HEAT EXCHANGERS

ZVU Engineering a.s., Member of ZVU Group

CONTENTS

1 INTRODUCTION

ZVU Engineering designs and delivers heat exchangers for various process applications, namely for chemical and power industries. Tradition of many years at delivery of this commodity and vast know-how in the field of heat exchange equipment design allow our specialists to design and implement technically demanding heat exchangers in compliance with specific process requirements of customers.

ZVU Engineering belongs to experienced suppliers of shell & tube heat exchangers. Acting as a member of ZVU group, ZVU Engineering has designed, delivered, installed, and commissioned over 60 pieces of heat exchangers.

Heat exchangers designed by ZVU Engineering permanently feature verified construction elements and sub-assemblies which principally influence effectiveness and lifetime of the entire heat exchange unit. Actual technical solutions reflect the output requirements, and are aimed to satisfy customers´ needs through high quality delivery and long-termed reliability.

Therefore, lasting attention is devoted to critical parts, such as tube-to-tubesheet joints, weld joints of shell with tubesheets and girth flanges respectively, etc.

ZVU Engineering deliveries comprise mainly shell & tube heat exchangers and special heat exchangers, produced of carbon steel, stainless steel, alloy steel, and non-ferrous metals. Working pressures cover a wide range beginning with vacuum up to 20 MPa, while working temperatures are within minus 200 °C up to 850 °C.

Fig.1 Heat Exchangers for Petrochemical Unit

2 CONCEPTION OF SHELL & TUBE HEAT EXCHANGERS

2.1 Complex Solution

For a long time, ZVU Engineering has been delivering complex heat exchange systems, partial systems, and individual heat exchangers to both domestic and foreign markets.

ZVU Engineering advantage is, before all, its ability to solve heat exchange process systems in complex manner, i.e. not only from simple heat exchange physics, but with regard to operation economy and maintenance of complete unit as well.

From user's point of view, it is recommended to contact ZVU Engineering experts already in the very beginning of heat exchange system concept solution so that most optimum design could be mutually proposed to fit with the entire heat exchange operating unit.

As en example for the complex solution of heat exchange operating unit is the gas cooling unit with steam by-production where both heat exchanger operation size had to be taken into account, and the requirements for steam production, condensate outlet control, and economic expenses for cooling water

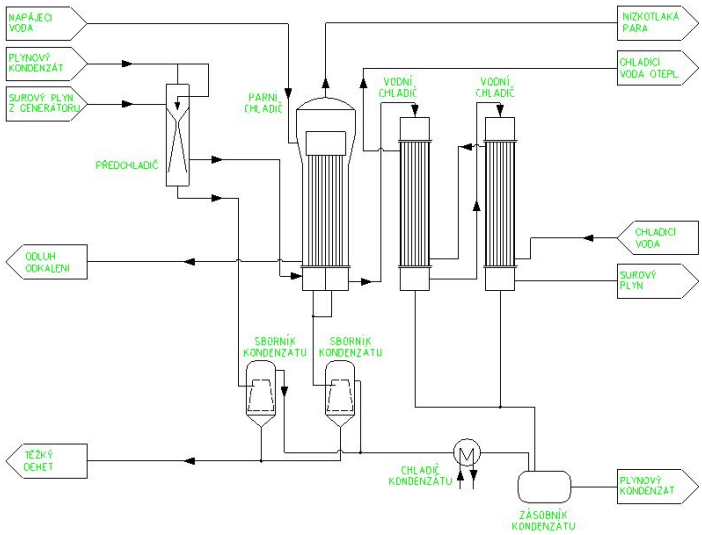


Fig.2 Diagram of Cooling Raw Gas Generated in Coal Pressure Gasification Unit

Within complex solution framework of heat exchange operating units, ZVU Engineering applies standard shell & tube heat exchangers, as described in greater details consequently, to minimize investment expenses.

However, in many cases the standard heat exchangers do not satisfy the technological process of heat exchange, and different solutions shall be applied to provide complex design suitable for the process technology. Special heat exchangers are those ones derived from the standard heat exchangers, but adapted in their conception to suit the relevant heat exchange characteristics and process media. Examples of several special heat exchangers delivered by ZVU Engineering are described as follows.

