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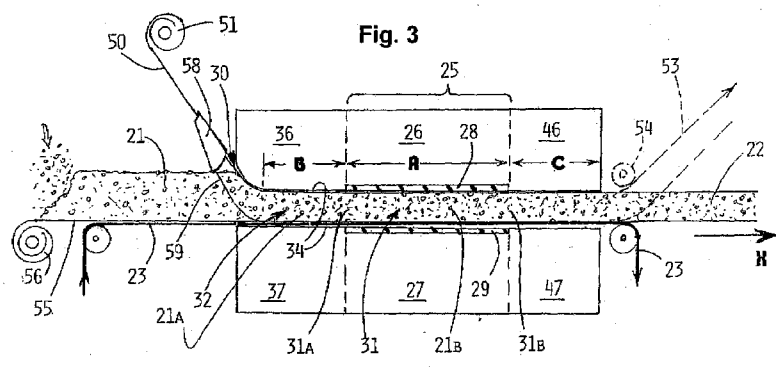
Fig. 3



(57) Abstract: Methods and apparatus are disclosed for binding of particulate materials to manufacture articles including continuous panels or sheets (22). Particulate feed materials arc mixed with a heat curable binder and the mixture (21) is fed to and compressed in a die (25). A radio frequency (RF) field is applied across electrodes (28, 29) between which the mixture is held compressed to inductively or dielcctrically heat and cure the binder. Prior to entering the die (25) the mixture is first fed to an intake zone (32) where the mixture is shaped into substantially the same shape as the shape of the mixture in the die so that any curing of the binder due to heating of the mixture in the intake zone (32) occurs while the mixture is in the desired final shape. Operating parameters including shape and dimensions of the intake zone, mixture advancement lengths, are disclosed.

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BINDING PARTICULATE MATERIALS TO MANUFACTURE ARTICLES

CROSS REFERENCE TO RELATED APPLICATION

This is a Convention patent application claiming priority from Australian Patent Application No. 2008902622 filed 26 May 2008, and the contents of that specification are incorporated herein by this cross reference.

FIELD OF THE INVENTION

This invention relates to the manufacture of bound bodies or articles composed partially of particulate materials, such as bodies in the form of panels, sheets, and other formed shapes and particularly to the manufacturing methods and the products of such methods.

BACKGROUND OF THE INVENTION

In Australian patent specification No. AU-48947/93 (Patent Serial No. 651285) there is described a process for manufacturing bodies composed of a binder mixed with a feed material including rice hulls and/or particles obtained by comminuting rice hulls. The binder comprises a heat curable composition. The mixture of the feed material and binder is formed into the generally desired shape of the body e.g. in a mould or in a press, and the binder is cured to form an adherent body having substantially the required shape, e.g. by applying to the formed shape an RF field of a suitable frequency and intensity and for a suitable period of time to cause dielectric heating within the mixture so as to cure the binder to form the final adherent body. The body is then removed from the mould or press. Reference may be made to this patent specification for further background information particularly in relation to rice hulls and their properties and preparation.

A further patent specification AU-2001100327 by the present applicant further describes processes for forming bodies by extrusion using rice hulls. This patent specification is also incorporated herein in full by cross-reference for the purpose of providing further background information about particulates, fillers, binders, additives, reinforcing, etc that can be used in such bound bodies.

The above references to and descriptions of prior proposals or products and processes are not intended to be, and are not to be construed as, statements or admissions of common general knowledge in the art.

Problems with RF heating and curing, particularly if continuous production of bound bodies is attempted, are outlined later in relation to Figs. 1 and 2 of the drawings. These figures however do not depict known or published apparatus to the applicant's

knowledge, but rather they are used to illustrate difficulties the inventor faced and overcame with the present invention.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a manufacturing method for producing bound bodies composed at least partially of particulate materials which can provide a useful alternative to known or previously proposed methods.

It is a further and preferred object to overcome the problems with the batch type systems, and to be able to produce a continuous board or panel, or other continuous bound body, using Radio Frequency heating.

According to a first aspect of the present invention there is provided a manufacturing method for producing a bound body composed at least partially of particulate material, the method including the steps of:

providing a feed material which includes a substantial proportion of particulate material,

introducing to the feed material a binder which includes a heat curable or activated adhesive substance so that the binder contacts significant proportions of the surfaces of the particulate material,

feeding the mixture of feed material having the binder therein into a die so that it adopts substantially the shape of the body to be produced, and

heating the mixture in the die until the binder has cured sufficiently to enable further handling as an integral bound body comprising the bound particulate materials,

wherein the method includes the further step of feeding the mixture through an intake zone prior to entering the die where the mixture is shaped into substantially the same shape it adopts when subsequently fed into the die so that any progress of curing of the binder due to heating the mixture resident in the intake zone is effective in curing binder while the mixture is in the desired final shape.

