

Multi-layer Pipe and Method for its Production

The present invention relates to a multi-layer pipe according to the generic part of claim 6 and a method for its manufacture according to the generic part of claim 1 (see in each case for example,
5 US-A-3327383). Multi-layer pipes are preferably used when high demands exist against corrosion or abrasion.

Corrosion-resistant pressure vessels or pressure lines can be produced in a more cost-effective way than solid versions of corresponding materials when multi-layer pipes are used. This is achieved by
10 load distribution on a thin, corrosion-resistant internal layer (e.g. stainless and acid-resistant steel) and a high-strength and pressure-proof external layer (e.g. fine-grained structural steel). Steel consumption can be considerably decreased as a result and a large part of the remaining steel consumption can be shifted to more cost-effective materials.

15 In certain grades, abrasion-resistant pipelines can only be manufactured when being executed as a multi-layer pipe (for instance with mechanical bonding, see below), since materials (e.g. high-strength steels with high hardness) can be used as an internal layer which for itself cannot be processed into pipes or only under great difficulties.

20 Other material combinations are possible in a great diversity but basically the combination possibilities of materials are restricted in this context only by the processing methods eligible in each case.

When creating the pipe sheathing, there are two possibilities

25

- **metallurgical** bonding over the entire surface (requiring cladmed plates as initial semi-finished product), and
- merely **mechanical** bonding (for instance friction bonding) between internal and external pipe - preferably internal and external plates and their welding on the plate
30 edges.

Manufacture of such multi-layer pipes is done as follows in Prior Art :

For multi-layer pipes with metallurgical bonding between the layers - for instance multi-layer pipes
35 out of metal plates, preferably steel plates - a cladmed composite plate made out of two different (steel) materials is used as an initial semi-finished product. The multi-layer pipe is then manufactured as follows:

- At first the composite plate is produced by roll-bonding or explosion cladding,
- then pipe forming is made in accordance with usual methods such as for example
5 by means of a bending roller or a bending press and
- subsequently welding occurs with the outer wall of the multi-layer pipe being
executed in accordance with the usual pipe welding methods pursuant to the
material used and inner wall welding occurring as deposition welding likewise
10 pursuant to the material.

The disadvantage of this procedure according to Prior Art is on the one hand the high cost of the initial semi-finished product and thus also of the final product, but on the other hand also insufficient availability of the initial semi-finished product, because production capacities are very restricted for
15 it on a world-wide basis. Thus, as far as is known to the applicant and the inventor, only a few installations exist for the production of roll-bonded multi-layer plates, for instance in Austria and in Japan, but for example, not a single one in the Federal Republic of Germany. Neither installations for explosion cladding do hardly exist as far as is known to the inventor and the applicant. For example, at Dynamit Nobel at Burbach, Federal Republic of Germany, one of a few of such plants
20 exists. The production engineering used for it is also a great problem and therefore expensive and intricate taking into consideration in addition that it is only available for very small production lots, anyhow.

Moreover, the number of materials, which can be processed in this way, is restricted. Thus, for
25 example, certain abrasion-resistant steels cannot be used as an internal layer, if they can hardly be welded or not welded at all due to their high carbon content.

In the case of multi-layer pipes with mechanical bonding, several - preferably two - finished pipes are used as an initial semi-finished product. The process will be explained below by way of an
30 example with two pipes (in the event of more layers, the explanations have to be understood accordingly):

- two finished pipes are manufactured in close fit and moved into each other without friction with the external pipe requiring a higher yield point than the internal pipe
- 35 by expansion (mechanically - for example, by means of an expansion die - or by fluid pressure with the pipes placed into each other being pressed into a die comprising the external pipe) the internal pipe is pressed into the external pipe by

elastic expansion of the external pipe. After the expansion forces are omitted, the external pipe places itself non-positively around the internal pipe due to the higher elastic resiliency

5 - finally the two materials are welded on their faces.

