

Description

This invention relates in the most general terms to a composite product having a tubular envelope, comprising a metallic envelope and a core of a pulverulent or granular material which adheres to the envelope, which product can be easily wound up and then unwound and straightened.

The invention also relates to the process for manufacture of this composite product.

10 Lastly, the invention also relates to a process for the treatment of molten metallic baths by means of this composite product.

The introduction into molten metallic baths of substances designed to refine, deoxidize, degas, kill and/or modify 15 their composition is current practice in metallurgy.

Numerous processes or apparatus have been used to improve the yield of introduction of these substances as well as the effectiveness and reproducibility of the results.

20 Thus, US Patent No. 2 705 196 describes the addition, to liquid cast iron or steel, of aluminium, silicon, silicocalcium or other materials as deoxidants. In order to prevent oxidation of these additives at the surface of the bath, they are covered in an envelope which may 25 be made, for example of soft steel and which is immersed in the bath by any suitable method.

FR 2 269 581 describes a method for the introduction of a wire of aluminium or of some other reducing metal or alloy into liquid steel to deoxidize it or kill it 30 in the case of a continuous casting installation. To prevent superficial oxidation of the wire, the latter is coated with a thin envelope of steel which protects it against oxidation before it enters the metallic bath. This enables the deoxidation of steel to be carried out 35 continuously by enabling the aluminium wire coated with its envelope to be introduced at a suitable speed directly into the continuous casting mould during the entire

casting time.

Covering of the wire of reducing metal is carried out very simply by enveloping the wire in a thin metal strip which is applied to the wire by passing the whole
5 arrangement through dies of decreasing diameter, the strip being thereby wound round the wire so as to result in covering of the wire accompanied by drawing, the wire functioning as mandrel. A composite product with circular cross-section is thus obtained which can be wound on
10 a spool and which is unwound when required for use by means of a suitable unwinding and driving device which enables it to be introduced at the desired speed into the metallic bath which is to be treated.

French Patent 2 402 000 describes an apparatus for
15 introducing a continuous band of aluminium into liquid steel.

This cold rolled band has a width equal to about twice its thickness and has rounded edges. It is unwound from a spool and straightened before its introduction
20 into the liquid steel.

The apparatus may also be used for introducing pulverulent products enclosed in a tube of the same cross-section as the band into the liquid metal.

Lastly, US Patent 3 915 693 describes a composite
25 product comprising a metallic envelope and a core consisting of a granular material, which product is used in particular for treatments such as deoxidation, refining of the grain or the like in the continuous casting of metals such as aluminium or steel.

30 The product is produced by filling a pre-existing tube with the granular material or enclosing the granular material in a metallic envelope continuously formed from a band. In both cases, the diameter of the filled tube is progressively reduced by different methods such as
35 rolling, hammering or drawing, which enables the length of the tube to be increased while reducing its diameter and its thickness. The composite product obtained is

always circular in cross-section.

Thus, for example, the said Patent describes a tube filled with granular material, having an external diameter of 1 inch (25.4 mm) which is reduced to a final diameter of 3/8 inch (9.5 mm).

In the process of this reduction in thickness, the length of the tube is increased from 246 feet (about 75 m) to 1755 feet (about 535 m), amounting to an elongation ratio of about 7.1. It will be evident that under these conditions, the initial thickness of the wall of the tube is divided by about 2.7.

Tests carried out with a view to applying the teaching of these Patents to the manufacture of composite tubular products comprising a core of pulverulent or granular material and an envelope produced from a metallic strip or band have shown that it is difficult to effect a reduction by drawing after the envelope has been closed. In fact, in the absence of a ductile core capable of serving as support for this envelope and of undergoing deformation at the same time as the envelope, the envelope tends to elongate in an irregular fashion and break and also to assume an external form which is difficult to control.

Furthermore, tests have shown that it is difficult to preserve the quality of a composite product comprising a thin envelope of steel of circular cross-section and a core of a pulverulent material, particularly as regards the form of this envelope and the cohesion of the core, when the product is subjected to operations comprising winding on a drum or a spool followed by unwinding and then straightening.

It has been found that if the pulverulent material inside the envelope is not compacted, the material will not adhere and tends to shift inside the envelope in the course of being handled and thus to become distributed in a heterogeneous fashion, which interferes with the use of the product.

It has therefore been attempted to find means of

resolving these difficulties, that is to say to realise a composite product having a tubular envelope and comprising a pulverulent or granular porous core which adheres to the envelope and remains coherent in spite of being
5 handled, which product can be wound on a spool or drum and unwound.

