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(54) **METHOD OF FORMING ALUMINIUM HEAT EXCHANGERS HEADER TANKS**

VERFAHREN ZUR HERSTELLUNG VON ALUMINIUMWÄRMETAUSCHERSAMMELKÄSTEN

PROCÉDÉ DE FORMAGE DE COLLECTEURS D'ÉCHANGEURS THERMIQUES EN ALUMINIUM

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Description

Technical field

[0001] This invention relates to a method for producing a header tank, also called manifold tank, for brazed automotive or stationary aluminium heat exchangers, with almost arbitrary tank shapes.

Background of the invention

[0002] Today's automotive engineers face increasingly large difficulties to fit and assemble all underhood components in a rational fashion. Engines become more powerful and an increasing amount of different components are fitted to support the engine, and to supply passengers with a continuously increasing level of driving experience, safety and comfort. This makes available underhood space a scant resource. Heat exchangers have, almost by default, a rectangular shape which restricts the automotive engineer concerning suitable locations for heat exchanger assembly into the car. Much of the restrictions on heat exchanger geometry are set by the economical feasibility of producing header plates and tanks to make such irregularly or custom shaped heat exchangers; such headers and tanks give too expensive heat exchangers with present production methods.

[0003] Also, the increasing amount of underhood safety, comfort and performance components makes the front end of the vehicle increasingly heavier than the rear end which is undesirable. In ordinary passenger vehicles, heat exchangers like CAC, condensers, radiators and EGR coolers need to be positioned near the extreme front of the vehicle to facilitate sufficient heat exchange performance. The present invention facilitates weight reduction of these components while reducing the cost and increasing the geometrical flexibility for packing without sacrificing performance.

[0004] The most commonly used production method for heat exchanger header tanks is to provide a flat rolled brazing sheet and forming it such that a header with tabs for crimping a plastic tank, slots for inserting flow tubes used for the circulation of cooling fluid and the final shape of the formed header is produced. This is normally done by cutting a flat rolled sheet to the correct dimension, punching the sides to make a rectangular shaped edge of the sheet (for the tabs), deep drawing the piece of sheet to form a header plate and finally punching the slots into which the flow tube/fin package is inserted. Thereafter the normal brazing procedure commences. After brazing the cladding on the header surfaces has melted and flowed to the header tube joint to make a fillet with the correct size and shape. Thereafter the tank is crimped onto place.

[0005] The tank is commonly made of polymer materials in the case of radiators and heaters and for CAC it is usually made of aluminium. Another technique previously used for forming header tanks is hydroforming.

[0006] EP 0 930 109 A2 discloses a hydroforming process for forming a component from an aluminium tubular blank of a deformable metal. The process comprises placing the blank in a die and sealing opposed ends of the blank, heating the blank to a deformation temperature, supplying gas at a predetermined pressure to the interior of the sealed tubular blank to cause deformation of the blank by drawing/stretching of the metal.

[0007] The above manufacturing procedures are costly and require very tight control with respect to tool geometry and lubrication of the tool/sheet contact. It also requires a controlled disposal and cleaning of the lubrication residues and disposal of metal scrap from e.g. punching on the production site, as well as manning, floor space and investments in controlled machinery which adds to the cost. Additionally, since deep drawing is made at room temperature one is restricted to the use of cold work tool steels that are normally very difficult and expensive to machine to tight tolerances.

[0008] The manufacture of plastic tanks by injection moulding is a comparatively slow and costly procedure which requires large investments in machinery, tooling and control. The tank is a multi-functional part of the heat exchanger and is also made with fixtures and easy-to-access assembly locations for e.g. in-tank oil coolers and sensory equipment. Also, since plastic materials are considerably less stiff as compared to aluminium the wall thickness of the tank is thick, and the tank is made with integrated external stiffening frame-works to achieve sufficiently large torsional stiffness. The tank thus becomes heavy despite being produced using a material with low density. However, it is possible to increase the stiffness substantially with the use of whisker or fibre reinforcement but that incurs a substantial cost increase

[0009] In the case of CAC the operating temperature may exceed temperatures where plastic materials lose too much strength to be of practical use. Therefore the tanks are nowadays usually made of aluminium. Most often such tanks are made using die casting technology which commonly restricts the tank wall thickness in the range above 1.5 mm, which adds weight to the heat exchanger. Also, cast aluminium is not easy to crimp onto the header and the usual joining method is melt welding by means of MIG or TIG. This type of tank and joining method normally gives a strong assembly. However, the welding is expensive, time consuming and adds a significant weight to the heat exchanger, particularly since the tank is made to have a very large thickness where the welding should take place and also the header plate needs to be thick to accommodate a successful weld joint.

Summary of the invention

[0010] There is thus a need for an efficient and flexible method for producing heat exchanger header tanks.

[0011] The present invention fulfills this need by providing a method according to the features of claim 1.

[0012] The group of alloys commonly used for heat exchanger header tanks, AA3XXX, is difficult to form to desired shapes by means of the methods hitherto typically used for manufacturing header tanks. These alloys do not in the cast and rolled condition have the formability required for advanced shaping of header tanks at room temperature.

[0013] Previous methods have not been able to satisfy the long felt need for header tanks, which can be brazed and which can be formed in complicated shapes. According to the present invention a method is provided for the manufacture of such header tanks, by means of the steps as set out in the appended claims.

