

Description

The invention relates to a process for producing brazed, multi-layer metal tubes in which a metal band, in particular a steel band, is gradually plastically formed into a multi-layer, preferably double-layer tubular body with the introduction of a brazing filler metal, in particular consisting essentially of copper, the moved tubular body is then conductively heated to brazing temperature via two electric contact points, distanced from one another and limiting a heating zone, is held for a period at brazing temperature while an annealing zone forms and is then cooled again. The process described above has become known from the German Patent Specification 813,839 (see in particular Fig. 2 in this document). Connected with the known process was the intention, to be welcomed per se, of having the production of multi-layer metal tubes, in particular steel tubes, proceed continuously, while also including the brazing operation, with copper as the brazing filler metal. However, the continuous brazing operation or brazing in a continuous process by way of conductive heating, because of several technical difficulties which have never been overcome, has hitherto led to no significant practical stage of development. The technical difficulties have hitherto partly consisted in the fact that tolerance variations in the dimensions of the basic material, e.g. in steel band or in its copper coating, changed the masses introduced per unit time into the heating zone and thus changed at the same time the result of the conductive heating. This is because increasing the tubular-body masses supplied at first results in a lowering of the brazing temperature, resulting in cold brazing, which means inadequate coherence of the layers to be joined together. To avoid cold brazing, it would have been possible, in purely theoretical terms, in the known process described at the beginning, to increase the electric power, in particular by increasing the current intensity. However, during the

work of the patent seeker which preceded the invention, it was found that an increase in the electric power (as a reaction to an increase in the tubular-body masses supplied) results in nonuniform heating combined with local overheating. But over-heating of the tubular body causes vaporization or a too pronounced diffusion of the copper filler metal into the steel structure, or else uncontrolled running of the brazing filler metal with the disadvantageous result of defective coherence between the layers of the tubular body which are to be joined together.

Variations in the mass with similar negative effects can also be caused by the rolling or roll-up operation, since with the plastic formation into the tubular body the band material is possibly stretched not only in the longitudinal direction but also in the transverse direction.

Moreover, difficulties have arisen hitherto with the disadvantage of nonuniform heating as a result of variable cold hardening of the plastically formed material. This is because, for example, steel band which has been hardened to a relatively high degree requires relatively more energy to heat up.

In spite of all that, it must not be forgotten that uniform heating of the tubular body provided with the brazing filler metal to brazing temperature only leads to success if at the same time a holding time, to be determined empirically, is maintained during brazing. This is because if the holding time is too short, cold brazing occurs again, whereas if the holding time is too long, the brazing filler metal diffuses disadvantageously to an excessive degree into the adjacent metal, e.g. the copper into the steel band, or else the brazing filler metal runs in an uncontrolled manner.

The above-described, hitherto unsolved difficulties with the continuous brazing process by means of conductive heating finally led to the continuously rolled tubular body provided with brazing filler metal being subdivided into fixed discontinuous lengths of, for example, about 32 m and such longitudinal sections of tube being heated uniformly to brazing temperature in batches in a separate brazing

furnace, with each longitudinal section of tube being accommodated in a separate socket tube. Since the continuous brazing process could not be realized technically, the discontinuous brazing process has been retained to the present day (cf. German Auslegeschrift 2,839,684, column 4, lines 23 -26, Figs. 14 and 15).

Based on the process (German Patent Specification 813,839) described at the beginning, the object of the invention, in the knowledge of the disadvantages of the known process, is to develop the known process in such a way that a continuous brazing process, despite nonuniformity in the non-brazed tubular body, can be manipulated in simple manner and at the same time leads to a satisfactory working result. This object is achieved according to the invention when, for the purpose of uniformly heating the tubular body to brazing temperature for the necessary period, the length of the annealing zone is measured for a certain feed rate of the tube and kept constant by setting the distance between the two electric contact points and if necessary also the electric power ... [sic] of the degree of cold hardening and proportionally to the mass of the tubular body moved per unit time into the heating zone.

