

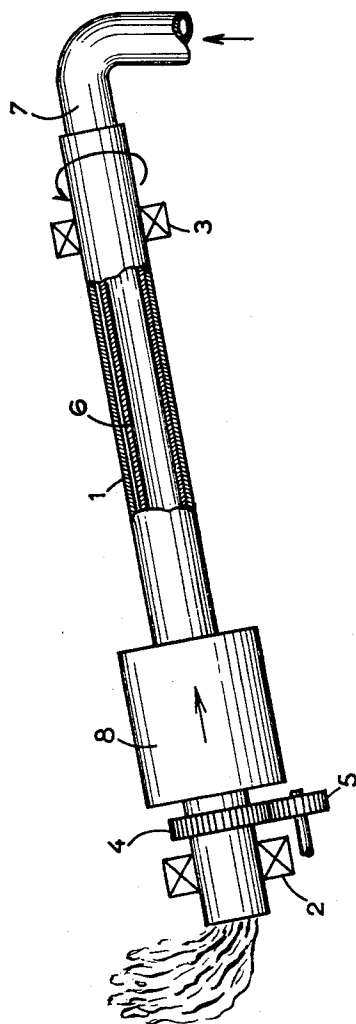
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METHOD OF MANUFACTURING A SINTERED METAL TUBE

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METHOD OF MANUFACTURING A SINTERED METAL TUBE

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The present invention concerns the manufacture of porous or non-porous tubes, having a density equal to or less than the density of the metal used, by sintering metallic powders.

The manufacture of tubes from sintered metal presents several difficult problems, particularly with regard to preserving the shape of the tube while applying heat during the sintering process.

On the other hand, sintering devices should be designed in such a way that the tubes, while still unsintered, do not break.

According to the method of the present invention, the tube is first formed by the agglomeration of a metallic powder with a binder, and is then placed in an inclined position, rotated substantially about its axis and heated starting from the lower part of the tube.

The invention also includes an apparatus for manufacturing tubes from sintered metal, which comprises an inclined refractory tube for containing a tube formed of a mixture of a metal powder and a binding agent, the inner diameter of the refractory tube being at least 0.5 mm. greater than the outer diameter of the metal powder tube, a motor for rotating the refractory tube about its axis and an annular furnace surrounding the refractory tube and arranged to undergo displacement upwardly along the refractory tube during the sintering process.

The inclination of the outer tube is preferably such that the angle formed by it with the horizontal plane is between 5° and 30°; in this way, the sinter tube is prevented from sliding relative to the outer tube. Moreover, since there is a clearance between the sinter tube and the outer tube and the former rests on the latter substantially along one of its generatrices, the frictional forces between the two tubes are decreased because of the inclination, although for inclinations less than 5° these frictional forces could be sufficient to produce fracture of the tube into several pieces when the inner sinter tube shrinks. The maximum angle of inclination depends principally on the nature of the surfaces in contact (the sinter tube and the outer tube). If the outer tube is ridged, for example, this maximum angle of inclination can be increased, since there is less tendency for sliding of the sinter tube relative to the outer tube.

The outer diameter of the sinter tube is less than the inner diameter of the outer tube by an amount sufficient to prevent their coincidence during sintering, and to enable the sinter tube to roll inside the outer tube during the rotation of the latter. The clearance between the two positioned tubes, namely the difference between the two diameters mentioned, should be at least 0.5 mm.

The inner tube undergoes shrinkage during sintering and becomes oval shaped if it does not rotate, that is to say, if the outer tube does not transmit its own rotary movement thereto. Because of this rotation, the formation of an oval shape is completely prevented. The speed of rotation v_R of the outer tube should be a minimum of the order of 1 revolution during the period of sintering; since the speed can vary between 10 minutes and one hour, particularly according to the nature of the sintering powder and temperature chosen, it can be seen that the minimum speed of rotation is of the order of 1 to 6 revolutions per hour; the maximum value of the speed of rotation is limited only by the resistance to vibration of the sinter tube, but there is no purpose in trying to

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obtain an apparatus which can raise the speed of rotation above 5,000 revs./hour.

The sinter heating should take place so that the zone of the tube maintained at the sinter temperature moves from the lower part of the sinter tube to the upper part. The length L of the zone at the sintering temperature should be a fraction (not more than half) of the length of the outer tube. According to the importance of the length of this zone, its speed of displacement v will conform more or less to the formula $v=L/t$, where t is the duration of sintering (between 10 minutes and an hour). As the length of this zone is dependent upon the means being used to produce it and consequently has a minimum value (5 cm. in the case of a movable electric resistance furnace), there are minimum and maximum values for the speed v ; the minimum value will be equal to 5 cm. per hour in the case where the furnace is 5 cm. in length; in the same case and with an outer tube of 110 cm. in length, the heating zone may have a maximum length of about 55 cms. and the value of v will be in the region of 330 cm./hour.