The object of the present invention is a composite product having a tubular envelope, comprising a metallic envelope closed by hooking and possibly crimping parallel
10 to its axis, in which envelope is housed a compacted pulverulent or granular material.

The cross-section of this product has at least two parallel flattened portions which face each other.

This cross-section may be, for example, square or
15 rectangular or it may have the form of a flattened oval. Particularly favourable results are obtained with cross-sections in which the ratio between the greater axis and the smaller axis, the latter being the distance between two parallel flattened zones facing each other, is at
20 least 1.1.

Another object of this invention is a process for obtaining this composite product having a tubular envelope.

According to this process, there is used, as starting material, a tubular envelope substantially circular in
25 cross-section obtained by any method and inside which is housed, again by any method, a pulverulent or granular material which has not been compacted.

This starting product is subjected to a deformation of its cross-section while its perimeter is kept substantially constant and without significant increase in its
30 length so that the pulverulent or granular material gets compacted without significant displacement in relation to the envelope. Furthermore, this deformation is carried out in such a manner that two parallel flattened zones
35 facing each other are obtained.

The product according to the invention is preferably produced as follows:

a) Shaping a metallic band to impart to it the form of a channel,

b) introduction into this channel of a predetermined quantity of pulverulent or granular material,

5 c) shaping of the two edges of this channel and then bringing together of these two edges to enclose the pulverulent or granular material introduced,

d) hooking the two edges together, then optionally crimping, so as to produce a composite product having
10 a substantially circular cross-section,

e) deformation of the cross-section of the composite product while maintaining its perimeter substantially constant and without significantly elongating the product, so as to compact the pulverulent material and obtain
15 at least two parallel flattened portions facing each other.

Compacting of the pulverulent material carried out under "e" above is thus effected by simple reduction of the cross-section without elongation and without modification of the thickness of the envelope, the material
20 constituting the core being left in a porous state. This prevents hardening of the metallic envelope of the composite product and facilitates subsequent use of the finished product.

25 The detailed description and the non-limiting example which follow enable the invention to be better understood with the aid of the attached Figures, the list of which is given below.

Figure 1 illustrates in a general manner a forming chain using the process according to the invention.
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Figures 1a to 1f illustrate the shape of the profile at different points of Figure 1.

Figure 2 illustrates a variation of the forming chain according to the invention.

35 Figures 3 to 5 illustrate different forms of composite products with tubular envelope manufactured according to the invention.

Figure 6 illustrates how the composite product with tubular envelope according to the invention can be stored, wound on a drum or spool.

Although the invention may be applied in a general manner, the detailed description given hereinafter relates more particularly to refining, deoxidation, degassing and killing of molten metallic baths and/or the modification or adjustment of the composition by means of a composite product of which the envelope is a band of a metal which is compatible with the bath, such as a steel, aluminium, copper or some other metal or alloy. The core consists of the pulverulent or granular treatment material.

In Figure 1, a roll (10) delivers a metallic band (101), for example of steel, in the direction of the arrow to a continuous cold forming chain commencing with a first set (11) of forming rollers such as (110) to (115). At point a (Figure 1a), the band begins to be deformed by having a hollow profile imparted to it (102). At point b (last rollers 115 and Figure 1b), the band has received a half closed cross-section in the form of a channel, its two edges (116) and (117) being suitably shaped to enable them to be subsequently attached to one another. At point c (Figure 1c), a distributor nozzle (120) fills the channel (103) moving past with the pulverulent treatment material (105). This filling operation may be quantified by regulating the rate of feed of pulverulent material (by the pressure applied, for example).

The dosage of the pulverulent material is then preferably adjusted, for example by equalizing its level by means of a scraping device (125, Figure 1d). This advantageously at the same time wipes the edges (116) and (117) on the inside.

The forming chain further comprises a second set (13) of forming rollers such as (130) to (135). These rollers move the edges (116) and (117) towards each other and hook them together at the point e (Figure 1e) and then preferably crimp the bond thus formed by pinching

the joint between the two edges (Figure 1f).

The forming chain is completed by a third set (14) of rollers such as (140) to (145) which deform the envelope without significantly elongating it in the axial direction and bring about a reduction in cross-section while the perimeter is kept constant by conferring on the product a cross-section which has at least two parallel flattened portions facing each other.

The reduction in cross-section is preferably of the order of at least 15%.