The process according to the invention preferably relates to copper-brazed double-layer steel tubes. In this case, the copper filler metal is first of all preferably applied on one side or on two sides, in a known manner in each case, by electroplating or by cladding, to the steel band to be plastically formed afterwards into a tubular body.

As soon as a change occurs, for the reasons described further above, in the tubular-body data, e.g. an increase in the mass of the tubular body, this definite circumstance is treated according to the invention by the distance between the two electric contact points being increased. If the change in the mass of the tubular body moved per unit time into the heating zone exceeds a certain rate, the invention, apart from making provision for an increase in the distance between the two contact points, also makes

provision for an increase in the electric power, namely the current intensity, to be supplied via the contact points. When the electric power is increased, surprisingly no damaging local overheating of the tubular body occurs at the end of the heating section. This effect can perhaps be explained by the fact that an increase in the distance between the two contact points at the same time extends the heating zone in the sense that it is rendered uniform.

An increase in the distance between the two contact points, if necessary combined with an increase in the electric power to be supplied, is also to be provided according to the invention if the tubular-body material supplied to the heating zone has a higher degree of cold hardening.

Conversely, according to the invention, the distance between the two contact points is reduced and if necessary the electric power to be supplied is affected, e.g. reduced, if the mass of the tubular body moved into the heating zone is reduced or the material of the tubular body has a lower degree of cold hardening.

An indicating feature which is essential to the invention and simple to realize for maintaining optimum brazing relationships is that the length of the annealing zone is measured for a certain feed rate of the tube and essentially kept constant. The determining annealing zone for the invention (at reduced atmosphere) is characterized by white heat, combined with a green shimmer. If the annealing zone is therefore shortened on account of a change in the tubular-body data, the distance between the two electric contact points is increased, if necessary under the effect of the electric power to be supplied, in particular with an increase in the electric power. But if the annealing zone is extended on account of a change in any of the tubular-body data, then in the application of the process according to the invention the distance between the two electric contact points is shortened (if necessary also under the effect of the electric power, in

particular by a reduction in the electric power).

In the process described above, the feed rate or conveying speed of the tubular body is essentially kept constant, although the process according to the invention also permits in simple manner adaption to the most varied conveying speeds.

As already mentioned further above, it is essential for an optimum brazing result that the holding time during the brazing operation to be determined empirically in each case is essentially maintained. The holding time of a certain tubular cross section to be subjected to the brazing operation is in particular also a function of the feed rate or conveying speed of the tubular body. The process according to the invention at the same time offers the advantage of affecting the holding time in the sense that it is kept constant when the feed rates of the tubular body vary.

When the feed rate is increased, the distance between the two electric contact points is increased, if necessary with an increase in the electric power to be supplied, whereas when the feed rate is reduced the distance between the two electric contact points is reduced and the electric power to be supplied is if necessary reduced at the same time.

Otherwise, it is known in principle from a process for producing brazed, multi-layer metal tubes (German Patent Specification 886,945) to displace electrodes (contact rollers) provided for conductively heating the tubular body in the longitudinal direction of the tube during operation. For this purpose, the known process requires at least three electrodes which define between them two resistance sections directly following one another. In the first resistance section, arranged upstream, between the two first - displaceable - electrodes, the tube is heated up to the melting temperature of the bonding metal (copper), whereas in the following second resistance section located downstream the temperature of the bonding metal is slightly higher than its melting temperature.

In the known process, the temperature represents the

control variable, in which case the holding time of the tube in the brazing zone which is described further above and is so important for a good brazing result can only be estimated with great difficulty. In addition, the temperature control with the two resistance sections connected like an electric current divider can also require an independent adjustment of both moveable electrodes relative to one another, which is on no account simple from a control point of view.