2.2 Kinds of Heat Exchangers

2.2.1 Liquid, Gas – Liquid, Gas

Heat transfer processes between liquid or gas on one side, and liquid or gas on the other side are relatively widely worked out so that there exit relations verified by good engineering practice for a long time, thus enabling to determine the required heat exchange area in comparatively precise way.

Pre-condition how to determine heat exchange area with regard to investment and operation expenses is professional assessment of conditioning parameters, such as media flow velocity, temperature gradient, heat exchanger arrangements, etc.

Based on long-termed practical experiences and operation result measurements, ZVU Engineering is in possession of vast database of different alternatives, enabling most optimum selection how to provide the heat exchanger arrangement.

Fig.3 Liquid-Liquid Heat Exchangers

2.2.2 Gas, Liquid – Boiling Liquid

Heat transfer processes between liquid or gas on one side, and boiling liquid on the other side can be proposed in good framework way, using advanced calculation programs. A lot of calculation models can found in technical literature.

Nevertheless, practical applications do not provide unambiguous and precise definitions in order to decide whether marginal conditions for heat exchange area design as well as calculation formula comply fully with theoretical presumptions

Therefore, theoretical calculation formulas shall be subject to corrections, based on know-how of their own, gained by actual operation evaluation.

On designing heat exchangers operating under change of state at boiling working medium, significant role is played by problems of spaces for steam generation and

separation of entrained non-evaporated liquid and liquid circulation in evaporator as well. Those facts bring about extreme impact on heat exchanger dimensioning.

ZVU Engineering designed, delivered and put into operation many heat exchangers of reboiler type, both of horizontal and vertical arrangements. Utilizing those operation references, it gained know-how which is unconditional presumption to implement heat exchangers of that heat transfer kind.

Fig.4 Heat Exchanger / Boiler with Steam Generation

2.2.3 Gas, Liquid – Gas, Steam at Condensation

To solve mechanism of heat transfer between liquid and gas on one side and steam at condensation state on the other side, the above mentioned notes are valid in full extend, i.e. the state when the task given can seldom be solved by calculation models being in compliance with textbook examples.

On designing those heat exchangers, significant role is played by problems of controlled condensate discharge, presence of inert phase, and fouling manner of heat exchange surface.

Engineers of ZVU Engineering had the chance to apply, confirm in back way, and carry our calculation corrections of total or partial condensation at many an actual deliveries. The fact enabled the company to reach renowned position among the suppliers, being able to solve the task.

ZVU Engineering designed, delivered and put into operation many heat exchangers with vapour compound condensation, both of horizontal and vertical arrangements. Utilizing those operation references, it gained know-how which is unconditional presumption to implement heat exchangers of that heat transfer kind.

Fig.5 Bundle of Heat Exchanger with Condensation

2.3 Standard Types of Shell & Tube Heat Exchangers and Their Usage

2.3.1 Heat Exchangers with Fixed Tubesheets and Shell Side Expansion Joint Respectively

Heat exchangers with fixed tubesheets are used for the operating parameters when temperatures and heat expansion of heat exchange tube material do not evoke expansion disproportion, thus avoiding excessive load in tubes and tubesheets due to different expansion. In contrary case, an expansion joint has to be installed in heat exchanger shell side.

This heat exchanger type is relatively of simple design, however it is not recommended for the operation cases when deposits can occur in shell side, caused by medium characteristics.

Owing to impossibility to clean mechanically the tube outer surface, any deposits can be removed by chemical cleaning only.