The pulverulent material is thus compacted in situ, whereby good cohesion is imparted to it and the material is excellently held inside the envelope enclosing it. Limited compression of the pulverulent or granular material is obtained, and the material remains porous. Since the closed channel (Figure 1f) is substantially circular, a flattened profile close to a rectangle (106, Figure 3), a flattened oval (107, Figure 4) or a rectangle with small semi-circular sides (108, Figure 5) is easily obtained according to the invention. The crimped joint is finally turned down, preferably as shown in Figures 3 to 5, over a large side of the rectangle or oval at the level of one of the two flattened portions.

If the composite product with tubular envelope thus obtained is more or less rectangular in cross-section, it can easily be wound on a drum (150) as shown in Fig. 6 by a guide system, for example of the type with heart-shaped cam, or any other means providing a suitable to-and-fro travelling movement of the product over the drum.

In certain cases, in particular where the envelope has a considerable thickness, introduction and dosage of the pulverulent material may be carried out as illustrated in Figure 2: A hollow mandrel (200) is supported by a hollow bar (201) to be introduced into the channel before the latter is closed, this closure being effected at (210) by rollers (not shown). The pulverulent or granular material is pushed inside the hollow mandrel-

support bar (201) and mandrel (200) to be introduced into the channel at the level of the head of the mandrel (205). If this has been widened to a suitable form, it also serves as support for closing the edges (116) and (117) as illustrated in Figure 1f. The material is then compacted according to the invention with the aid of the third set (14) of forming rollers (Figure 1).

It is to be understood that this filling may also be carried out by other injection means, with or without gas pressure, depending on the characteristics of the pulverulent or granular material and the geometric form of the envelope.

Treatment of the molten metallic baths is carried out as follows: The quantity of product required is known. The drum (150) is carried to a position above the bath and the required length of composite product according to the invention is unwound into the bath within a short time and cut by suitable means at the end of the process. This arrangement is particularly suitable for steel ladles or continuous casting distributors.

The metallic envelope is generally produced from a bent and crimped band made of the same basic metal as the liquid metal. This envelope is therefore in this sense unreactive in relation to the metallic bath.

The envelope may also be used as feed metal properly speaking, for example an envelope of aluminium may be used for introduction into a bath of steel.

The pulverulent or granular material which constitutes the core may be based on metals or alloys, slags or a mixture of these products. This material may in particular include reactive substances for refining, deoxidizing, degassing or killing the molten metal bath or for modifying the nature of the inclusions or to play the role of additives. The following may in particular be mentioned: Reducing metals such as calcium, magnesium, sodium, boron, titanium, zirconium, rare earths or other reducing elements or compounds,

additive elements for modifying the properties of the metal or various addition elements such as lead, bismuth, selenium, tellurium or sulphur, addition elements for adjusting the composition of the metal bath with a high degree of analytical precision, such as C, Si, Mn, N, Cr or Mo, any alloys containing the above mentioned elements combined with two base metals such as, in particular, iron, silicon, aluminium or copper.

10 The material may also comprise, in whole or in part, powdered slag, the composition of which corresponds to that of slags generally used in metallurgical reactions of synthesis or refining of the treated liquid metal such as a mixture of chromium, aluminium and fluorspar.

15 The non-limiting example given below describes one embodiment of the invention.

Example 1

A composite product having a tubular envelope was produced by the above process from a strip of steel 0.4 mm in thickness and 36.4 mm in width. After the strip had been formed into a channel, a pulverulent material based on SiCa containing 30% of Ca was introduced into the channel. The strip was then rolled up, hooked and crimped to form a tube 10 mm in external diameter filled with pulverulent material.

The tube was then flattened to convert the cross-section into a virtually rectangular cross-section having rounded corners and measuring 11 x 6 mm. This final deformation was carried out in the cold without significant elongation and resulted in a reduction of the internal cross-section by about 16%. The pulverulent material was thereby effectively compacted and the envelope tightly closed over this compacted material so that the pulverulent or granular material remained in place during subsequent manipulations.

The composite product was wound by a to-and-fro winding motion on a spool 600 mm in diameter. The density of filling

of the spool obtained was 20 to 25% greater than that which would have been obtained with a product having a circular cross-section.

5 The composite product was found to have excellent mechanical strength during this winding operation and in the course of subsequent unwinding for use. The composite product entered right into the interior of a molten steel bath. While remaining both porous and compressed, the pulverulent or granular material reacted
10 with the liquid steel under optimum conditions of efficiency and yield.

The invention is also suitable for applications other than the treatment of metal baths, such as, for example, its use for steel welding electrodes containing their
15 flux inside them, for welding in a bath.