In the known process (German Patent Specification 886,945), the annealing zone extends only as a function of the desired temperature, but regardless of a certain annealing zone length, as it were arbitrarily over the entire second resistance section and in addition projects upstream into the first resistance section. Depending on the temperature control, the annealing zone in this case can be too long (risk of evaporation of the brazing filler metal) or too short (risk of a cold joint).

On the other hand, the invention has recognized that in a process according to the German Patent Specification 813,839 (see Fig. 2 in this document) mentioned at the beginning, requiring only two electrodes but not as yet put into practice, the length of the annealing zone, which only represents a part of the heating zone arranged exclusively between the two electrodes, is increased or reduced as a function of a change in the tube data. This change in length of the annealing zone, on which both the temperature and also directly the tube holding time during the brazing operation have a bearing, is used by the invention as a complex control variable, in contrast to the process according to the German Patent Specification 886,945. The simple preconditions, as pertaining to the apparatus, of the process according to the German Patent Specification 813,839, which forms as it were an integrated preheating and annealing zone between two electrodes, have thus been successfully developed, with the simplest control means, by the invention in such a way that a change in the tube data during operation is immediately taken into account and thus a satisfactory product can be

achieved.

Although a continuous process for producing double-layered, copper-brazed steel tubes has recently become known from the German Offenlegungsschrift 2,828,960, this known process works with multi-stage heating together with variable heat transmission and therefore requires a considerable outlay on control means and on apparatus.

In addition, the invention relates to an apparatus for carrying out the process with a rolling or roll-up apparatus for producing the tubular body, a conductive heating apparatus with two electric contacts, distanced from one another with respect to the tubular body and contacting this tubular body, a heat chamber at least partly enclosing the heating zone, and also with a cooling chamber following the heating zone and accommodating a cooling section (German Patent Specification 813,839, Fig. 2).

Moreover, it is the object of the invention to develop the previously known apparatus defined in the preamble of Claim 2, pertaining to the apparatus, in such a way that it enables the inventive process described above to be carried out.

According to the invention, this object has been achieved according to Claim 2 when, for the purpose of uniformly heating the tubular body to brazing temperature for the necessary period, the length of the annealing zone can be measured for a certain feed rate of the tube and be kept constant when at least one contact is made moveable and lockable. Here, to achieve a simple construction it is expedient to design one contact to be spatially fixed and the other contact to be moveable and lockable.

A preferred embodiment according to the invention is that the contact located upstream with respect to the feed or conveying direction of the tubular body is arranged such that it can be moved and locked. The last-mentioned inventive features acquire special significance when the contact arranged upstream in such a way that it can be moved and locked is arranged outside of and upstream in front of the heat chamber. In this case, the invention utilizes the effect that the moving tubular body is heated

only relatively slowly after passing the contact arranged upstream and finally forms an annealing zone. According to the invention, the heat chamber operated under a protective gas atmosphere and parallel to the conveying direction of the tubular body need only be made so long that just the heating section portion to be protected from cooling and oxidation of the brazing filler metal (copper), but in particular the annealing zone as a whole, is enclosed by the heat chamber. On the other hand, remaining upstream of the heat chamber is a tubular-body section of adequate size, along which the moveable contact, for maintaining optimum brazing conditions, can be displaced backwards and forwards and set.

Advantageous exemplary embodiments according to the invention are shown in the drawings, in which:

Fig. 1 shows a perspective partial view of a double-layer, copper-brazed steel tube,

Fig. 2 shows a part of an apparatus for producing copper-brazed steel tubes which is arranged upstream with respect to the feed or conveying direction of the tube, and

Fig. 3 shows the associated part of an apparatus for producing copper-brazed steel tubes which is arranged downstream and, for graphical reasons, is shown separately.

In Fig. 1 a copper-brazed double-layer steel tube is provided with the reference numeral 10. The two steel-band layers are designated with the reference numeral 11 and the copper coatings or copper layers (thick continuous lines) are designated with the reference numeral 12. The basic material for the copper-brazed double-layer steel tube shown in Fig. 1 is a steel band 11 which is provided on both sides with in each case a copper coating 12 applied by electroplating and forms a coil 13 according to Fig. 2.