[0014] Elongations to fracture exceeding 20% are invariably needed for a successful high quality forming to take place. To obtain the very good formability the core ingot of the clad brazing sheet material is in the state of the art processes exposed to a high temperature homogenisation treatment. The homogenisation treatment gives a microstructure that after hot and cold rolling and anneal, if correctly performed, increases formability of the alloy strip. During the homogenisation most of the manganese present in the alloy is precipitated to form large dispersoid particles, whereby some of the strength potential supplied by manganese in solid solution is lost. The corrosion resistance of the AA3XXX alloys may also be negatively affected by the homogenisation treatment. Homogenisation and anneal also incurs additional cost to the material as compared to only pre-heating before hot rolling. Therefore it is desired to avoid homogenisation and annealing for alloys which are intended for use as header tanks in heat exchangers.

[0015] To obtain the high elongation in the delivery condition the material is supplied in the fully soft O-temper or sometimes in the H112 temper, i.e. an annealed condition. This operation also adds to the cost of the heat exchanger material. By producing a heat exchanger header tank by the method of the present invention the alloy of the tube need not be homogenised, which allows efficient forming of non-homogenised aluminium alloy tubes. Further, the tube blank need not be annealed before forming, which makes the method even more cost efficient.

[0016] The present invention provides a method for producing a heat exchanger header tank comprising the steps of providing a tube having a core made from a AA3XXX-aluminium alloy; optionally pre-heating the tube; inserting the tube into a forming tool having a forming cavity with the shape of the final header tank; plugging the ends of the tube; heating the tube to the forming temperature if the tube has not been sufficiently pre-heated and internally pressurising the tube by the use of a gas so as to make it conform to the shape of the tool cavity, thus obtaining the final header tank; removing the header tank from the tool; and cooling the header tank. This method allows an efficient production of header tanks made of AA3XXX aluminium alloy.

[0017] By using a material for the tube, that has not

been homogenised, improved corrosion and mechanical properties can be obtained. A tube that has not been annealed, contributes to cost reduction and reduced environmental load. Thus, a non-homogenised AA3XXX alloy header tank produced according to the method of the present invention will have higher strength and improved corrosion resistance as compared to a deep drawn header tank made from the corresponding but homogenised AA3XXX alloy.

[0018] The tube core may have at least one cladding made from an aluminium alloy, in order to enhance brazability. Slots for tubes or connections may be made in the shaped header tank subsequent to forming, in order to facilitate the manufacture of a heat exchanger.

[0019] The gas pressure used during forming may preferably be higher than 85 bar, in order to obtain an efficient forming of the tube against the forming cavity of the tool.

[0020] If desired an axial pressure can be applied to the tube ends during forming thereof, in order to feed in material into the forming cavity during forming.

[0021] Further, connections, threads or anchors can be formed on the end of the tube during forming thereof, to make the assembly of the heat exchanger easier.

[0022] Pressures above 200 bar may be needed depending on the shape of the tank and the thickness of the aluminium blank.

[0023] The tube from which the header tank is formed can be made from a rolled aluminium alloy blank welded to produce the tube. Thereby, the tube can be effectively provided. It is particularly advantageous to produce the tube from a rolled braze clad aluminium blank, since this is an efficient method of obtaining a braze clad tube. Braze clad tubes is very costly and extremely difficult to extrude.

[0024] Alternatively the tube can be made from an extruded aluminium alloy, which is advantageous in some situations, in particular when no braze clad is provided on the tube.

[0025] The present invention further provides a preferred method for producing a heat exchanger, where the header tank is connected to a plurality of tubes and corrugated fins inserted between the tubes, followed by brazing of the fins to the tubes.

[0026] The hot metal gas forming allows the construction of aluminium header tanks of almost arbitrary shape made from AA3XXX alloys for heat exchangers.

[0027] The header tanks for such heat exchangers are of low weight and can be optimised at a low cost compared to competing technology.

[0028] The elimination of plastic tanks makes material recovery easier. The cross-section geometry of the tank can be varied within greater limits than with competing aluminium forming techniques, e.g. hydroforming or deep drawing. Tensile tests made have shown that the formability of the header tank material increases significantly when the temperature at forming is increased, which means that the elongation to rupture can increase to over 100% when the temperature is increased to 400

°C, as compared with 20-30% at room temperature.

[0029] The geometry of the header tank is not constrained to make rectangular heat exchangers - irregular shapes are equally possible. In particular non-rectangular heat exchangers can be formed with a great flexibility as concerns the shape.

[0030] The header tanks made with the method according to the present invention give a very high material yield, which is higher than the deep drawing or hydroforming techniques that are used today.

[0031] The header tanks facilitate economic production of heat exchangers that allow automotive engineers to pack more efficiently in the underhood compartment and at the same time opens possibilities to optimise heat exchange performance.

[0032] Header tanks made with the method according to the present invention can be made using materials that have higher strengths and higher corrosion performance, and the materials can be made according to a more environmentally friendly process route with fewer thermo-mechanical operations compared with competing technology.

DRAWINGS

[0033] Embodiments of the present invention will be readily understood by the following detailed description in conjunction with the accompanying drawings. Embodiments of the invention are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

FIG. 1 is a view of a heat exchanger header tank made with the method in accordance with one embodiment of the present invention.

FIG. 2 is a view of a heat exchanger header tank in figure 1, rotated 90°.

FIG. 3 is a selection of tube cross section shapes for header tanks made with the method according to the present invention.