The disadvantage of this process of Prior Art is that the external pipe must have a higher yield point than the internal pipe, since otherwise the elastic resiliency of the external pipe causing the non-positive connection with the internal pipe and therefore being necessary, is missing. This is
10 particularly disadvantageous, because high-strength materials - for instance, especially high-strength steels - as they are especially advantageous preferably for abrasion-resistant pipelines inside the pipe, have high or even very high yield points, and are therefore unsuitable for this manufacturing process.

It is therefore the object of the present invention to provide on the basis of the State of the Art a
15 multi-layer pipe as well as a method for its manufacture, which on the one hand tries and avoids the above mentioned disadvantages and thus not requiring roll-bonded and/or explosion cladded semi-finished products but which on the other hand is neither subject to the restrictions involved in manufacture of multi-layer pipes according to the State of the Art with frictionally engaged mechanical bonding of layers among each other.

20 This object is met according to the invention at first by a method for manufacture of a multi-layer pipe after claim 1 and by a multi-layer pipe after claim 6.

Preferred embodiments could be found in the dependent claims.

25 Here, application of roll-bonded and/or explosion cladded semi-finished products can be avoided by pressing the respective material layer acting as an internal pipe already during pipe forming in the bending roller and/or the bending machine, usually necessary for final shaping, non-positively into the material layer acting as an external pipe so that it is frictionally maintained in the respective
30 external pipe without the necessity to expand the multi-layer pipe and thus running into the disadvantages already mentioned. It is pointed out that in some cases, however, final forming or shaping is already possible in the bending roller alone, for example, in the event of shorter bending rollers which can include the function of end forming of the pipe. In that cases a bending machine is not included in the method according to the invention.

35 In the method for manufacture of a multi-layer pipe by means of a bending roller according to the present invention, the multi-layer pipe is preferably closed by welding of the external pipe alongside

the pipe seam and a deposition welding of the internal pipe in order to produce the multi-layer pipe body.

Also, the material layers can be connected on the pipe faces, for example to prevent that humidity
5 penetrates between the material layers which are metallurgical not connected over the entire surface.

A preferred application of the methods for manufacture of pipes according to the invention, especially the method of the present invention itself, is the manufacture of inventive double-layer pipes, although the invention is not restricted to it. Also three-, four-layer pipes and pipes with even
10 more layers can generally be produced according to the present invention which is far more difficult in Prior Art or even not possible at all.

In another especially preferred embodiment of the present invention, plates, preferably metal plates, and more preferably, steel plates, are used as material layers or elements of the material layer.

15 According to the method of the present invention also such materials - as for example very high-strength steels - can be used as a respective internal layer which cannot be welded or can be welded only under great difficulties. The principle of the invention remains: The material layer acting as an internal pipe already during pipe shaping in the bending roller is non-positively pressed into the
20 material layer acting as an external pipe and thus frictionally maintained in the respective external pipe.

A gap is preferably left between the edges of the material layer positioned on top and the stop edges which will close only during the pipe shaping process.

25 After forming of the pipe body, the material layer acting as an internal pipe due to the impact of force can be shifted within the material layer acting as an external pipe so that a plug-in sleeve is formed permitting pipes to be plugged into each other so that pipe assembly on site is extremely simplified.

30 For completion of the pipe body also in this embodiment of the procedure according to the present invention welding of the external pipe is preferably done alongside the pipe seam.
The inventive multi-layer pipe, in particular the multi-layer pipe obtained according to the inventive method, is formed such that a material layer positioned inside has a higher yield point or proof stress
35 (see below) compared with the outer material layer with at least one material layer comprising preferably a metal plate, and more preferably, a steel plate.

An especially preferred embodiment of a multi-layer pipe according to the present invention is characterised in that the multi-layer pipe is formed as a double-layer pipe exhibiting two steel plate material layers with the steel plate, which acts as an internal pipe, having a high up to a very high carbon content and thus is at least not necessarily weldable any more.

