

# WASTE HEAT BOILERS

 **ZVU** Engineering a.s., Member of ZVU Group

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# 1 INTRODUCTION

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

The projects concern mainly steam generators installed after sources of heat energy which is released by chemical reaction. Heat bearing medium (gas, flue gas) enters the unit in gaseous phase.

In chemical units, waste heat boilers form a separate power system which completes or solves in many a case the operating unit power balance.

As a rule, any heat recovery unit is designed by ZVU Engineering specialists as an original solution being in compliance with the client's data basis, including engineering design of heat recovery unit layout and relevant machinery. Demanding industrial applications always call for an actual assessment of conception arrangement and selection of equipment arrangement type in order to achieve effective and reliable function of heavy duty equipment mostly.

Acting as a member of ZVU group, ZVU Engineering has designed, delivered, installed, and commissioned over 20 heat recovery units.

Waste heat boilers can be of different design types, such as pressure vessels with tube bundles, fire-tube and water-tube arrangements, vertical or horizontal executions.

Based on operating parameters, waste heat boilers are produced of carbon steel, stainless steel, alloy steel, and often combined with parts of high alloy steels to provide resistance under high temperature impact.

Working pressures cover a range up to 13 MPa, while working temperatures of hot operating media can reach nearly 1200 °C.



*Fig. 1 Heat Recovery Steam Generator Unit for Raw Gas Cooling*

# 2 CONCEPTION OF WASTE HEAT BOILERS

## 2.1 Complex Solution

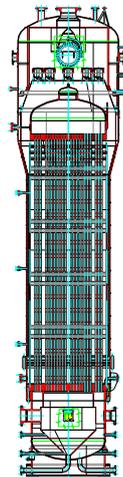
For a long time, ZVU Engineering has been delivering complex heat recovery systems to both domestic and foreign markets. Company has got important references as a supplier of individual heat recovery apparatuses, nevertheless, the scope of supply always includes a significant portion of engineering design.

ZVU Engineering advantage is, before all, its ability to solve heat recovery 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 recovery and exchange operating unit.

As an example for heat recovery from raw gas generated in coal pressure gasifier is the vertical steam boiler where raw gas is cooled down to generate steam.

On designing that demanding apparatus, a complicated mechanism had to be taken into account, namely partial condensation of steam contained in raw gas, steam generation requirements, and how to solve internal circulation relations in evaporator.



*Fig. 2 Vertical Steam Boiler with Floating Head*

## 2.2 Kind of Heat Exchange

### 2.2.1 Gas – Boiling Liquid

Heat transfer processes between gas on one side, and boiling liquid on the other side being principal mechanism how to achieve effective cooling down gaseous phase, are subject of relatively comprehensive works and there exist procedures in professional sources, specifying necessary conditions to determine heat exchange area required.

Nevertheless, practical applications mostly do not provide precise definitions, and the heat exchange area calculated by using theoretical procedures may not correspond with the actual heat exchange requirements. Therefore, theoretical calculation results shall be subject to corrections, based on know-how of their own, gained by actual operation evaluation.

In the field of waste heat boiler design, the above stated problems are often deepened when operating the equipment under high pressure and temperature of working media, thus facing even more demanding requirements for a precise thermal calculation.

A significant role having impact on waste heat boiler design is played by problems of spaces for steam generation and separation of entrained non-evaporated liquid and liquid circulation in evaporator as well.



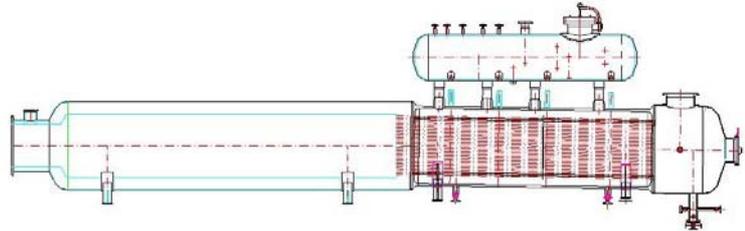
Fig. 3 Tube Bundle of Vertical Waste Heat Boiler

## 2.3 Heat Recovery Units and Their Usage

### 2.3.1 Heat recovery steam generation units are determined for chemical, petrochemical, and power industries

Usual applications are the waste heat boilers being operated mainly with hot process gas under high pressure, where the generated steam serves to generate electricity, to drive machines, or to be utilized as working medium in various chemical processes and to heating purposes as well.

