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Aluminum Plate-fin Heat Exchanger

铝制板翅式热交换器

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Aluminum plate-fin heat exchanger

1 Scope

This standard specifies the requirements of design, manufacture, inspection acceptance, installations, application and maintenance of Aluminum plate-fin heat exchanger (hereinafter referred to as heat exchange).

1.1 This standard is applicable to the heat exchanger with design pressure no greater than 8.0MPa. For the heat exchanger with design pressure greater than 8.0MPa, it may be designed and manufactured with reference to this standard when the buyer is agreed upon.

1.2 The design temperature range suitable to this standard is -269°C~200°C.

1.3 This standard is applicable to the heat exchangers applied in the situation of air separation and liquification equipment (ASU), natural gas processing (NGP) and liquification (LNG), petrochemical engineering and mechanical power devices.

1.4 The pressure parts of heat exchanger which couldn't be determined by this standard, through the assessment and ratification of the National Technical Committee on Boilers and Pressure Vessels of Standardization Administration of China, may be designed by adopting the following methods:

a) The stress analysis (except the unit qualified for analysis design) including finite element method;

b) Replication experimental analysis (such as experimental stress analysis and replication hydraulic test);

c) The comparable structure which has been put into service shall be adopted to carry out the comparison empirical design.

2 Normative References

The following documents are indispensable to the application of this standard. For dated reference, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

GB 150 Steel Pressure Vessels

3.4.1.6 When the heat exchanger is operated in vacuum state, the design pressure of vacuum layer shall be considered according to the bore external pressure and when the safety control device is installed, the design pressure is taken with the minimum value of 1.25 times of the maximum internal and external pressure difference and the 0.1MPa; when no safety control device is installed, it shall be taken as 0.1MPa.

3.4.2 Design temperature

3.4.2.1 The increase of internal thermal stress shall not exceed the ultimate strength of material and the maximum recommended allowable temperature difference is 50°C between the aluminum heat exchanger layers (on the same section) in the steady state; However, for the fluid with phase change and instant circulation, the recommended temperature difference shall be 20°C~30°C.

3.4.2.2 When the design temperature is not greater than 65°C, the aluminum alloy with magnesium content of more than 3% shall not be adopted.

3.4.2.3 The design temperature shall not be less than the maximum temperature attained by the parts metals under operating conditions. For the metal Temperature of below 0°C, the design temperature shall be -269°C at the lowest.

3.4.2.4 When the metal temperatures of heat exchanger parts are different under operating conditions, the maximum temperature shall be complied with to design. In any case, the metal surface temperature of parts shall not exceed the allowable service temperature of material.

3.4.2.5 The metal temperature of parts may be attained by heat transmission calculation or measured on the heat exchanger in the same applied working condition or determined according to the medium temperature. For the heat exchanger in different working condition, it shall be designed according to the harsh working conditions group; the pressure and temperature values in the working conditions shall be indicated in the drawing or corresponding technical provisions.

3.4.3 Fluid medium

The media characteristics used in the operational process shall be restricted. The fluid shall be clean and free of corrosive action to the aluminum alloy; generally the corrosion allowance is not taken into consideration. The media which can easily be scale formed, settled and block the heat exchanger shall be controlled.

3.4.4 Load

The following loads shall be taken into consideration in design:

determined according to those specified in JB/T 4734 or according to the mechanical property and safety factor as provided by the corresponding standards; for the materials of pressure parts, such as heat transfer fin and parting sheet, it shall be determined by dividing the tensile strength value as specified in GB/T 3198 and YS/T 69 by the safety factor 4~6.

3.6 Welded joint factor

The welded joint factor φ shall be determined according to the welding method and welded joint mode of pressure parts as well as the linear scale of nondestructive test:

a) For the butt joint of both sides welding and the full penetration butt joint equivalent to the both sides welding:

   The 100% nondestructive test φ=0.95;

   Partial nondestructive test φ=0.8.

b) The joint of single welded butt joint (stool plate is closely clung to the base metal along the seam root full length):

   100 % nondestructive test φ=0.90;

   Partial nondestructive test φ=0.8.