5

According to the present invention it is on the one hand not necessary to use clad plates (with the disadvantages, already discussed at the beginning, of long delivery times and limited availability as well as high prices), on the other hand nevertheless multi-layer pipes - especially double-layer pipes out of steel plate material layers - with a high yield point of the material of the respective internal
10 pipe and simultaneous low yield point of the material of the respective external pipe can be manufactured, which is necessary, for example, for such applications of multi-layer pipes requiring a possibly high abrasion resistance of the internal pipe, since high abrasion resistance normally coincides also with a high hardness which in turn coincides with a high yield point. Such multi-layer pipes having an internal pipe made out of a material with a higher yield point than the respective
15 external pipe but which have nevertheless no metallurgical connection of adjacent layers over the entire surface, cannot be manufactured according to Prior Art. They do not exist until now. But they become possible due to the present invention. It must be pointed out that in the event of a not very distinct yield point - for example, in cases of only increased plastic deformation - the proof stress will be substituted for the yield point as the amount of stress of a plastic permanent expansion under
20 a certain impact of force.

Independent of what has been said above, the method according to the present invention permits in addition a far greater plurality of material combinations for the inventive multi-layer pipes. For example, in Prior Art certain abrasion-resistant steels cannot be used as an internal layer, since these
25 not only due to the high yield point usually coinciding with their high abrasion resistance are not suitable to be used alone (e.g. as a single layer pipe) for the pipe shaping process, and also would have to be welded for internal pipe formation, but are hardly or not at all suitable for it due to their high carbon content, i.e. cannot necessarily be welded (see above). Therefore, corresponding pipes do likewise not exist until today. But the method according to the present invention, which takes
30 advantage of the non-positive pressing of the respective internal pipe into the respective external pipe during the manufacturing process, permits manufacture also of such multi-layer pipes, which use as an internal layer a non-weldable or not necessarily weldable material - for example a steel with a high, and preferably very high carbon content -. Thus also the use of materials not weldable at all such as for example modern plastics having the desired properties of an internal pipe layer,
35 becomes possible at all. Pipes with such internal layers do likewise not exist until today.

Again independent of it, also multi-layer pipes can be manufactured by means of the method according to the present invention, without using expensive and hardly available, cladded plates (mechanically connected over the entire surface), in almost any large diameters, which is not possible according to Prior Art, since here the necessary expansion is limited by the dimensions of the expansion die used, or by a die necessary for uniform shaping in the case of a hydraulic expansion force impact which encloses the multi-layer pipe to be manufactured. Compared with this the inventive roll bending process permits multi-layer pipes, which are not subject to such predetermined limitations, since the bending roller, which intervenes for shaping purposes always only in one location of the pipe radius of curvature, does not limit the diameter of the inventive multi-layer pipe. Thus in particular also multi-layer pipes without cladded plates can be manufactured which exceed - and preferably exceed by far - the limit of the present State of the Art of a diameter of approx. 610 mm (24").

The present invention permits manufacture of multi-layer pipes with partial internal layer at all, i.e. an internal pipe forming a graduated circle in cross-section, for example in the form of a channel insert at the pipe base which is likewise not possible in Prior Art until now.

In this connection it should be mentioned that according to the method of the present invention of course also pipes in only very small quantities, especially also individual pipes, can be economically manufactured, which in Prior Art on the one hand is impeded by the intricate cladding and the minimum production lots necessary for it, and on the other hand by the especially set up tools and appliances required for expansion.

Below, non-limitative embodiments will be discussed by means of the drawings, in which

Fig. 1 a perspective view of the base plate subsequently constituting the external pipe, with stop edges, and the internal plate subsequently constituting the internal pipe, in the still flat, unworked condition, and

Fig. 2 a perspective cross-section of a multi-layer pipe according to the present invention with the base plate of the external plate exhibiting stop edges and the internal plate constituting the internal pipe being clamped in-between these stop edges after the corresponding shaping progress.

Fig. 1 shows a perspective view of the base plate 2 subsequently constituting the external pipe, with stop edges 10a, 10b, and the internal plate 1 subsequently constituting the internal pipe, in the still flat, unworked condition. The multi-layer material thus formed is shaped into a multi-layer pipe

according to the present invention by means of a bending roller with the material layer 1 acting as an internal pipe being clamped between the stop edges 10a, 10b and thus being pressed non-positively into the material layer 2 acting as an external pipe. One can also see here that between the edges of the material layer above and the stop edges 10a, 10b, a gap is left which closes only during the pipe
5 shaping process.