It can also be seen from Fig. 1 that the band material is bevelled at each of the points 14 and 15 in order to achieve a uniformly rounded tubular body.

The process and the apparatus will now be described as follows with reference to Fig. 2 and 3:

Two draw-off rollers 16 draw off the copper-coated

steel band 11 and 12 from the coil 13 (rotatably mounted in a manner not shown) and accordingly move the copper-coated band 11 and 12 in the feed or conveying direction x. In the roll stands A and B, the copper-coated steel band 11 and 12 is then plastically (cold) formed into a slotted tube having an upwardly pointing slot 17. A mandrel 19 mounted in spatially fixed manner at 20 at its end 18 passes through the slot 17 into the interior of the slotted tube and extends in the feed direction x over the roll stands C, D and E. Relative to the conveying direction x, behind the roll stand E, a tubular body R has developed which corresponds to Fig. 1, though with the difference that it is not yet brazed. The tubular body R then runs in the conveying direction x through a contact 22 which, with respect to a heat chamber 21, is arranged on the upstream side outside the heat chamber 21. The contact 22 has an upper contact shoe 23 and a lower contact shoe 24. The contact shoe 23 and the contact shoe 24 are connected together in an electrically conducting manner (not shown). The contact shoes 23 and 24 each have contact surfaces 25 and 26 which are indicated in broken lines and are in the form of segmental cylinder jackets and which at the same time ensure that the as yet unbrazed tubular body R retains its cohesion.

The upper and lower contact shoes 22 and 23 (sic) are coupled together as a moving unit in a tensile-resistant and compression-resistant manner, with the lower contact shoe 24 being carried on a sliding bracket which is designated overall as 27 and is slideably arranged on a support 30 fixed at the supporting points 28 and 29 and extending parallel to the conveying direction x.

The sliding bracket 27, together with the contact shoes 23 and 24 carried by it, can accordingly be moved in and against the conveying direction x and can be locked at any point by means of a fixing screw 31.

Whereas the contact 22 forms a contact point located upstream with respect to the conveying direction x, a contact roll pair 32 and 33 located downstream represents the contact which is located downstream and is designated

overall as 34. In order to ensure good electrical contact, the contact rollers 32 and 33 have grooves 35 and 36, each of which have a cross section of circular-segment form. At the point at which the copper filler metal 12 has liquefied, the contact rolls 32 and 33, apart from being used for their electrical contact function, are at the same time used for holding the tubular body R together before the latter has stabilized to form a copper-brazed double-layer steel tube 10 work-hardened after cooling.

Upstream of its part 37 accommodating the contact rolls 32 and 33, the heat chamber 21 has a stepped extension 38 with a lead-in bush 39 of suitable material, e.g. steel, with polished bush sliding surfaces.

In the same way as the cooling chamber 40 which is connected on the outlet side and is cooled, if necessary, on the outside with water, the heat chamber 21 is filled with a protective gas, in the present case with hydrogen or else a hydrogen-nitrogen mixture, so that oxidation of the surface is prevented.

The contacts 22 and 34 are supplied with electric power from the secondary side II of a transformer T, the primary side of which is designated as I. As shown graphically, the primary side I has the transformer winding with the higher number of turns, whereas the secondary side has the transformer winding with the lower number of turns. The source of alternating voltage is designated in Fig. 3 as W. On the primary side, a variable ohmic power resistance 41 for controlling the current intensity is connected in series on the outlet side of the source W of alternating voltage.

When the electric power is switched on, heating accordingly takes place over the heating zone Z limited by the contacts 22 and 24 [sic].

