

Method for joining dispersion-strengthened alloy

The present invention relates to a method for joining two or more components and/or construction parts, at least one of which consists of a dispersion-strengthened alloy.

## Background of the Invention

Construction parts of dispersion-strengthened material, such as, e.g., Kanthal APM or APMT have turned out to best meet the requirements that are made on the construction parts in so-called high-temperature applications, where, e.g., gases are led through a radiant tube that has been heated by means of surrounding burners to a sufficiently high temperature, for instance about 1100 °C. The tube is heated from the outside to a temperature at which the chemical reaction occurs. Typical for the temperature of the tube at the inlet end of the gas is 900 °C and at the outlet end 1125 °C and up to 1200 °C.

In the Swedish patent No. 467 414, a dispersion-strengthened FeCrAl material is disclosed where it is stated that the creep strength is increased by the fact that the material is alloyed with cobalt, nickel, silicon, manganese, zirconium and titanium as well as a small quantity of yttrium and hafnium after which the material is heat-treated at minimum 1050 °C. Radiant tubes are manufactured from the same material.

In the Swedish patent No. 513 989, a method is disclosed for the manufacture of a dispersion-strengthened FeCrAl material by gas atomization. The problem in gas atomization, which is solved according to the patent, is that in the manufacture of a dispersion-strengthened material containing titanium, small particles of TiN and TiC are formed in the charge before the atomization, which particles stick to the melt nozzle being used for the atomization and that the same get clogged. The solution consists of the charge to be atomized being brought to contain 0,05–0,50 % by weight of tantalum and simultaneously less than 0,10 % by weight of titanium. In the patent No. 513 989, it is stated that the material may contain molybdenum (Mo).

Above, it was stated that the creep strength was increased by means of a material according to the patent No. 467 414. However, additional raised requirements on creep strength, ductility, as well as raised requirements on the service life of said tube have been added. It would also be desirable to be able to manufacture longer tubes that resist the high temperature during longer time than tubes known hitherto.

The Swedish patent application No. 0301500-5 discloses radiant tubes in a cracking furnace, where hydrocarbons are cracked into ethylene in a tube through which hydrocarbons flow, which is heated from the outside to a temperature at which cracking of hydrocarbons occurs, and is characterized in that the tube is made from a FeCrAl material containing, in addition to Fe, 10–25 % by weight of Cr, 1–10 % by weight of Al and 1,5–5 % by weight of Mo as well as a smaller quantity of alloying elements.

Dispersion-strengthened alloys are mostly used in applications where temperatures up to 1200 °C occur. This, in combination with construction principles that require long, suspended tubes, imposes special requirements on welds and joinings, respectively, of the tubes. The construction is optimized in terms of the wall thickness. The decisive factors are the service life and a maximum heat transfer from the outside of the tube, which are promoted by thinner tubes and higher strength. The strength of the tube has to be chosen so that at least the dead load is carried. A construction part may typically be up to 10 to 17 m long and may, for instance, be composed of two or more parts, e.g., tubes, welded together.

Upon joining of one or more components or construction parts where at least one of the parts is a dispersion-strengthened alloy, wide zones including precipitations of, e.g., nitrides and/or larger oxide clusters occur, which results in a considerable weakening of the construction at said welds and jointings, respectively. This weakening means that the joint in the dispersion-strengthened material at a certain combination of temperature and load does not meet the strength criteria for the construction. In many constructions where

dispersion-strengthened material is used, the dead load is the largest load on the joint. Therefore, it is not possible to enlarge the wall thickness on the entire tube in order to meet design criteria in the joint since the load then increases. Also from a cost and heat transfer point of view, it is not desirable to use a thicker wall than in conventional design of the tube construction.

With the purpose of joining construction parts with one or both parts consisting of a dispersion-strengthened alloy, the mechanical strength in the joint falls to half the value in comparison with the basic material as consequence of the necessary heating. This entails that welds, joinings or the like form potential indications of fracture.

#### Summary of the Invention

Therefore, it is an object of the present invention to provide a method for joining components, at least one of which consists of a dispersion-strengthened alloy where the above-described disadvantages can be eliminated and the construction is optimized.

#### Detailed Description of the Invention

The present invention provides a method for joining construction parts where one or both parts consist of a dispersion-strengthened alloy by combining known joining techniques with cross-section enlargement of the joint area with the purpose of increasing the strength in the joint and weld area, respectively, to such an amount that the load is carried by the tube.

The present invention provides a method for joining construction parts where one or both parts consist of a dispersion-strengthened alloy by cross-section enlargement of the joint area before the joining with the purpose of increasing the strength in the joint and weld area, respectively, to such an amount that the load is carried by the tube and the use of the construction part in high-temperature applications.

The dispersion-strengthened alloy that is used in the method according to the present invention has a composition according to the following (in % by weight):

C up to 0,08

Si up to 0,7

Cr 10–25

5 Al 1–10

Mo 1,5–5

Mn up to 0,4

balance Fe as well as normally occurring impurities

- 10 It is preferred that the material contains smaller fractions of one or more of the alloying elements hafnium, zirconium, yttrium, nitrogen, carbon and oxygen.