When the welded joint couldn't be carried out with nondestructive test due to structure, full penetration structure shall be adopted for the welded joint and the welded joint coefficient is generally not greater than 0.6.

3.7 Pressure test

Pressure test shall be carried out after the heat exchanger is manufactured. The manner, requirements and test pressure of pressure test shall be indicated in the drawing.

The pressure test is generally adopted with hydraulic test and the testing liquid shall be carried out according to those specified in 6.2.

For the heat exchanger which is not allowed to have residual liquid or the hydraulic test couldn't be carried out with full liquid due to structure may be adopted with the pneumatic test. The heat exchanger to carry out pneumatic test and leakage test shall be in accordance with those specified in 6.2.

3.7.1 Test pressure

d) When assembling, each seriate braze welding component shall be drawn aside with each other, but not wrap. When the design pressure p≤2.5MPa, the splicing gap of the braze welding cellular shall not be larger than 1.5mm, and the part shall not be larger than 3mm, and when the design pressure p>2.5MPa, the splicing gap of the braze welding cellular shall not be larger than 1mm, and the part shall not be larger than 2mm. The special requirements of splicing gap shall be noticed in the pattern.

6.1.3.2 Joint brazing procedure

The establishment of the joint brazing procedure shall be carried out according to the qualified evaluation of the joint brazing procedure.

6.1.3.3 Appearance of the block

a) The welded joint of the block shall be satiation and smooth, the phenomenon which the spelter blocked the channel shall be avoided.

b) The wing shape of the distributor fin shall be regular, and shall not come out of the parting sheet.

c) The cove of the side bar between two adjacent floors which outer flip quantity shall not excess 2mm;

d) The dislocation quantity of the upper and lower plane of the block shall be no larger than 1.5mm of each 100mm, and the total dislocation quantity shall be no larger than 8mm.

e) The total amount of the inferior fovea pleural shall not excess 1% of the block lamination gross thickness.

6.1.4 Welding

6.1.4.1 Type of welded joint

The welded joint type shall be chosen according to the medium temperature and loading conditions, when choosing the welded joint type, the generation of oversized stress concentration and obvious profile revulsion shall be avoided, the alternative welded joint type is provided in annex B.

6.1.4.2 Welding process

a) The welding procedure qualification before the construction of heat exchanger shall be carried out according to the JB/T 4734 in annex. The welding process

document of the heat exchanger shall be formulated according to the pattern technical requirements and evaluation qualified welding process and the JB/T 4734 in annex E.

b) Welding procedure qualification report, welding procedure specification, welding records and the welder identification must be kept for at least 7 years. The welder identification shall be written at the specified part of the container, but the steel seal shall not be written on the corrosion proof surface.

c) The requirements of the shape, dimension and appearance of the welded joint, the repairing requirements of the welded joint shall be in accordance with relevant provisions in JB/T 4734.

d) The tungsten electrode argon arc welding, consumable electrode argon arc welding or other welding methods which have passed the test and can be sure of the welding quality shall be adopted in the welded joint and solder joint of repairing welding of the A, B, C, D type compression components.

6.1.5 Header

The wall thickness reduction quantity of moulding rear head shall not be larger than 10% of the pattern nominal thickness, even no larger than 3mm.

6.1.6 The limit deviation of the linear dimension of machined and unmachined surfaces shall respectively comply with the requirements of Class m and Class c in GB/T 1804.

6.1.7 Nondestructive testing

6.1.7.1 The compression components noumenon of the header and nozzle etc. and the nondestructive testing of the complex part welded joint shall be in accordance with those specified in JB/T 4734. The radiographic testing shall be carried out according to JB/T 4730.2 or the ultrasonic testing shall be carried out according to JB/T 4730.3 on the butt joint.

6.1.7.2 The full penetration structure shall be adopted on the welded joint of the header and block. The penetrant testing shall be carried out according to JB/T 4730 when heat treatment is adopted to improve the material mechanical strength of the header, and also shall be carried out in accordance with the pattern if required.

6.1.7.3 The butt joint between the adjacent headers which need to be done when final assembling, as to the part which the ray or ultrasonic testing cannot be carried out, the penetrant testing shall be carried out according to JB/T 4730.5, and Level I is qualified.