Preferably the mixture of feed material and binder formed into the desired shape is compressed in the die and is resident in a compressed condition in the die for a period of time for the binder to be cured sufficiently to enable removal of the compression and handling of the bound body. The intake zone may be defined by intake guides composed of insulating material. Preferably the intake guides have substantially the same profile and separation as the die so that the die is effectively a continuation of the intake guides whereby mixture within the intake zone feeds smoothly into the die. The die is preferably

a continuous extension of the intake zone so that the mixture passes from the intake zone into the die without any intervening transition zone.

In the preferred embodiment the heating may comprise heating by RF energy applied through opposed conductive die plates (electrodes) between which the mixture is located and the intake guides are composed of electrically insulating material. Preferably the length of the intake zone along which the mixture is fed before entering the die is at least equal to the separation of the die plates, and is most preferably in the range of about 2 to 3 times the separation of the die plates, whereby the length of mixture shaped and resident in the intake zone is substantially equal to or greater than the distance between the die plates. Apparatus according to this embodiment has been successfully trialled with an intake zone length of about three times the distance separating the die plates.

Preferably the mixture is fed into the intake zone through a mouth which has a progressively narrowing shape in the direction of advance of the mixture into the intake zone so that the mixture is progressively compressed as it is fed through the mouth into the intake zone.

The step of feeding preferably comprises feeding the mixture in batches or in an indexed manner from the intake zone into the die so that each indexed batch of mixture in the intake zone is a continuous extension of the preceding batch now in the die and so that the successive formed cured batches that are moved out of the die form a continuous body emerging in a stepped manner. In this method, a leading portion of the batch in the intake zone immediately upstream of the batch in the die and which is subject to at least some heating during heating of the mixture in the die is, upon being advanced into the die, located in the die before the exit of the die so that it is substantially entirely resident in the die for the heating cycle of its batch.

In the preferred method, the longitudinal distance by which the mixture is fed in each batch or indexing movement along the path from the intake zone into the die is less than the longitudinal length of the die in which heating of the mixture occurs, whereby all of the mixture will experience a residence time completely within the longitudinal boundaries of the die.

Preferably the die has side walls which confine the mixture laterally within the die during the heating of the mixture in the die. The side walls of the die may slightly diverge in the direction of advance of the mixture through the die so as to promote the release of the bound body from the die at the end of each operation to cure the binder within the mixture in the die. Alternatively or additionally, the side walls of the die may

be movable towards each other to laterally confine the mixture in the die before commencement of the steps of compressing and heating the mixture in the die and may be movable apart to release the bound body formed by curing of the binder in the die.

The preferred method may further including a step of locating a face member on at least one of the upper and lower surfaces of the mixture being fed into the intake zone and into the die whereby the face member is advanced through the intake zone and through the die. In one possible method, the face member remains attached to its associated surface of the bound body that emerges from the die after curing of the binder in the mixture within the die so that the face member forms a surface part of the bound body. In an alternative possible method, the face member is removed from the associated surface of the bound body after the bound body emerges from the die whereby the mixture within the die can be prevented by the removable face member from contacting and fouling the surfaces of the die.

Preferably the face member comprises a flexible sheet material progressively fed from a roll so as to enter the intake zone and progress to the die with the face sheet separating the mixture of particulate material and binder from direct contact with the surfaces of the intake zone and die. The flexible sheet may be wider than the final width of the bound body that emerges from the die, and the flexible sheet may be shaped at its side edges to form side members for assisting to enclose the mixture in the die against lateral expansion.

The method may include the step of providing and locating a selectively replaceable wear sheet so as to extend completely through the intake zone and continuously through the die on a lower face thereof thereby providing a sacrificial wear member protecting the faces of the intake zone and the die from abrasion and adhesion.

The invention also provides a bound body composed at least partially of particulate material when manufactured by a method according to the invention.

The invention also provides apparatus for manufacturing a bound body composed at least partially of particulate material, the apparatus comprising means operative to perform the steps of a method according to the invention.

According to a second particular aspect of the invention, there is provided an apparatus for manufacturing a bound body composed at least partially of particulate material, the apparatus comprising:

means for introducing to a feed material which includes a substantial proportion of particulate material a binder which includes a heat curable or activated adhesive

substance so that the binder contacts significant proportions of the surfaces of the particulate material,

a die having substantially the shape of a body to be produced and means for feeding the mixture of feed material having the binder therein into a die so that it adopts substantially the shape of the body to be produced,

means for heating the mixture in the die until the binder has cured sufficiently to enable further handling of the integral bound body comprising the bound particulate materials, and

an intake zone into and through which the mixture is fed prior to entering the die and wherein the mixture is shaped into substantially the same shape it adopts when subsequently fed into the die so that any progress of curing of the binder due to heating the mixture resident in the intake zone is effective in curing binder while the mixture is in the desired final shape.