FIG. 4 shows a schematic drawing of a non rectangular heat exchanger comprising header tanks produced by the method according to the present invention.

FIG. 5 shows a side view of a heat exchanger where the header tank is curved across its length axis.

Detailed description of the invention

[0034] The header tanks are produced by the process steps: i) brazing sheet production according to standard industry practices, ii) welding and possibly bending of tubes made from the brazing sheet, iii) hot metal gas forming of the tube in a tool which interior is designed

according to the header tank product, iv) making slots for flow tubes and connections to the remainder of the heat exchanger system.

[0035] A brazing sheet consists of a core material that may be clad on one or both sides of the sheet surfaces. The core material is chosen in the AA3XXX-series with melting temperatures exceeding 610°C, e.g. AA3003 or AA3005. The braze cladding is normally chosen from the low melting hypoeutectic AA4XXX alloys, e.g. AA4343 and AA4045.

[0036] Furthermore, either or both sides can be clad with more than one material, a so-called multi-clad. Additionally, in particular on tube strip for radiators and heaters but also for other heat exchangers, the cladding may be made of a material that is electrochemically balanced such that it is sacrificial to the core in corrosive environments. Thus, the core material can be clad on one or both sides or no side at all. The claddings may be single layer or double layer on one or both sides, the cladding can consist of a low melting braze or a sacrificial cladding or a cladding that is present in between the braze and the core to reduce braze-core interaction by e.g. diffusion.

[0037] The claddings are applied to the core by means of hot rolling followed by cold rolling and necessary heat treatments to achieve the correct intermediate and final tempers before slitting to the correct width. The products made from the brazing sheet can then be brazed either using controlled atmosphere brazing (CAB) or vacuum brazing.

[0038] 6XXX or 5XXX alloys are commonly used for products that are not intended for brazing (with CAB). These alloys are used for products where high strength is desired, such as e.g. construction details. 6XXX or 5XXX alloys receive their strength through the high content of Mg. CAB-brazing of these alloys is difficult due to a reaction between magnesium and the flux.

[0039] For radiator manufacturers using controlled atmosphere brazing (CAB) two major problems arise with the previously available header core materials, namely too low mechanical strength and too low corrosion resistance. AA6063, a heat treatable alloy with an Mg content of about 0.7 wt-%, is not considered brazeable in the CAB process. AA6060, containing about 0.4-0.5 wt-% Mg, is possible to braze, albeit it requires more flux, special flux and special flux application techniques and the strength after brazing is for some applications not sufficient.

[0040] In AlMgSi alloys, small Mg₂Si precipitates form during ageing, causing the strength increase. Thus the trivial solution to increase the strength would seem to be to increase the Mg and the Si contents, allowing more Mg₂Si to form. However, since Mg reacts with the flux during brazing and this limits the amount of Mg, alloys having a Mg content of more than 0.4 % are difficult to braze effectively in CAB. Also, the above mentioned AA6060 and AA6063 typically exhibit low perforation corrosion resistance due to e.g. intergranular corrosion.

[0041] 3XXX alloys with a maximum of about 0.4% Mg may be brazed in CAB. By the method of the present invention the difficulties of forming 3XXX alloys into the desired shape are overcome. Thus the method of the present invention allows the choice of 3XXX alloys for the header tanks, which results in that the header tank can be CAB brazed in a later stage.

[0042] According to the present invention one of the intermediate products in the production of a header tank is a tube. To be able to make a tube from clad or unclad brazing sheet it is necessary to make a welded tube from it. The actual welding method may be induction welding, MIG, TIG, friction stir welding or any other suitable welding method.

[0043] The tube may have a circular, elliptic, square, rectangular, triangular or any other suitable symmetric or asymmetric cross-section geometry. The tube can be made either with a constant or varying cross-section geometry and dimension along its length, depending on customer demands. It is wise, though not always necessary, to choose a cross-section to avoid excessive deformation requirements in subsequent processing. Also, if the tube is welded such that the cross-section geometry is constant along the length the material yield is theoretically 100% in the welding operation which is followed by a cut-to length operation.

[0044] Heat exchangers used within the automotive industry typically have a rectangular shape. This has resulted in a limitation concerning suitable positions for the heat exchanger assembly in the car. In some situations a circular, bent or step-shaped, or even irregularly shaped heat exchanger would be the ideal for assembly into the available underhood space, or using the available underhood space in the best way to optimise heat exchange performance.

[0045] In such situations it may be desirable to provide heat exchanger which has a shape that is adapted to the space available in the car, or is adapted to a desired flow pattern. Such heat exchanger would need a tailored header tank. The method of the present invention allows for forming of header tanks of any desired shape in three dimensions. Conceivable shapes are for example ring-shape, S-shape, L-shape or C-shape. The header tank may be curved or bent along its length axis and/or across its length axis. The flow tubes are to be attached in a line along the length of header tank, which means that the entire heat exchanger will assume a cross-sectional shape which corresponds to the shape of the header tank.

[0046] There may thus be a need for a non-rectangular, e.g. a circular shaped heat exchanger for reasons of underhood packing, heat exchange performance or simply customising a product. This need can then be satisfied by bending the welded tube made from clad brazing sheet to a form with suitable radius of curvature. Alternatively, an S-, trapezoid- or irregularly shaped header tank may be needed.