The reason for producing progressive displacement of the heating zone is that the zone in which the binding material is eliminated (in the part below the sinter zone) is of small dimensions and moves progressively in such a way that, in contrast to methods in which the binding material is eliminated simultaneously over an extended zone in the inner tube, it cannot produce fractures of the tube during sintering. Furthermore, as the zone in which a longitudinal shrinkage of the sinter tube is produced at a given moment corresponds to the sinter zone and does not cover the entire length of the inner tube, fractures are prevented which result when the shrinkage occurs at the same moment on all parts of the tube.

In order that the invention may be more readily understood, the preferred embodiment thereof is described below in conjunction with the accompanying drawing, which shows an elevational view, partly in section of one form of apparatus for manufacturing tubes.

The apparatus comprises a tube 1 of stainless or refractory steel inclined in such way as to form an angle, preferably in the region of 20°, with the horizontal plane.

The tube 1 is supported by two bearings 2 and 3 and is rotated by a known type of mechanism. This mechanism may comprise a fixed pinion 4 mounted on the tube 1 in mesh with a pinion 5 driven by a reduction motor.

The speed of rotation of the tube 1 about its axis is in the region of one revolution per minute. A tube 6 which is 80 cm. long is mounted inside the tube 1, which has a length of 110 cm., and the tube 6 is formed by metal powder agglomerated by a binder, for example collodion. This tube may be formed by many different methods, for example by centrifugal action and drying or by extrusion.

A clearance of 1 mm. is left between the adjacent walls of tubes 1 and 6 to accommodate the tube 6, which has an outer diameter for example between 5 and 25 mm.

When the tube 6 is located inside the tube 1, a conduit 7 is introduced into the upper end of the tube 1 for supplying a stream of hydrogen into the latter or, in general, any reducing gas (or a vacuum may be provided in tube 1); the gas is burnt at the lower end of the tube 1.

The sintering heating is effected by a furnace 8 initially disposed at the lower end of the tube 1 and provided with driving means of a known type (endless screw for example) for progressively and slowly moving upwards along the tube 1.

The sinter temperature may for example be in the region of 600° to 1200° C. During the sintering, the tube 6 undergoes shrinkage, which, if the tube 1 is not rotated, could give the sinter tube 6 an oval shape. Owing to the rotation (the speed of rotation $v_R=60$ revs./hour),

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formation of the oval shape is completely avoided. Moreover, the sintered tube is fully protected during the sintering operation (in particular mechanical protection is provided by the outer tube 1) that is to say, during the time at which the tube is the most fragile.

The speed of displacement v of the furnace 3 (length L of the furnace = 20 cm.) is of the order of 1 metre an hour which corresponds to a duration of sintering of 12 minutes (the pitch of the helix described by a point on the region of the sintered tube situated at the intersection of one generatrix of this tube and of the zone of sintering is thus equal to 1.65 cm.).

During the sintering, the collodion or other binding agent is destroyed by the heating and the metallic powder forming the tube 6 becomes sintered. The gases formed by destruction of the binding agent are evacuated at the same time as the excess hydrogen.

Of course, the invention is not limited by the details of the method described, the expert being able to modify these methods, within the scope of the invention. The nature of the metal comprising the sinter powder and the nature of the binding agent may be varied. Such metals are, for example, iron, bronze and nickel, and the binding agent may be collodion, polyvinyl alcohol in water or gum tragacanth in water.

What I claim is:

1. A method of manufacturing a sintered metal tube, which comprises forming a mixture of powdered metal and a binding agent into a tubular shape, locating the thus-formed metal powder tube with a clearance in an outer tube of refractory material disposed at an angle to the horizontal, the clearance between the metal powder tube and the outer tube being sufficient to prevent their coincidence during sintering, rotating the outer tube about its longitudinal axis at a speed of rotation corresponding to at least one revolution during the period of the sintering thereby rolling the powder metal tube inside the outer tube during rotation of the latter tube, and supplying heat to sinter the metal powder tube.

2. A method as claimed in claim 1, in which the heating step is effected by a heat source which is moved longitudinally along said refractory tube from the lower

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portion thereof to the upper portion thereof during the period of sintering.

3. A method as claimed in claim 2, in which said heat source is moved so as to provide an overall sintering time of 10 to 60 minutes.

4. A method as claimed in claim 1, in which the refractory tube is disposed at an inclination of 5° to 30° to the horizontal.

5. A method as claimed in claim 1, in which the sintering temperature is 600° to 1200° C.

6. A method as claimed in claim 1, in which the clearance between the metal powder tube and the refractory tube is at least 0.5 mm.

7. A method as claimed in claim 1, in which the speed of rotation of the refractory tube is up to 5 revolutions per hour.

8. A method as claimed in claim 1, in which a stream of hydrogen or other reducing gas is passed through the refractory tube during sintering.

9. A method as claimed in claim 1, in which the binding agent is selected from the group consisting of collodion, polyvinyl alcohol and gum tragacanth.

10. A method as claimed in claim 1, in which the metal powder is selected from the group consisting of iron, bronze and nickel.

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