The present invention may be varied in respect of the material composition  
15 above all regarding alloying elements that have low content in the material.

In order to be able to use a dispersion-strengthened alloy, the wall thickness of the construction part should be enlarged only at the joint area. No noticeable increase in dead load arises and the heat transfer does not become  
20 altered in comparison with conventional design.

The load experienced by the joint is calculated according to equation 1.

Equation (1)  $\sigma = F/A$

25

$\sigma$  = Tension [MPa]

F = Force [N]

A = Cross section area [mm<sup>2</sup>]

- 30 If the force F yields the creep rupture criterion  $\sigma_b$  for the joint, e.g.,  $\sigma_b = 4$  MPa at 1100 °C/100 000 h and the strength in the dispersion-strengthened joint is  $\sigma = 2$  MPa, the material cannot be used in conventional design of the joint.

However, if enlargement of the wall thickness at the joint area is employed, where  $A$  is increased by, e.g., a factor of 2, the force  $F$ , which is unchanged, yields a reduction of the creep rupture criterion by a factor of 2. In the case above, this means that the creep rupture criterion is decreased from  $\sigma_b = 4$  MPa to  $\sigma_b = 2$  MPa, and the strength in the joint where one or both parts consist of a dispersion-strengthened alloy thereby meets the design criterion.

In the case of conventional design, equation (1) yields the following  $\sigma_b$ :

$$\begin{aligned} F &= F_1 & [\text{N}] \\ A &= A_1 & [\text{mm}^2] \end{aligned}$$

$$\text{Equation (1)} \rightarrow \sigma_b = F_1/A_1$$

In the case with enlargement of the wall thickness when  $A$  is increased by a factor of 2 in relation to conventional design, equation (1) yields:

$$\begin{aligned} F &= F_1 & [\text{N}] \\ A &= 2A_1 & [\text{mm}^2] \end{aligned}$$

$$\text{Equation (1)} \rightarrow \sigma_b = F_1/2A_1$$

The desired enlargement of the wall thickness of said construction parts that are to be joined may be achieved by a plurality of manufacturing methods such as forging, HIP-ing and turning. In high temperature applications with the construction parts of the above-described material being used, the tube length frequently exceeds 6 m. This entails that forging is the most cost-effective method for joining or welding tubes to desired construction and/or length.

Thus, the geometry of the tube at the joint having enlarged wall thickness does not affect the flowing properties in the process significantly, neither on the outside nor on the inside of the tube. For practical reasons, wall thickening should have an extension in the longitudinal axis of the construction part

and of the tube, respectively, of at least 30 mm. The cross section should be enlarged by an amount that at least corresponds to the load decrease that is aimed at, i.e., the cross-section enlargement is inversely proportional to the load according to the equation above.

5

The method according to the present invention also has the advantage that one or more construction parts of dispersion-strengthened and/or other materials, such as, e.g., stainless steel, can be joined.

10 The method according to the present invention has the advantage to be capable of making use of conventional methods, such as, e.g., conventional welding as TIG for the joining of the forged construction parts, which is a significant factor in respect of construction and assembly.

15 A possible field of application for tubes joined by the method according to the present invention is so-called radiant tubes in cracking furnaces.

In cracking furnaces or ethylene furnaces, hydrocarbons are cracked into ethylene,  $H_2C = H_2C$ , which constitutes a raw material for the plastics industry.

20

Radiant tubes occur in a cracking furnace, where hydrocarbons are cracked into ethylene in a tube through which hydrocarbons flow. The cracking takes place by the fact that hydrocarbons are led through a radiant tube that has  
25 been heated by means of surrounding burners to a sufficiently high temperature at which cracking occurs, for instance about 1100 °C, for ethylene to be formed in the tube. Typically, the temperature of the tube at the inlet end of the gas is 900 °C and at the outlet end approx. 1125 °C and up to 1200 °C.

## Claims

1. Method for joining one or more construction parts, at least one of the parts consisting of a dispersion-strengthened alloy, c h a r a c t e r i z e d in that  
5 the cross section in the joint is enlarged by forging before joining.

2. Method for joining one or more construction parts according to claim 1, at least one of the parts consisting of a dispersion-strengthened alloy that has a composition according to the following (in % by weight):

10

|       |            |
|-------|------------|
| C     | up to 0,08 |
| Si    | up to 0,7  |
| Cr    | 10–25      |
| Al    | 1–10       |
| 15 Mo | 1,5–5      |
| Mn    | up to 0,4  |

balance Fe as well as normally occurring impurities

20

3. Construction part manufactured according to method according to claim 1 and 2 for the use in high-temperature applications at temperatures above 900 °C.

25

4. Construction part manufactured according to the method according to claim 1 and 2 for the use in cracking furnaces.

5. Construction part manufactured according to the method according to claim 1 and 2, where the creep rupture criterion  $\sigma = F_1/A_1$  in the joint is increased by cross-section enlargement.