[0047] When a bent or curved tank is to be produced

the tube may be bent to a suitable pre-shape before hot gas forming. The bending of the tube may take place using any bending method that is suited for the particular shape to be produced. The bending can be undertaken at ambient or elevated temperature to fit the needs for the particular shape required for the final header tank.

[0048] The tube, welded and bent according to customer demands, is optionally heated by any suitable means, e.g. furnace, flame or induction or using a heated tool. Induction and flame heating have the advantages that the thermal input can be localised to selected regions of the tube. This can be employed as a means to vary the mechanical properties on selected regions as it is known that material temperature is decisive in affecting properties like yield stress, ultimate tensile stress, elongation to fracture and formability. Depending on alloy type, temper, sheet thickness and the deformation necessary to make the header tank the desired forming temperature may vary between 250°C and 550°C.

[0049] The tube is placed into a forming tool, made such that the internal surfaces of the tool correspond to the external geometry of the final header tank. The tool can be cold (e.g. room temperature), in which case the tube must be pre-heated, but the tool is preferably heated to a suitable elevated temperature, either before or during forming. The choice of tool and tube temperatures is determined by the mechanical and formability properties of the tube material and the final geometry of the header tank.

[0050] Subsequently, the tube ends are plugged and the tube is connected to a high pressure gas system. During forming the tube is at a temperature of between 250°C and 550°C. This forming temperature can be achieved by pre-heating the tube to this temperature before inserting it into the forming cavity, or by having pre-heated the tool before inserting the tube into it, or by heating the tool during forming, e.g. by induction. The pressure of the gas is increased inside the tube, which responds to the increasing pressure by deforming. The pressure is increased until the tube has conformed to the surfaces of the tool. The actual final pressure and the gas pressure increase rate are determined by, among other things, the mechanical properties of the tube alloy at the temperature, tube wall thickness, final header tank shape and the amount of deformation needed for the tube to attain the desired shape.

[0051] After forming the high pressure gas can be vented and the shaped product removed from the tool. The gas can be air, nitrogen, inert gases or any other suitable gaseous substance. The pressure during forming is quite low, much lower than those employed in e.g. hydroforming. An approximate upper limit of 250 bar should be sufficient to form the aluminium alloy material for heat exchanger purposes to the desired shape. Due to the limited pressure during forming of the tank, the forming tool used in the production of header tanks may be made of other materials than is used for tools used in the previously used forming methods. After the forming has been final-

ised, the formed product can be cooled either in air or quenched in water.

[0052] It is also possible to feed in material into the tool by applying axial pressure on the tube ends during forming. This can be beneficial for obtaining a smaller tube wall thickness variation after forming or avoiding tube fracture for very demanding tube shapes that require large local deformations, e.g. near a sharp radius or corner.

[0053] To avoid sticking of the tube on the tool surfaces one may need to apply a release agent or high temperature lubricant. The application may be undertaken either on the tube or on the tool surfaces and may be applied before each new tube to be formed or in the form of a coating that does not need to be replenished either than on rare occurrences.

[0054] There are several ways of producing the slots needed for the insertion of the tubes, connections and fasteners. One way is to process the hot gas formed product by punching the slots either individually or several or all in one punch. The holes and slots may also be milled or drilled or formed by the use any other suitable techniques on the hot gas formed product. Alternatively, the holes may be punched during the later stages of the hot gas forming process, when the final shape of the tube has been attained and when the hot gas pressure can provide support from the inside of the tube to prevent a collapse as a result of the punching action. Fasteners may be attached to the hot gas formed product by any suitable means, e.g. riveting, brazing, welding or gluing. The choice of fastening method depends on customer needs, allowed costs, performance and whether the fastening should take place before or after brazing. The header tank can be formed with indentations for facilitating the forming of slots in the header tank, an example of that is shown in Fig. 2.

[0055] To provide for the gas to enter the tube during hot gas forming, at least one of the plugs at the end of the tube has an opening attached to the pressure gas system. Before the tank is used in a heat exchanger application the opening must be closed. This can be made in several ways. Firstly, an open tube end can be plugged by attaching the inlet and outlet connections for the heat exchange medium, whether it is liquid or gaseous. Secondly, it can be closed by means of a seal that can be brazed, welded or glued in this position or attached by any other suitable means. Alternatively, the end can be squeezed shut and the remaining gaps and crevices filled with a suitable metallic or polymeric filler to ensure a leak free closure. The application of such sealants is made using any suitable method.

[0056] To facilitate easy connection of pipes or hoses one may envision forming threads on the end of a tube onto which the pipe can be screwed. Alternatively one may form anchors for attachment of hoses by means of clamps.

Description of a preferred embodiment

[0057] For better understanding of the invention, an example of how to perform the invention will now be given.

[0058] An aluminium sheet of 3 mm thickness form alloy AA3003 clad with AA4343 is welded to form a tube of 40 mm diameter. The tube is pre-bent to the shape according to figure Y, and put into a tool preheated to 500 °C of a similar shape. The tool has been lubricated with a solid lubricant capable of withstanding the forming temperature without decomposition. The tube ends are plugged and a force applied by hydraulic cylinders to avoid the two tool parts from separating. A gas with is applied to the inside of the tube through one of the plugs and the pressure increased from 0 to 200 bar. The pressure is released after a few seconds at maximum pressure and the formed tube is removed from the tool and cooled by spraying water onto it. Slots are punched where connections are required.

[0059] The tube now has the final form of the header tank with preformed slots and bulges. Heat exchanger fins and flow tubes may now be assembled with the tank and brazed to form a heat exchanger.