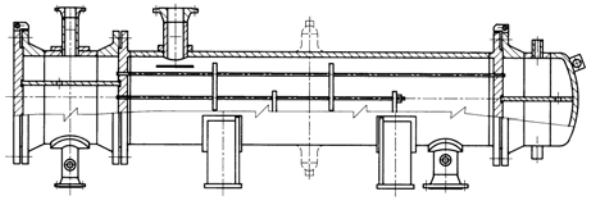
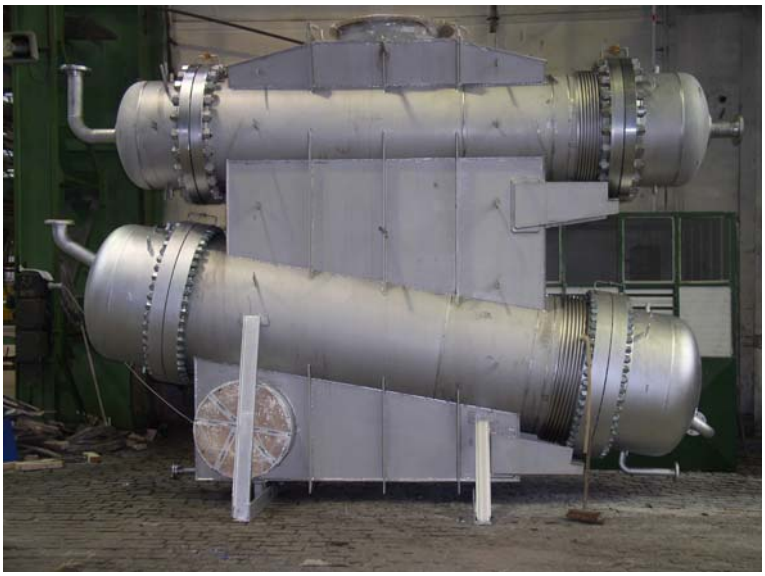


Fig. 6 Heat Exchanger with Fixed Tubesheets and Shell Expansion Joint Resp.

The heat exchangers are determined to provide heat exchange between two operating media (both liquid and gaseous ones) in industrial power supply, petrochemical industry, chemical and foodstuff industries, ecological equipment, etc.

Fig.7 Heat Exchanger with Fixed Tubesheets and Shell Expansion Joint Resp.



Obr.8 Heat Exchanger with Fixed Tubesheest and Shell Expansion Joint. - Stacked Arrangement

2.3.2 Heat Exchangers with Floating Head

Heat exchangers with floating head are used for the operating parameters when heat expansion of heat exchange tubes and heat exchange shell exceed the allowable difference, and different expansions would bring about excessive load in tubes and tubesheets.

Furthermore, this heat exchanger type is recommended for the operation cases when deposits can occur in shell side. After dismantling tube bundle out of the heat exchange, outer surface of heat exchange tubes can be cleaned mechanically.

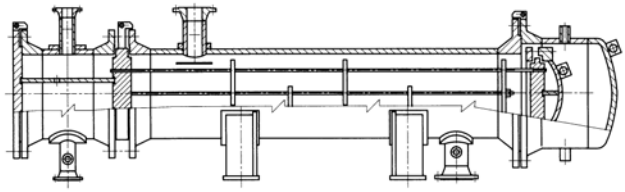


Fig. 9 Heat Exchanger with Floating Head

The heat exchangers are determined to provide heat exchange between two operating media (both liquid and gaseous ones) in industrial power supply, petrochemical industry, chemical and foodstuff industries, ecological equipment, etc.

Fig. 10 Tube Bundle of Vertical Steam Cooler with Floating

2.3.3 Heat Exchangers with U-Tubes

Heat exchangers with U-tubes (called hairpin types too) are also used for the operating parameters when heat expansion of heat exchange tubes and heat exchanger shell exceed the allowable difference.

This heat exchanger type enables to clean its tube bundle without any problems.

ZVU Engineering designed the heat exchanger type also for applications with water steam condensation inside U-tubes and reached excellent operation results. There are mastered the technologies where U-tubes are installed with sloped arms so that condensate could flow out in continuous way.

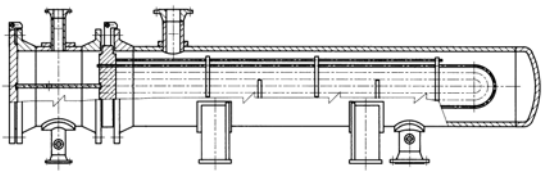


Fig. 11 Heat Exchanger with U-Tubes

The heat exchangers are determined to provide heat exchange between two operating media (both liquid and gaseous ones) in industrial power supply, petrochemical industry, chemical and foodstuff industries, ecological equipment, etc.

