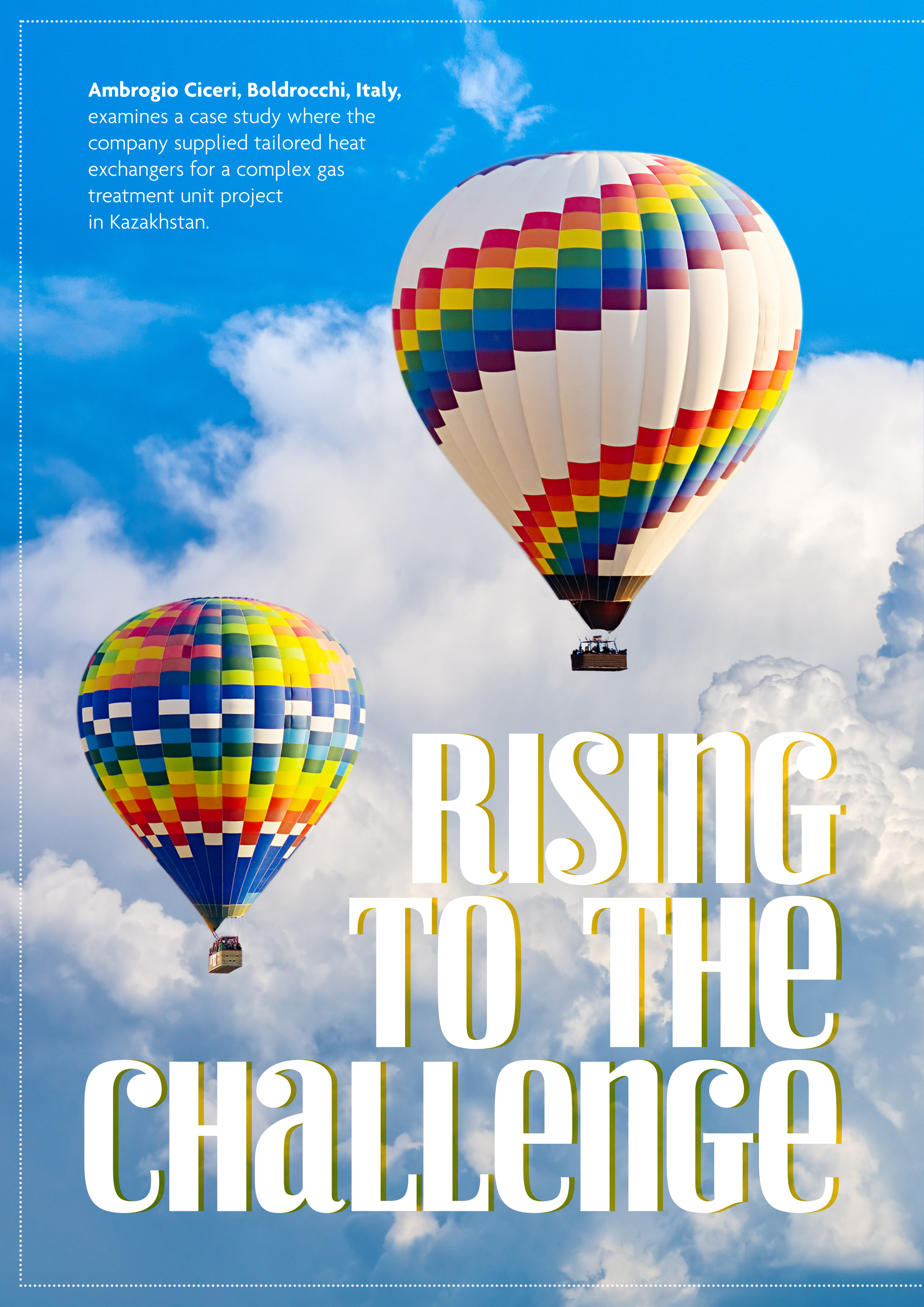

Ambrogio Ciceri, Boldrocchi, Italy, examines a case study where the company supplied tailored heat exchangers for a complex gas treatment unit project in Kazakhstan.