Claims

1. A method for producing a heat exchanger header tank comprising the steps of;
 - a) providing a tube having a core made from a AA3XXX-aluminium alloy
 - b) optionally pre-heating the tube;
 - c) inserting the tube into a forming tool having a forming cavity with the shape of the final header tank;
 - d) plugging the ends of the tube;
 - e) heating the tube to the forming temperature if the tube has not been sufficiently pre-heated and internally pressurising the tube by the use of a gas so as to make it conform to the shape of the tool cavity, thus obtaining the final header tank;
 - f) removing the header tank from the tool;
 - g) cooling the header tank.
2. Method for producing a heat exchanger header tank according to claim 1 in which the material used for the tube has not been homogenised.
3. Method for producing a heat exchanger header tank according to claim 1 or 2, in which the tube has not been annealed.
4. Method for producing a heat exchanger header tank according to claim 2, wherein the tube core has at least one cladding made from an aluminium alloy.

5. Method for producing a heat exchanger header tank according to any of the previous claims, where slots for tubes or connections are made in the shaped header tank, during forming, or subsequent to forming. 5
6. Method for producing a heat exchanger header tank according to any of the previous claims, wherein the gas pressure used is higher than 85 bar. 10
7. Method for producing a heat exchanger header tank according to any of the previous claims, wherein an axial pressure is applied to the tube ends during forming thereof. 15
8. Method for producing a heat exchanger header tank according to any of the previous claims, wherein threads or anchors are formed on the end of the tube during forming thereof. 20
9. Method for producing a heat exchanger header tank according to any of the previous claims, wherein a tube made from a welded blank is provided in step a). 25
10. Method for producing a heat exchanger header tank according to any of the previous claims, the heat exchanger being of non-rectangular shape. 25
11. A method for producing a heat exchanger, comprising the steps of: 30
 - producing a header tank by means of the method of claims 1-10
 - providing openings for flow tubes in the header tank
 - connecting a plurality of flow tubes to header tank at the openings
 - inserting fins between the flow tubes
 - brazing the fins to the flow tubes. 40

Patentansprüche

1. Verfahren zum Herstellen eines Wärmetauschersammelbehälters, folgende Schritte umfassend: 45
 - a) Bereitstellen eines Rohrs mit einem Kern, der aus einer AA3XXX-Aluminiumlegierung hergestellt ist;
 - b) optionales Vorerwärmen des Rohrs; 50
 - c) Einlegen des Rohrs in ein Formwerkzeug, das einen Formhohlraum mit der Form des endgültigen Sammelbehälters hat;
 - d) Verstopfen der Enden des Rohrs;
 - e) Erwärmen des Rohrs auf die Formgebungstemperatur, falls das Rohr nicht ausreichend vorerwärmt wurde, und Beaufschlagen des Rohrs innen mit Druck durch Verwendung eines

Gases, um es sich der Form des Formwerkzeugs anpassen zu lassen, womit der endgültige Sammelbehälter erhalten wird;
 f) Annehmen des Sammelbehälters vom Werkzeug;
 g) Kühlen des Sammelbehälters.

2. Verfahren nach Anspruch 1 zum Herstellen eines Wärmetauschersammelbehälters, wobei das Material, das für das Rohr verwendet wird, nicht homogenisiert wurde.
3. Verfahren nach Anspruch 1 oder 2 zum Herstellen eines Wärmetauschersammelbehälters, wobei das Material nicht spannungsarmgeglüht wurde.
4. Verfahren nach Anspruch 2 zum Herstellen eines Wärmetauschersammelbehälters, wobei der Bohrkern mindestens eine Auskleidung besitzt, die aus einer Aluminiumlegierung hergestellt ist.
5. Verfahren nach einem der vorhergehenden Ansprüche zum Herstellen eines Wärmetauschersammelbehälters, wobei Schlitze für Rohre oder Anschlüsse während des Formens oder anschließend an das Formen im dem geformten Sammelbehälter hergestellt werden.
6. Verfahren nach einem der vorhergehenden Ansprüche zum Herstellen eines Wärmetauschersammelbehälters, wobei der verwendete Gasdruck höher ist als 85 bar.
7. Verfahren nach einem der vorhergehenden Ansprüche zum Herstellen eines Wärmetauschersammelbehälters, wobei ein Axialdruck an die Rohrenden während dessen Formung angelegt wird.
8. Verfahren nach einem der vorhergehenden Ansprüche zum Herstellen eines Wärmetauschersammelbehälters, wobei Gewinde oder Verankerungen am Ende des Rohrs während dessen Formung ausgebildet werden.
9. Verfahren nach einem der vorhergehenden Ansprüche zum Herstellen eines Wärmetauschersammelbehälters, wobei ein aus einem geschweißten Rohling hergestelltes Rohr im Schritt a) bereitgestellt wird.
10. Verfahren nach einem der vorhergehenden Ansprüche zum Herstellen eines Wärmetauschersammelbehälters, wobei der Sammelbehälter von einer nicht rechteckigen Form ist.
11. Verfahren zum Herstellen eines Wärmetauschers, folgende Schritte umfassend:

Herstellen eines Sammelbehälters mittels des Verfahrens der Ansprüche 1 bis 10,
Bereitstellen von Öffnungen für Durchflussrohre im Sammelbehälter,
Anschließen mehrerer Durchflussrohre an den Sammelbehälter, und zwar an den Öffnungen,
Einsetzen von Rippen zwischen den Durchflussrohren,
Anlöten der Rippen an den Durchflussrohren.