Fig. 12 Heat Exchangers with U-Tubes

2.3.4 Reboilers

Heat exchangers of reboiler type are used for the cases where heated medium in shell side is exposed to boiling, and if it is necessary to provide a sufficient area for steam generation. Shell side upper part can be utilized for installation of separation internals in order to catch droplets of non-evaporated liquid.

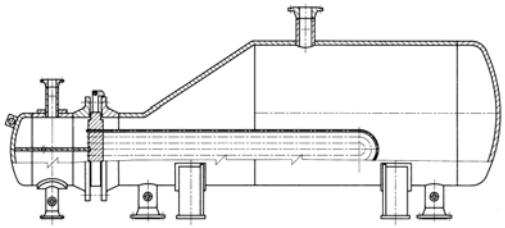


Fig. 13 Reboiler

The heat exchangers are determined to provide heat exchange between two operating media (both liquid and gaseous ones) in industrial power supply, petrochemical industry, chemical and foodstuff industries, ecological equipment, etc., while one working medium is exposed to boiling.

2.4 Materials of Constructions, Standards

2.4.1 Materials of Construction

Selection of materials of construction depends before all upon individual process media characteristics, their corrosion properties, and pressure and temperature parameters.

As for standard cases of fabricated heat exchangers, ZVU Engineering uses carbon steels, stainless steels, and non-ferrous metals.

In special applications, ZVU Engineering uses low and high alloy steels, and clad steels as well.

When choosing a suitable material of construction, ZVU Engineering takes advantage of its own corrosion bulletins, gained on basis of long-termed practical experiences that enable to select the most efficient combination of materials of construction. The choice is subject to evaluation carried out by experts-metallurgists.

2.4.2 Standards

ZVU Engineering has long-termed experiences with deliveries of heat exchanger for both domestic and foreign customers. Based on the experiences, ZVU Engineering can implement heat exchangers in accordance with the Czech Standards (ČSN), respecting the requirements of Directive 97/23/EC of the European Parliament and of the Council - PED, EN standards, as well as in accordance with requirements of the recognized international standards, such as ASME and GOST.

All heat exchangers comply with the latest recommendations of TEMA.

2.5 Designing Heat Exchangers, Dimensions

2.5.1 Dimensional Design

Dimensional design of heat exchangers is based on the required heat exchange area.

To optimize heat exchange area in significant way, question of investment expenses should be taken into account. Determination of heat exchange area is conditioned by significant experiences, namely when solving more demanding cases of heat transfer, such as boiling and condensation states.

Optimizing heat exchange area is relatively time consuming operation that cannot be performed without having at disposal advanced calculation software and vast database of physical-chemical properties of various media, by means of which reasonable solution alternatives can be evaluated and the most advantageous selected.

Considering long- termed operation, the required heat exchange area is influenced principally by fouling factor. Fouling of heat exchange area can be assessed for individual operating media only through lasting engineering practice and operation measurements performed.

During its extensive practice, ZVU Engineering has delivered, put into operation, and tested a great number of heat exchangers. Practical experiences and verified operation results enabled ZVU Engineering to elaborate its own calculation manuals and software how to determine heat exchanger size for a wide scope of operation conditions.

2.5.2 Preliminary Assessment

To provide for a preliminary assessment of investment expenses, the user can make use of heat transfer coefficient guiding values which are stated in this brochure, covering a part of practical applications.

Nevertheless, the values should be considered guideline only, requiring to be verified by a reliable calculation.

Medium I Hot side	Medium II Cold side	Heat transfer coefficient ($W/m^2 K$)
water	water	850 - 1600
gas	water	20 - 270
light oil	water	350 - 900
heavy oil	water	60 - 300
water	brine	580 – 1150
gas	brine	20 – 280
steam condensation	water	2000 - 4400
steam	water evaporation - boiling	2000 - 4400

2.5.3 Parameters

ZVU Engineering delivers shell & tube heat exchangers within the parameters as follows:

Parameters	*Units*	*Values*
temperature	°C	-200 to +600
pressure	MPa	Full vacuum to 10
diameter	mm	273 to 4 000
heat exchange area	m^2	5 to 10 000
weight	kg	to 120 000

3 FABRICATION, ERECTION AND OPERATION

3.1 Fabrication

All heat exchangers are fabricated under strict supervision of ZVU Engineering quality inspector. Quality control of fabricated parts is continuously inspected in accordance with the verified and approved quality control plan.