As for a typical example of heat recovery unit, the horizontal waste heat boiler is shown, having an integrated steam collector of mono-block arrangement which is used to cool down process gas in sulphur recovery units.



*Fig. 4 Horizontal Waste Heat Boiler with Steam Collector*

Waste heat boilers are used in various industrial process technologies, such as:

- Nitrogen and hydrogen mixture production for ammonia synthesis
- Ammonia synthesis
- Ethylene production
- Rubber production
- Raw gas production from coal pressure gasification plants
- Sulphuric acid, sulphur oxide and sulphur productions
- Nitric acid production
- Exhaust gas liquidation
- Distillery slops liquidation – potash production
- Hydrogen production
- Methanol production



*Fig. 5 Waste Heat Boiler in Hydrogen Production Unit*

### 2.3.2 Flue Gas Heat Recovery Units

Waste heat boiler for those applications recover the heat contained in flue gas (under about atmospheric pressure) leaving combustion facility to generate saturated or superheated steam, or to produce hot water. Boilers are designed to various heat output capacities, pressures a temperatures, complying in extend and layout with the actual conditions and client's requirements.

Based on local conditions, boilers generating saturated steam can be completed with economizers to heat up boiler feed water, or superheaters to produce superheated steam.

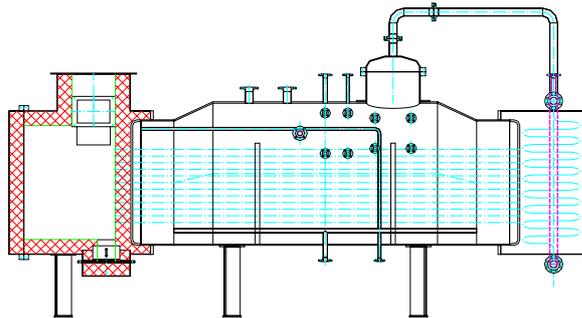


Fig. 6 Waste Heat Boiler for Flue Gas Cooling

## 2.4 Materials of Construction, 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.

Moreover, basic role is also played by the fact that process gases, heat of which is utilized in waste heat boilers, contain high corrosive compounds as well that can condensate on heat exchange surface when cooled down.

As for standard cases of fabricated waste heat boilers, 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 recovery units 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.

## 2.5 Designing Waste Heat Boilers, Dimensions

### 2.5.1 Dimensional Design

Dimensional design of waste 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, as boiling state.

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 waste heat boilers. Practical experiences and verified operation results enabled ZVU Engineering to elaborate its own calculation manuals and software how to determine waste heat boiler size for a wide scope of operation conditions.

### 2.5.2 Parameters

ZVU Engineering delivers waste heat boilers within the parameters as follows:

<i>Parameters</i>	<i>Units</i>	<i>Values</i>
temperature	°C	up 1 200
pressure	MPa	13
diameter	mm	4 000
weight	kg	to 120 000

# 3 FABRICATION, ERECTION AND OPERATION

## 3.1 Fabrication

All parts of waste heat boilers 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, execution of shell-to-tubesheet and tube-to-tubesheet joints, execution of ferrules at tube bundle inlet part, etc.

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



*Fig. 7 Waste Heat Boiler at Fabrication*

## 3.2 Erection

Depending on outline dimensions, waste heat boilers are delivered in completely assembled state, allowing direct resting on foundations. Equipment erection is rather simple and the user has at disposal detailed erection instruction.

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.

Depending on user's wish, ZVU Engineering is ready to deliver waste heat boilers and related technological equipment on the basis of turn-key projects.



*Fig. 8 Process Unit Erection - Heat Recovery from Liquid By-Product Gasification Unit*

### **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 quality of delivered equipment.



*Fig. 9 Waste Heat Section*

# 4 SERVICE, MODERNIZATION

## 4.1 After Guarantee Service

ZVU Engineering's waste 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 heat curves of waste heat boilers and in case of significant deviation from the standard operating parameters, the unit shall be inspected and cleaned eventually.

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