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Revendications

1. Procédé pour fabriquer un réservoir collecteur d'échangeur thermique, comprenant les étapes de : 15
 - a) fourniture d'un tube possédant une âme faite d'un alliage d'aluminium AA3XXX ;
 - b) préchauffage facultatif du tube ;
 - c) insertion du tube dans un outil de formage possédant une cavité de formage avec la forme du réservoir collecteur final ;
 - d) obturation des extrémités du tube ;
 - e) chauffage du tube jusqu'à la température de formage si le tube n'a pas été suffisamment préchauffé et mise sous pression interne du tube par l'utilisation d'un gaz pour qu'il se conforme à la forme de la cavité d'outil, obtenant ainsi le réservoir collecteur final ;
 - f) dépose du réservoir collecteur à partir de l'outil ;
 - g) refroidissement du réservoir collecteur.
2. Procédé pour fabriquer un réservoir collecteur d'échangeur thermique selon la revendication 1, dans lequel le matériau utilisé pour le tube n'a pas été homogénéisé. 35
3. Procédé pour fabriquer un réservoir collecteur d'échangeur thermique selon la revendication 1 ou 2, dans lequel le tube n'a pas été recuit. 40
4. Procédé pour fabriquer un réservoir collecteur d'échangeur thermique selon la revendication 2, dans lequel l'âme de tube comporte au moins un gainage fait à partir d'un alliage d'aluminium. 45
5. Procédé pour fabriquer un réservoir collecteur d'échangeur thermique selon une quelconque des revendications précédentes, où des fentes pour des tubes ou raccords sont réalisées dans le réservoir collecteur mis en forme, au cours du formage, ou après le formage. 50
6. Procédé pour fabriquer un réservoir collecteur d'échangeur thermique selon une quelconque des revendications précédentes, dans lequel la pression de gaz utilisée est supérieure à 85 bars. 55

7. Procédé pour fabriquer un réservoir collecteur d'échangeur thermique selon une quelconque des revendications précédentes, dans lequel une pression axiale est appliquée sur les extrémités du tube au cours du formage de celui-ci.

8. Procédé pour fabriquer un réservoir collecteur d'échangeur thermique selon une quelconque des revendications précédentes, dans lequel des filets ou ancrages sont formés sur l'extrémité du tube au cours du formage de celui-ci.

9. Procédé pour fabriquer un réservoir collecteur d'échangeur thermique selon une quelconque des revendications précédentes, dans lequel un tube fait à partir d'une ébauche soudée est fourni dans l'étape a).

10. Procédé pour fabriquer un réservoir collecteur d'échangeur thermique selon une quelconque des revendications précédentes, l'échangeur thermique étant de forme non rectangulaire.

11. Procédé pour fabriquer un échangeur thermique, comprenant les étapes de :

fabrication d'un réservoir collecteur au moyen du procédé selon les revendications 1 à 10;
fourniture d'ouvertures pour des tubes d'écoulement dans le réservoir collecteur ;
raccordement d'une pluralité de tubes d'écoulement au réservoir collecteur aux ouvertures ;
insertion d'aillettes entre les tubes d'écoulement ;
brasage des ailettes aux tubes d'écoulement.