6.2.2.2 Pneumatic test

The dry and oil-free clean air, nitrogen or inert gases shall be adopted as the testing medium in the pneumatic test of heat exchanger; the test pressure shall be in accordance with those specified in 3.7.1. Reliable protective measures shall be set when adopting the pneumatic test.

6.2.3 Leak test

6.2.3.1 Gas-tightness test

The dry and oil-free clean air, nitrogen or inert gases shall be adopted as the testing medium in the gas-tightness test of heat exchanger, the design pressure is test pressure, when testing, all the channel shall be simultaneously filled with pressure to the respectively authorized pressure value, and the check shall be carried out in the channel one by one and also shall meet the requirements of the pattern.

6.2.3.2 Helium mass spectrum leak test

This test need to be carried out when design graph of the heat exchanger or delivery contract is required, the leak rate shall be meet the requirements of the heat exchanger technical parameter, working fluid classification, and the purity requirement etc., and shall be confirmed by the calculation of designer and then label to the pattern as the check criterion.

The helium leak test shall be carried out after the qualification of strength and leak check.

6.2.4 Pneumatic resistance test

The pneumatic resistance test of the heat exchanger relevant channel shall be carried out according to the requirements of design graph. The test conditions and requirements shall be in accordance with annex A 3 in this standard or those specified in design graph. As to the switching channel for switching the heat exchanger in space division devices, beside its in-house resistance value needs to be checked, and also shall meet the requirements of the mutual resistance differences between each other.

The allowable value of the switching heat exchanger resistance difference shall be confirmed by calculation.

6.2.4.1 The resistance deviation of the two switching channel (A, B) in the same unit (cold leg or hot leg) shall be calculated according to Formula (6.1).

6.3 Revision of inconsistent

The heat exchanger in fabrication process, if inconsistency with the requirements happened, then the revision is needed. The severity of inconsistent needs to be judged by the manufacturer, and makes sure whether buyer wants to participate in the treatment according to the requirements of the contract. If there is no requirement in the contract, the following method can be carried out to revision the inconsistency.

6.3.1 Codes and records

The revision work shall be carried out in obedience to reliable codes and technical regime requirements, and shall be sure of the performance and security of the heat exchanger insusceptible, even no impact on the structural integrity. The inconsistent document records shall be done by manufacturer, and supply to the buyer when they are required.

6.3.2 Solder joint leaky revision of side bar and parting sheet

The handwork tight weld shall be adopted in accordance with reliable repairing welding technological specification to revise the solder joint leak.

6.3.3 Block of the channel

The rectification method shall be adopted which confirmed by the design department when the canalization of parting sheet has caused to the internal leak between the channel.

Generally one certain channel can be locked, and the report for the heat exchanger performance and pressure sink incidence after the block of the channel shall be made.

6.3.4 Allowance existing surface defect

Under the condition of not impact the service performance and life of the product, the defect at the surface of unit body is allowed, but the defect depth of the header and nozzle shall not be larger than 0.3mm; the defect depth of the block shall not be larger than 0.5mm.

6.3.5 Repairing welding

a) If seepage or nondestructive testing disqualification is discovered on the welded joint after pressure test, the repairing welding is allowed. The repair welding technical regime shall be formulated by manufacturer when repairing welding, but the repairing welding on the same part generally shall not excess

2 times, if more than 2 times, relevant welding procedure qualification report is needed. The metal of defect part shall be eradicated before repairing welding, and the weld zone should be recleaned up, even repairing welding with pressure is no allowed.

b) As to the space division device like the switch heat exchanger, main heat exchanger, condenser-evaporator and the heat exchanger unit body which design pressure is larger than 2.5MPa, the allowable solder joint repairing welding length shall not be larger than 0.5% of the total length of the reveal parting sheet (containing the inside of the header), and as to other heat exchanger, the allowable repairing welding length of the solder joint shall not be larger than 1.5% of the total length of the reveal parting sheet (contain the inside of the header).

6.4 Quality certificate, mark, painting, package, transportation and storage

6.4.1 Preparation work before leaving the factory

6.4.1.1 Cleanness

The oil stain and dirt shall be removed to maintain cleanness at the external surface of product. Painting and other anticorrosion treatment shall be in accordance with the design graph and those specified in relevant technical documents.