Special attention is devoted to procedures and construction parts that have significant impact on reliability and lifetime of heat exchangers, such as material quality and identification, traceable parts, execution of shell-to-tubesheet and tube-to-tubesheet joints, etc.

Fabrication is normally concluded by pressure and leakage tests witnessed by user's representative.

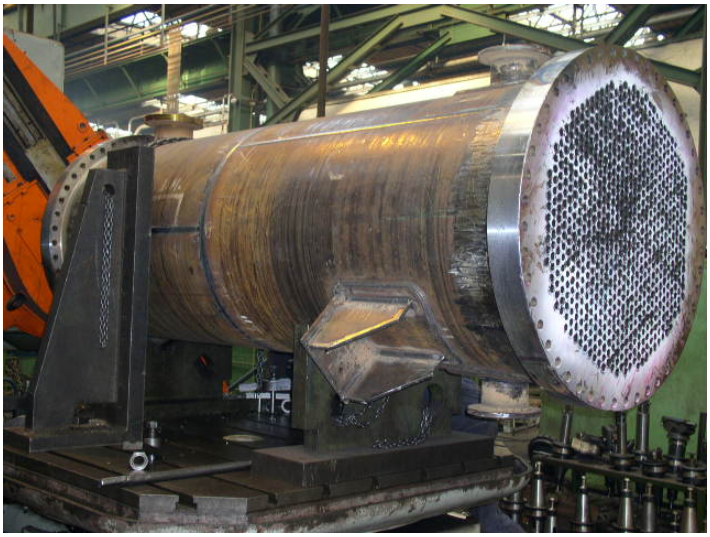


Fig. 14 Heat Exchanger Fabrication

3.2 Erection

Depending on outline dimensions, heat exchangers are delivered in completely assembled state, allowing direct resting on foundations. ZVU Engineering provides erection supervision of its deliveries. Provided client has decided to carry out the erection by its own capacity, the delivery comprises detailed erection instruction as well.

Based on contract agreement, heat exchangers can be delivered in skid-mounted execution, i.e. fully assembled and interconnected on load bearing frames including piping, valves, instrumentation and thermal insulation, if need be.

Equipment delivered in the above mentioned execution has decisive impact on erection period on site, since the time shortening may satisfy the user's need with regard to operation shut-down of consequent facility.

Equipment of greater dimension has to be delivered in divided execution due to transportation and handling reasons. Its erection may be relatively more demanding, therefore, ZVU Engineering supervisor/engineer on site is recommended.

Fig. 15 Erection of Recuperation Heat Exchanger

Fig. 16 Erection of Heat Exchanger Set of Crude Gas Cooling Unit

Depending on user's wish, ZVU Engineering is ready to deliver heat exchangers on the basis of turn-key projects.

3.3 Operation

Erection over, functioning and operation tests shall be carried out under presence of ZVU Engineering specialist.

Depending on user's wish, ZVU Engineering is ready to perform guarantee and output tests to monitor and evaluate all important process and technological parameters, thus proving heat exchanger quality.

Fig. 17 Heat Exchangers

4 SERVICE, MODERNIZATION

4.1 After Guarantee Service

ZVU Engineering's heat exchangers have been designed and fabricated to guarantee their lifetime maximum.

As long as the operating parameters specified by ZVU Engineering are kept, no special maintenance is required. However, ZVU Engineering recommends to check periodically their heat curves and in case of significant deviation from the standard operating parameters, the unit shall be inspected and cleaned eventually.

In similar periods, it is recommended to check tightness of joint having impact on heat exchanger function.

ZVU Engineering offers to perform regular inspections, including replacement of damaged parts.

4.2 Modernization

Although heat exchangers are designed to withstand operation lifetime for 15 years at least, it is obvious technical progress and innovation trends run more quickly.

Based on its own development, ZVU Engineering performs periodical innovation of heat exchangers in such a way so that their design and concept could comply with contemporary trends of modern technique.

Heat exchanger users are recommended to keep permanent contact with ZVU Engineering, and through that procedure obtain continuous information on current design improvements, and operation of their heat exchangers.