clamped between two steel plates. The insulating plate is made of PTFE for hot pipes and PA [6] for cold pipes. An example of an insulating plate is shown in Fig. 10. In Fig. 10 b) (Fix point) serves only as thermal insulation. Fig. c) (sliding point) serves as thermal insulation and as a sliding material.

Fig. 12. Photo-documentation from real incinerator construction - detail on selected piping parts and supports

5. Flow simulation and optimization

Simulations and possible optimization of the air flow in the ducts are carried out during the design of piping system. Fig. 13 shows an example of air temperature simulation. There is a preheater in the extended rectangular part. Before the pre-heater is a cold medium and behind pre-heater is a medium with a temperature exceeding 100°C.

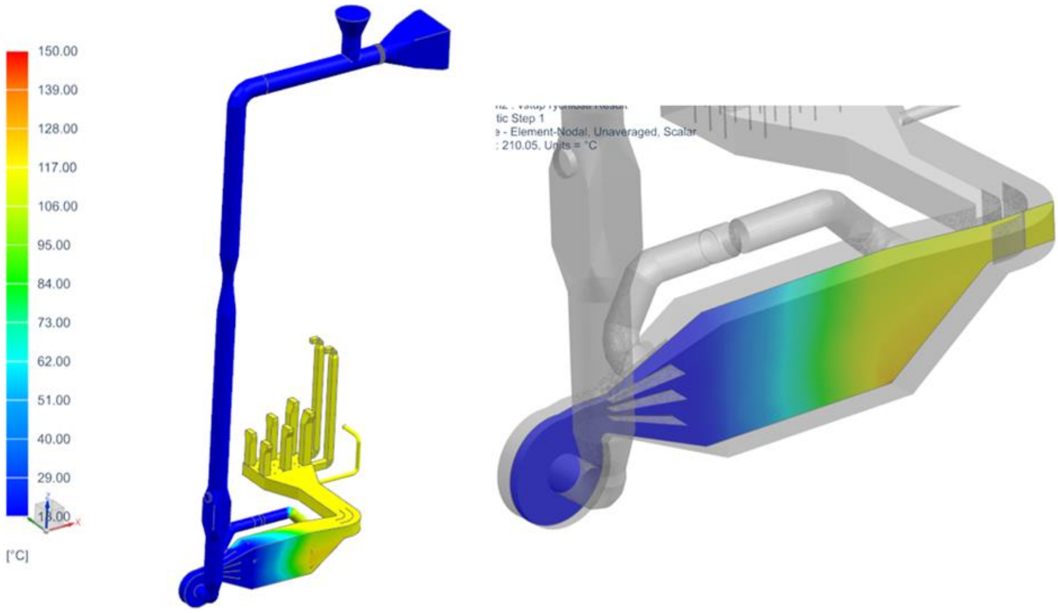

Fig. 13. Simulation of air temperature in ducts

Figure 14 shows the results of flow velocity in the pipeline. The highest medium velocity is seen at the top of the fan outlet. Figure 15 shows the course of temperature during start-up of incinerator.

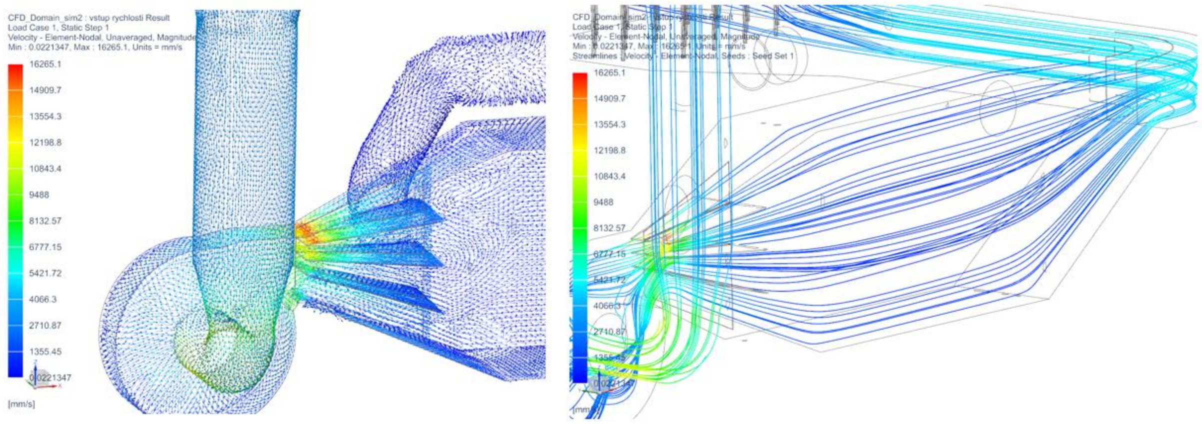

Fig. 14. Simulation of flow velocity in pipeline

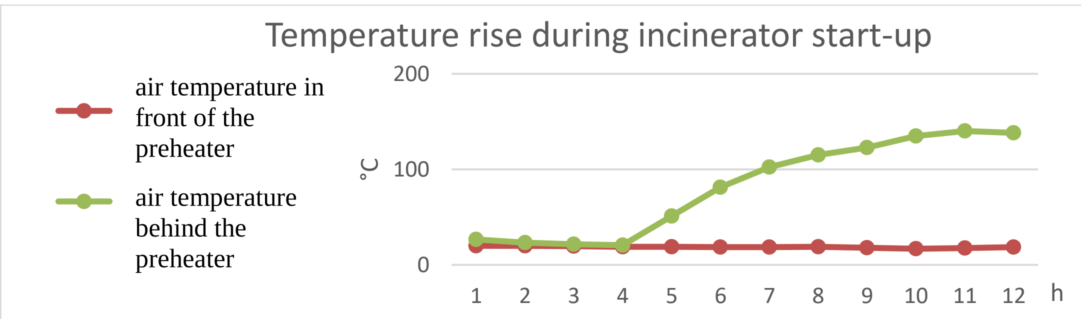

Fig. 15. Temperature course after preheating when the incinerator enters the operating mode

6. Conclusion

Parameterized sub-models of individual parts of piping system and supports have been created, which can now be easily modified and folded into larger units. For models, bolts and other fasteners can be simply suppressed or replaced with logical parameters. The structure of the sub-models allows the flat pattern of the sheet metal parts for laser as well as the drawings of the individual parts to be automatically generated. Created parameterized models lead to time savings and thus also financial savings.

It is also planned that automated sub-models will be stacked one after another, without manual definition of constraints.

7. Acknowledgments

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