6.4.1.2 Drying

The manufacturer shall be sure of all the pressure port intensive drying of heat exchanger before transportation; specific requirements shall be carried out according to those specified in annex A.

6.4.1.3 Flange protection

All the reveal treating interface of flange shall be proper protected to prevent from mechanical damage, especially the flange sealing surface.

6.4.1.4 Protection of dummy layer and dead area

The opening of the dummy layer and dead area, the opening of the closed dead area shall be properly protected to prevent from moisture and dust irruption.

6.4.1.5 Nitrogen seal

a) The pressure port of heat exchanger which is qualification after drying, dry and oil-free nitrogen shall be filled for the replacement and nitrogen seal, the

The supporter is generally installed on the upper part of block (core) (heat exchanger core), thus reducing the shake between the bracket and support slat junction when the device is started or stopped.

In addition to the main supporter, when the sliding guide-frame is required to be added, it shall be installed according to the structure as shown in Figure 7.1 and 7.2 and the following factors shall be taken into consideration:

a) Physical dimension of heat exchanger;

b) Weight of heat exchanger;

c) Site conditions (Earthquake, wind power and pipe load);

d) The relative position of the main supporter plane and the heat exchanger centre of gravity.

The external force and moment of force that are allowed to be exerted at the junction between header and nozzle of heat exchanger shall be provided by the manufactory when it is required by the buyer. The buyer shall ensure that the loads of all the connecting pipes shall not exceed the value provided by the manufactory.

7.2 Hoisting and transportation

The heat exchanger shall be installed with hoisting devices and the precautions shall be provided by the manufactory when the heat exchanger is hoisted and transported.

7.3 Supporting bracket

The installation of supporting bracket shall be in accordance with the following requirements:

a) Heat exchanger shall be installed on the supporting bracket. In addition to the heat exchanger deadweight, the force and moment of force exerted by the external shall be taken into consideration when the supporting bracket is selected.

b) The verticality deviation of the heat exchanger installed on the supporting bracket shall not be greater than 0. 5° or 15 mm and the verticality may be adjusted by padding the sheet metal.

c) The matching surface between supporting bracket and heat exchanger shall be thermal insulated and the thermal insulating material strength shall be attuned to the bore load and shake; the thermal insulating material thickness shall be

relevant specified requirements and the following requirements shall also be met:

a) Generally the test media is dry air and the dry nitrogen may be adopted if necessary;

b) Necessary safety measures shall be taken in pressure test;

c) The pressure test shall be respectively carried out by layer and when a layer is pressure tested, the other layers shall not be carried out with pressure test at the same time;

d) Depressurize after the pressure test and then the air tight test shall be carried out where after;

e) Ambient temperature variance during the pressure maintaining period shall be taken into consideration when the pressure test is assessed and the final pressure may be corrected according to the following formula:

Final pressure reading = original pressure reading× [final ambient absolute temperature (K)/ original ambient absolute temperature (K)].

f) The air tight test shall be carried out for the system after the layer pressure test is passed and it is qualified if no leakage occurs after 30 min of pressure maintaining.

7.8 Thermal insulation (heat insulation and cold insulation)

Thermal insulation treatment shall be carried out after the field test of heat exchanger and shall meet the following requirements:

a) For the heat exchanger in cold box, the minimum heat insulating layer between heat exchanger and cold box wall must not be less than the minimum thermal insulation thickness as specified in Figure 7.4. Thermal insulating material may be adopted with pearlitic sand or silicate cotton. The pearlitic sand density generally is 60 kg/m^3~ 80 kg/m^3. When the silicate cotton is filled, it shall avoid damaging the heat exchanger joint. Dry nitrogen shall be adopted to blow clear the residual air in the cold box thermal insulating material after the thermal insulation treatment;

b) For other heat exchangers, the thermal insulating material generally is adopted with polyurethane foam and the minimum thermal insulation thickness shall meet the requirements in the drawing. The thermal insulating material shall be seal protected by outer cover after the thermal insulation treatment.

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