The annealing zone produced by the conductive heating generally begins per se in an area downstream behind the lead-in bush 39. The determining annealing zone for the invention, which is characterized by white heat, combined with a green shimmer, is located in an area whose length is designated in Fig. 3 by the reference numeral G. By

the displacement of the contact 22 relative to the spatially fixed contact 34, the length of the annealing zone G can be kept constant when the tubular-body data vary. As soon as the annealing zone G extends beyond a certain amount, the contact 22 is slowly displaced to the right in the conveying direction x until the annealing zone G has been shortened to the desired size. However, if the annealing zone G is shortened in an inadmissible manner, the contact 22 is displaced to the left against the conveying direction x. When the contact 22 is displaced to the left, the current intensity is increased at the same time, if necessary by actuating the adjustable ohmic resistance 41, whereas the current intensity is if necessary reduced when the contact 22 is displaced to the right in the conveying direction x.

To observe the annealing zone G, it has proved expedient to provide the heat chamber 21 with a sight window which at the same time can have measuring scales.

A pair 42 of draw-off rollers ensures that the cooled, finished double-layer steel tube 10 is carefully conveyed out of the apparatus, and the steel tube 10 is then wound into a tube coil or can be subdivided into longitudinal sections of tube.

The temperature in the annealing zone G - when copper is the brazing agent - is above the melting point of copper, in the present application at about 1150°C.



Patent Claims

1. Process for producing brazed, multi-layer metal tubes (10) in which a metal band, in particular a steel band (11), is gradually plastically formed into a multi-layer, preferably double-layer tubular body (R) with the introduction of a brazing filler metal (12), in particular consisting essentially of copper, the moving tubular body (R) is then conductively heated to brazing temperature via two electric contact points (22, 34), distanced from one another and limiting a heating zone (Z), is held for a period at brazing temperature while an annealing zone forms and is then cooled again, characterized in that, for the purpose of uniformly heating the tubular body (R) to brazing temperature for the necessary period, the length of the annealing zone (G) is measured for a certain feed rate of the tube and kept constant by setting the distance (Z) between the two electric contact points (22, 34) and if necessary also the electric power as a function of a change in the tubular-body data, e.g. proportionally to the mass of the tubular body (R) moved per unit time into the heating zone (Z).

2. Apparatus for carrying out the process according to Claim 1, with a roller or roll-up apparatus for producing the tubular body (R), a conductive heating apparatus with two electric contacts (22, 34), distanced from one another with respect to the tubular body and contacting this tubular body, a heat chamber (21) at least partly enclosing the heating zone, and also with a cooling chamber (40) following the heating zone and accommodating a cooling section, characterized in that, for the purpose of uniformly heating the tubular body (R) to brazing temperature for the necessary period, the length of the annealing zone (G) can be measured for a certain feed rate of the tube and be kept constant when at least one contact (22) is made moveable and lockable.

3. Apparatus according to Claim 2, characterized in that one contact (34) is made spatially fixed, and the other contact (22) is made moveable and lockable.

4. Apparatus according to Claim 3, characterized in

that the contact (22) located upstream with respect to the feed or conveying direction (x) of the tubular body is arranged such that it can be moved and locked.

5. Apparatus according to Claim 4, characterized in that the contact (22) arranged upstream such that it can be moved and locked is arranged outside of and upstream in front of the heat chamber (21).



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Claims (as printed)

1. Process for the production of brazen, multilayer metal tubes (10) in which a metal band, especially steel band (11), is mouldably formed stepwise to give a multilayer, preferably double layer tubular body (R), with the introduction of a solder (12), especially one consisting essentially of copper, the moving tubular body (R) then conductively heated to brazing temperature via two electric contact points (22, 34) distanced from one another and bounding a heating zone (Z), maintained for a period of time at brazing temperature with the formation of an annealing zone and then again cooled, characterised in that, for the purpose of a uniform heating of the tubular body (R) to brazing temperature over the necessary period of time, the length of the annealing zone (G) is measured for a definite rate of tube advance and is thereby held constant, that the distance (Z) between the two electric contact points (22, 34) and possibly also the electric capacity are adjusted in dependence upon a change of the tubular data, e.g. proportionally to the mass of the tubular body (R) moved per unit time into the heating zone (Z).