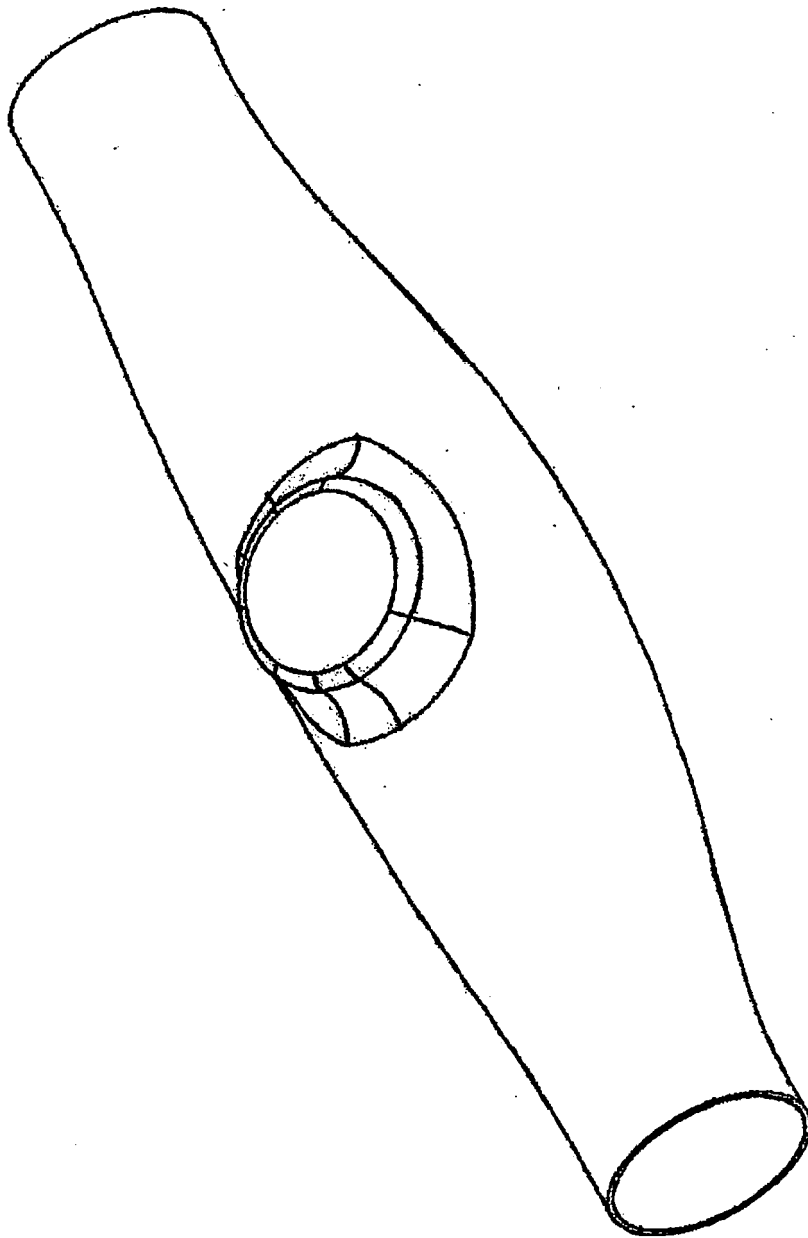


Fig. 1

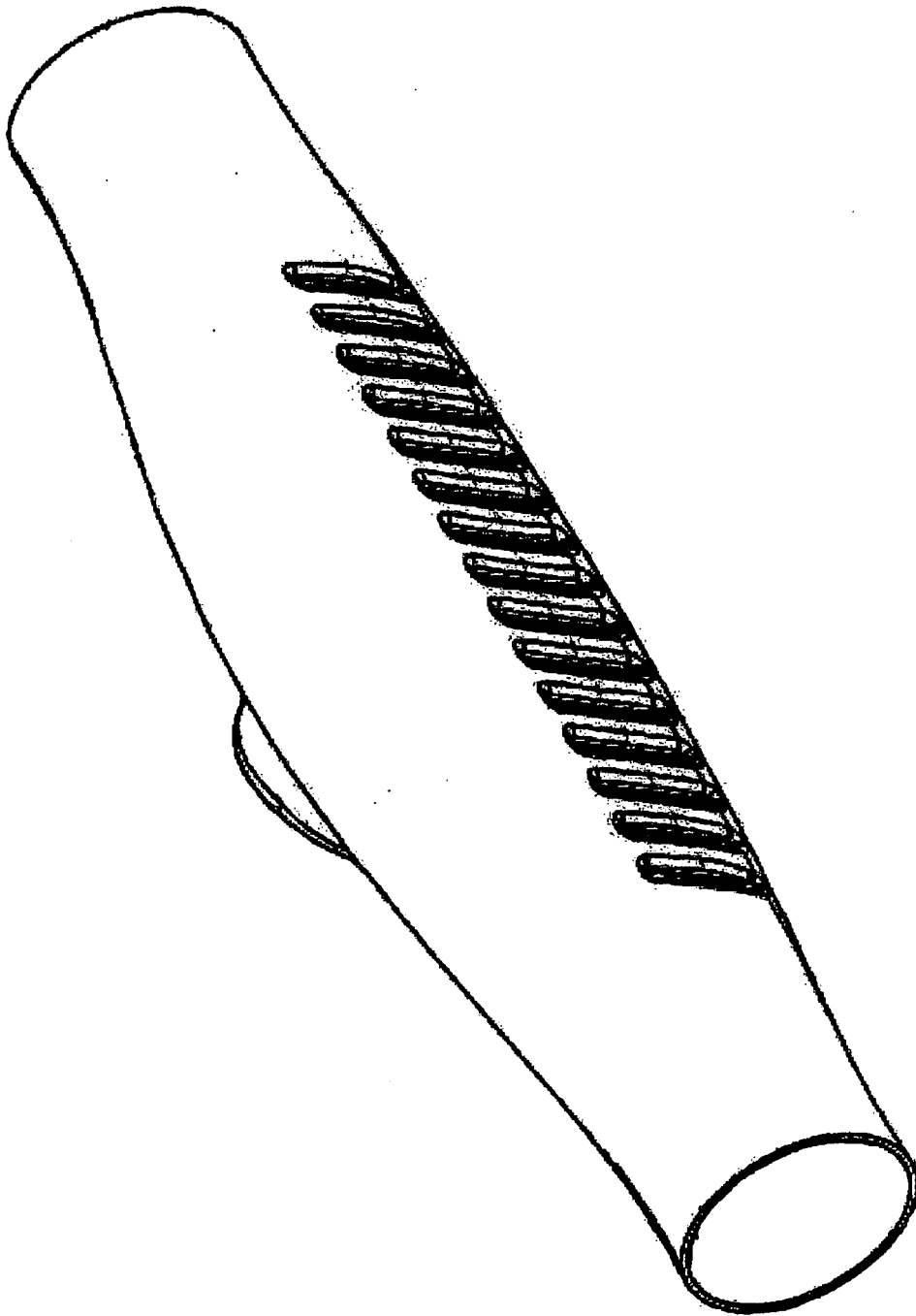


Fig. 2

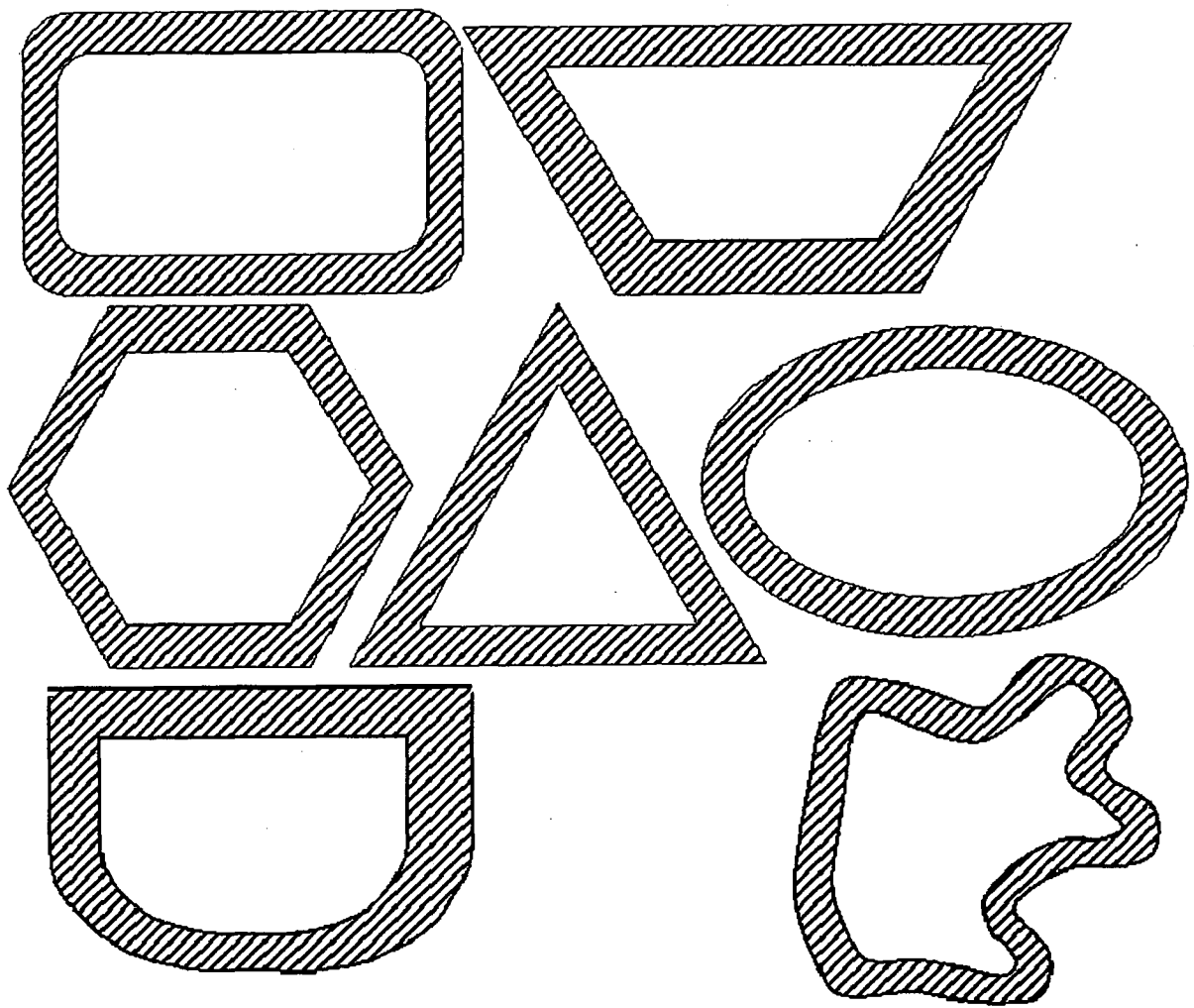


Figure 3