RISING TO THE CHALLENGE

Nostrum Oil & Gas (formerly Zhaikmunai), an independent oil and gas exploration and production company, is on schedule to complete its third gas treatment unit (GTU3) this year in the Chinarevskoye field, Kazakhstan. Situated in north Kazakhstan, Chinarevskoye is 75 km northwest of the super-giant Karachaganak field. Although Nostrum was granted the exploration and production license of the Chinarevskoye field under a production sharing agreement (PSA) in 1997, commercial crude oil production started in 2007 and the commercial production of gas treatment facility (GTF) products (stabilised condensate, LPG and dry gas) began later, in 2011. Operations have been ramping up ever since. Nostrum's third GTU is considered essential to the company's strategy of increasing operating capacity and the production of liquid hydrocarbons.

Boldrocchi Group was awarded a contract – through the engineering, procurement and construction (EPC) contractor – to engineer, purchase raw materials, manufacture, inspect, test and deliver nine process heat exchangers for the complex GTU3 project. In addition to the air-cooled heat exchangers, Boldrocchi was also contracted to design and manufacture the steel support structures, motors, fans, louvres, actuators, floors and complete cabinets for the coolers.

The project

The nine heat exchangers were installed to cool natural gas as part of the downstream process. There are special demands on heat exchangers in oil and gas processing. To ensure high performance under all conditions, reliability and longevity, the thermal and hydraulic design portion is complex yet crucial. It is also imperative to properly evaluate the life-cycle cost, footprint and weight of the system. The coolers must not only withstand corrosive media, but extreme pressure and temperatures. In this case, they also had to conform to a specific layout and be light enough to be placed atop pipe racks.

Although each of the nine heat exchangers was similar, they did vary in design, dimensions and construction material. The smallest was 3 m x 12 m x 10 m high, while the largest had four bays and measured 35 m x 12 m x 10 m high. All air coolers were built to the relevant codes and standards: API 661, ASME VIII div. 1 (with ASME U-stamp and National Board registration), as well as local Kazakhstan laws and regulations (e.g. GOST requirements).

Boldrocchi used both extruded finned tubes and embedded finned tubes.

Thermal challenges

Boldrocchi has had several contracts in Kazakhstan, Russia, and other countries in the region, over the years. It has a local manager in Russia, so the team was familiar with some of the challenges of this climate. This contract, similar to some of the others, presented complexities, mostly due to the weather. Kazakhstan is known for its bitterly cold temperatures, but also for its warm – if not considerably hot – summers. Arctic air masses can lead to -50˚C in winter, whereas summer months can see temperatures of up to +40˚C. During the design of the external air-cooled heat exchangers, in this contract, the ambient temperature fluctuations were a major challenge.

The company's engineers used data received from the customer to design the thermal requirements of the heat exchangers. This included flow rates, heat duties (the amount of heat needed to transfer from a hot side to the cold side over a

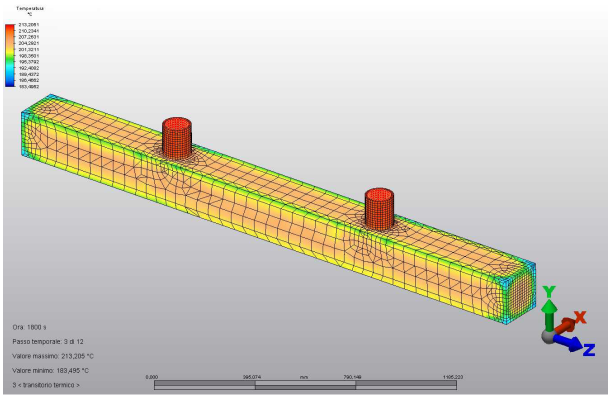

Figure 1. Thermal transitory (step 3 of 12).