Fig. 2 shows a cross-section of a multi-layer pipe 5 according to the present invention with the base plate of the external plate 2 exhibiting stop edges 10a, 10b and the internal plate 1 constituting the internal pipe being clamped in-between these stop edges 10a, 10b after corresponding shaping
10 progress and thus being pressed non-positively into the external pipe 1 as a result of the bending process. The gap between the edges of the material layer above and the stop edges 10a, 10b has already closed before.

Claims

1. Method for producing a multi-layer pipe (5) with the aid of a bending roll, wherein
 - individual layers of material (1, 2) to be combined to form the multi-layer pipe (5) are
 5 laid one on top of the other, wherein one layer of material (2) acting as the respective outer pipe forms a base plate, which has a stop edge (10a, 10b), preferably a welded-on stop edge (10a, 10b), approximately along both its longitudinal edges or approximately parallel thereto in each case, and the overlying layer of material (1) comes to lie loosely between these stop edges (10a, 10b), and
 - 10 - the multi-layer material formed in this way is formed with the aid of the bending roll into a multi-layer pipe (5), characterized in that the layer of material (1) respectively acting as the inner pipe has a higher yield point or proof stress than the layer of material (2) acting as the respective outer pipe, the layer of material (1) respectively acting as the inner pipe is clamped between the stop edges (10a, 10b) and the layer of
 15 material (1) respectively acting as the inner pipe is thereby pressed non-positively into the layer of material (2) respectively acting as the outer pipe in the final phase of the pipe forming in the bending roll and/or a bending machine which is subsequently used.
2. Method for producing a multi-layer pipe (5) with the aid of a bending roll according to claim 1,
 20 characterised in that, in the finished multi-layer pipe (5), the layer of material (1) acting as the inner pipe forms a pitch circle in cross-section and thus preferably forms a channel at the foot of the multi-layer pipe.
3. Method for producing a multi-layer pipe (5) with the aid of a bending roll according to claim 1
 25 or 2, characterised in that individual layers of material (1, 2) to be combined to form the multi-layer pipe (5) are laid one on top of the other, wherein an intermediate space is left between the edges of the overlying layer of material (1) and the stop edges, said intermediate space only closing during the pipe forming process.
- 30 4. Method for producing a multi-layer pipe (5) with the aid of a bending roll according to claim 1, 2 or 3, characterised in that
 - following the shaping of the pipe body (5), the layer of material (1) respectively acting
 as the inner pipe is displaced by means of applied force in the layer of material (2)
 acting as the outer pipe, resulting in the formation of a plug-in socket which allows
 35 pipes (5) to be plugged into one another.

5. Method for producing a multi-layer pipe (5) with the aid of a bending roll according to one of claims 1, 2, 3 or 4, characterised in that the multi-layer pipe (5) is closed by a welding (7) of the outer pipe (2) along the pipe seam (8).
- 5 6. Multi-layer pipe (5) having a layer of material (1) respectively lying on the inside and a layer of material (2) respectively lying on the outside, wherein no full-area metallurgical bonding exists between adjacent layers, characterised in that the layer of material (1) respectively lying on the inside has a higher yield point or proof stress than the layer of material (2) respectively lying on the outside, and in that the layer of material (1) acting as the inner pipe is pressed non-
10 positively into the layer of material (2) respectively acting as the outer pipe.
7. Multi-layer pipe (5) according to claim 6, characterised in that the multilayer-pipe (5) is closed by means of welding (7) of the outer material layer (2) alongside a pipe seam (8).
- 15 8. Multi-layer pipe (5) according to claim 6 or 7, characterised in that at least one layer of material (1, 2) consists of sheet metal.
9. Multi-layer pipe (5) according to claim 8, characterised in that at least one layer of material (1, 2) consists of sheet steel.
20
10. Multi-layer pipe (5) according to claim 9, characterised in that the multi-layer pipe is formed as a double-layer pipe (5) which has two layers of material (1, 2) made of sheet steel, wherein the layer of sheet steel (1) acting as the inner pipe has a high to very high carbon content and thus can no longer necessarily be welded.