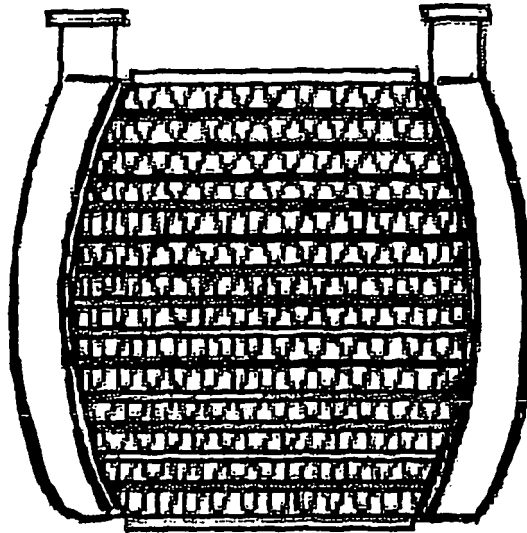


Fig. 4

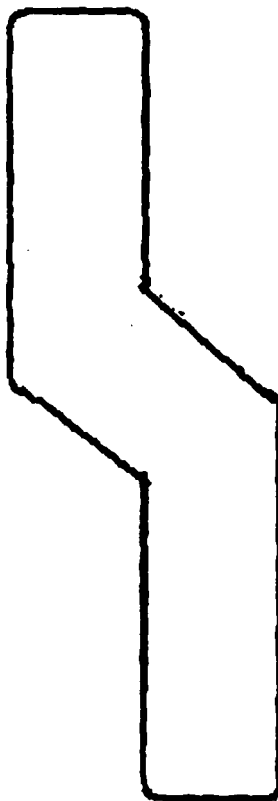


Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0930109 A2 [0006]