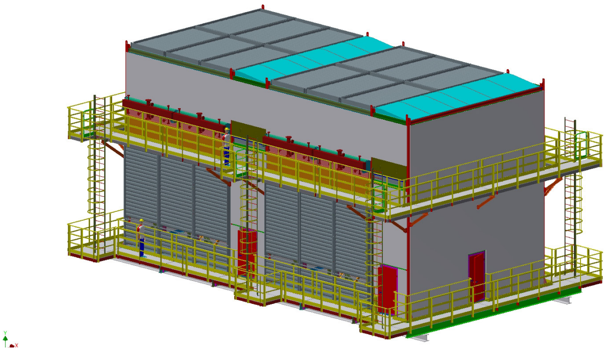

Figure 2. Stabiliser product cooler.

unit of time), physical properties of the gas, condensate curves for two-phase mixtures, environmental conditions, pressure drop and layout limitations. They used Xace®, by HTRI, to perform the thermal design. Boldrocchi's in-house testing facilities allowed the company to verify its thermal efficiency calculations, guaranteeing peak performance and reliability.

The client had requested that the recirculation was external – a more complex type of recirculation, especially considering the enormous temperature fluctuations. However, external recirculation in this case would better protect the equipment during start-up and shutdown. The heat exchangers also included hot oil coils, allowing the equipment to be pre-heated during start-up while also offering greater flexibility to control the ambient temperature during winter. Problem solving skills were necessary to find the optimal thermal design with this recirculation system, given the weather conditions.

In the end, the team based the heat exchangers' thermal design on spring/summer conditions, but enclosed them in cabinets (steel casings), as discussed further below, to allow for increased ambient heat capture during colder periods. It was also crucial to establish the minimum exchange tube wall temperature during significant temperature changes, to avoid hydrate formation. To avoid fouling, the team made thermal calculations that resulted in the reduction of the exchange coefficient (Figure 1). Practically speaking, it meant increasing the surface area. Boldrocchi engineers studied this at length, giving the customer specific instructions as to how to correctly control the inlet, exhaust and recirculation louvres, as these louvres control the ambient air temperature and, therefore, the tube wall temperature as well.

Mechanical challenges

Pressure parts (headers and connecting tubes) were calculated and designed based on ASME VIII Div. 1 code and, where applicable, the rules of the GOST code. However, these codes did not cover all details, and finite element analysis (FEA) was performed to check the stability of the nozzle openings on the headers, as well as the stress due to the piping loads on the nozzle attachments.

It was also important to verify that the connection between the headers and the bundle frames did not have a major effect on the stress distribution and the fatigue resistance. The fatigue potential due to the sinusoidal variation of the temperature had to be analysed, which was carried out at constant pressure. Engineers also used FEA to find the cyclic stress on the headers due to the strain generated by the tube bundle.

Steel structures and cabinets

The steel structures supporting the heat exchangers also required particular attention. It was imperative to carefully calculate the static and dynamic loads as the heat exchangers were to be mounted on the top of the pipe racks. In addition, they also had to be designed to withstand earthquakes, as Kazakhstan is in an active seismic zone.

Another challenge to the heat exchangers being on top of the pipe racks was accessibility. Boldrocchi's team had to ensure that all instruments on these coolers were fully accessible at any time. Each automatic louvre is actuated with a pneumatic piston that receives an electric signal to close and/or open it. All these actuators, along with all the instruments and valves assembled on the machines, had to be easily reachable for general operating purposes and for maintenance. To create an appropriate accessibility design, the requirements were analysed with a 3D model, allowing for an easy and more confident approach to designing the layout of the cable trays. The answer lay in carefully positioned platforms and ladders on each of the steel structures, for the respective air coolers.

The company also designed and manufactured the cabinets in which the heat exchangers are located (Figure 2). Due to the extreme temperature fluctuations, it was imperative to place the coolers in a 'cabinet' or steel structure that could be fully closed in winter, and opened partially or completely, due to louvres, at other times of the year.

Timing

Boldrocchi was contracted to execute the entire project within 11 months – a time frame that was respected. Indeed, all nine heat exchangers, the steel structures, motors, fans, etc. were delivered to the site in September 2016, on standby for when the site crew was ready for them.

Conclusion

Heat exchangers in oil and gas downstream processing must be designed for heavy duty, complex parameters. This was a project that required extra analysis, consideration and testing to ensure the solution's high performance under all conditions, reliability and longevity. The thermal and mechanical design of the heat exchangers was complex due to extreme environmental conditions, whereas the footprint and weight were crucial elements due to the coolers' placement atop pipe racks.