2. Device for the carrying out of the process according to claim 1 with a roller or rolling up device for the production of the tubular body (R), a conductive heating device with two electric contacts (22, 34) distanced from one another with regard to the tubular body and touching this, a heating chamber (21) encompassing the heating zone at least partly, as well as with a cooling chamber (40) following the heating zone and having a cooling stretch, characterised in that for the purpose of a uniform heating of the tubular body (R) to brazing temperature over the necessary period of time, the length of the annealing zone (G) is measurable for a definite rate of tube advance and can thereby be kept constant, that at least one contact (22) is made movable and stoppable.

3. Device according to claim 2, characterised in that one contact (34) is spatially bound and the other contact (22) is made movable and stoppable.

4. Device according to claim 3, characterised in that the contact (22) present upstream with regard to the tubular body advancing or conveying direction (x) is arranged to be movable and stoppable.

5. Device according to claim 4, characterised in that the contact (22) arranged to be movable upstream and to be stoppable is arranged outside of the heating chamber (21) and upstream before this.



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Revendications (as printed)

1. Procédé de fabrication de tubes métalliques brasés (10) à plusieurs couches, dans lequel on déforme plastiquement et graduellement une bande métal, en particulier une bande d'acier (11) avec amenée d'une brasure (12), en particulier formée essentiellement de cuivre, en un corps tubulaire (R) à plusieurs couches, particulièrement à deux couches, ensuite on chauffe le corps tubulaire (R) en mouvement, par conduction, à la température de brasage, par deux points (22, 34) de contact électrique espacés l'un de l'autre, délimitant une zone de chauffage (3), on le maintient à la température de brasage pendant un certain temps avec formation d'une zone de recuit et ensuite on le refroidit à nouveau, caractérisé par le fait qu'en vue d'un chauffage uniforme du corps tubulaire (R) à la température de brasage, on mesure, pendant le laps de temps nécessaire, la longueur de la zone de recuit (G) pour une vitesse déterminée d'avancement du tube et qu'ainsi on la maintient constante, que l'on règle la distance (Z) entre les deux points (22, 34) de contact électrique et éventuellement aussi la puissance électrique en fonction d'une variation des données du corps tubulaire, par exemple proportionnellement à la masse du corps tubulaire (R) qui est amenée, par unité de temps, à l'intérieur de la zone (Z) de chauffage.

2. Appareil pour la mise en œuvre du procédé selon la revendication 1, comportant un dispositif de laminage ou de roulage pour la fabrication du corps tubulaire (R), un dispositif de chauffage par conduction muni de deux contacts électriques (22, 34) espacés l'un de l'autre relativement au corps tubulaire, touchant celui-ci, une chambre de chauffage (21) entourant au moins partiellement la zone de chauffage, ainsi qu'une chambre de refroidissement (40) faisant suite à la zone de chauffage et logeant un parcours de refroidissement, caractérisé par le fait qu'en vue d'un chauffage uniforme du corps tubulaire (R) à la température de brasage, la longueur de la zone de recuit (G) pour une vitesse déterminée d'avancement du tube peut être mesurée pendant le laps de temps nécessaire et peut être maintenue constante par le fait qu'au moins un contact (22) est conçu pour pouvoir se mouvoir et être arrêté.

3. Appareil selon la revendication 2, caractérisé par le fait qu'un contact (34) est fixe dans l'espace et que l'autre contact (22) est conçu pour pouvoir se mouvoir et être arrêté.

4. Appareil selon la revendication 3, caractérisé par le fait que le contact (22), situé en amont relativement au sens d'avancement ou de transport (x) du corps tubulaire, est disposé de manière à pouvoir se mouvoir et être arrêté.

5. Appareil selon la revendication 4, caractérisé par le fait que le contact (22), disposé de manière à pouvoir se mouvoir vers l'amont et être arrêté, est disposé à l'extérieur de la chambre de chauffage (21), en amont de celle-ci.



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