BRIEF DESCRIPTION OF THE DRAWINGS

Possible and preferred features of the present invention will now be described with particular reference to the accompanying drawings. However it is to be understood that the features illustrated in and described with reference to the drawings are not to be construed as limiting on the scope of the invention. In the drawings:

Fig. 1 is a schematic side sectional view of a die using RF energy to induce heating within a mixture of particulate material and binder in the die;

Fig. 2 is a simplified view of a problem that arises using the die of Fig. 1 to try to produce a continuous panel;

Fig. 3 is a schematic cross-section through an apparatus for producing a continuous panel embodying aspects of the present invention; and

Fig. 4 is a schematic perspective view of aspects of the die used in the apparatus of Fig. 3.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The bound body in Fig. 3 is a panel or board but the invention is not limited to this single product. For example continuous rods, beams, corrugated or other cross sectional shaped bodies, arcuate pipe lagging, etc could be produced. The continuous bound body, panel, or formed shape can be made using any suitable particulate or fibrous materials, for example, wheat straw where the straw is preferably cut to a desired length and split or shaved or shredded (e.g. see US Patent 5932038 Bach et al. for wheat straw splitting or stranding system), or any other straw or fibre, such as oat straw, rice straw, whole or

comminuted rice hulls, or any cellulose or cellulosic or lignocellulosic materials agri-fibres, cotton, synthetic organic fibres (e.g. rayon), inorganic fibres (e.g. glass or mineral fibres), including any products that can be mixed with a heat curing resin, or any combination or percentage thereof, including infills and re-inforcing materials. Other ingredients could include protective substances such as fire retardants, vermin deterrents, insecticides. Layers of different materials can be laid for different physical, acoustic, thermal properties, and/or decorative aesthetic effects.

Radio Frequency (RF) heating is preferred as the heating source to set or cure said resins or binders. However the invention is not limited to RF heating and could be applicable to conductive heating using heated die plates, or heating by forcing heated fluid (e.g. air) through the mixture held in the die.

Any suitable resin that the setting or curing of resin is accelerated by or needs heat to set or cure, can be used. For example, MDI, pMDI type resins, a suitable resin is available from Huntsman Polyurethanes, is Suprasec 1041 binder. Some ttypes of MDI are water dispersable, set at about 80°C, and are useful for example with wheat straw which has a waxy surface.

Amongst the many problems encountered using a batch system for the High Frequency heating and curing of substrates, is the cumbersome and messy handling that arises by using this method. The moulds or dies need to be made with non-ferrous materials that have short working lives, and they are high maintenance items. Any product build up on the vertical side walls or between surfaces of the mould or die will increase the risk of what is termed "Flash Over" from live electrodes, and serious high frequency generator damage can result, especially with capacitors, transmitter valve (or tube), including high voltage transformers. This Flash Over has been known to render expensive High Frequency Generators totally inoperable, and at times unserviceable.

MDI and pMDI type resins, will bond to the metal electrodes or die surfaces more so than other types of resins or binders, and providing separating layer or sheet or membrane between the die plates and the resin-particulates substrate mixture tends to eliminate this problem, such as various types of paper, or coated papers, plastics sheet including plastics type films, or laminating sheet. Waterproof membranes are preferred so the die is not wetted which can promote arcing (Flash Over). Release compounds are also available and useable, e.g. waxes sprayed onto the conveyor upstream of the die, but are more difficult to apply.

It is preferred to fold the sides of a bottom separating sheet upwards (e.g. using a guide like a "mould board" of a plough, and/or sides of a top separating sheet downwards, so as to enclose or encapsulate the substrate mixture and hold it more manageably through the dies or press. If the separating sheet is in the form of a release film, it can be reclaimed or discarded once through the press. Alternatively, if desired, as well as separating the mixture from contacting the die surfaces the release film can become an integral part of the formed and bound body.

There are several problems with batch type moulding systems including:
(a) Loading and unloading dies and moulds, especially when High Frequency heating is used, because all moulds and dies must be made from non-metallic materials, and cleaning and maintaining them is very costly and frequently required. Also required when using batch systems is (i) the elaborate shuttle or traversing system to transport the dies or moulds into and through a press, (ii) the inefficient filling and emptying of the press moulds or dies, and (iii) the cleaning between usages.
(b) Difficulties in controlling uniform heat over and throughout large areas.
(c) The greater the area of a product becomes, the more difficult it is to tune the High Frequency generator to the product, or match or tune the load to the generator.
A problem or difficulty the inventor has discovered in producing a continuous board or panel, or other continuous shape using Radio Frequency as the heat source, is that the uncompressed upstream resin binder and particulates mixture (or substrate) 11, i.e. the mixture 11 beyond or outside of the live electrodes 18; 19 of the die 15, is also heated up to at least approximately the same distance as the distance between the live electrodes. This is illustrated in Figs. 1 and 2 where the RF field 10 is shown at 10a extending beyond the edges 16a, 17a at the entrance of the die 15 formed by top and bottom die members 16, 17. Hence the RF field 10a in use affects the mixture 11 outside of the entrance 15a of the die 15, thus initiating curing of the binder in the mixture before it enters the die. This poses a serious problem, since the binder in the uncompressed substrate 11 will be at least partially set or cured in that uncompressed condition. When that substrate is then indexed into, and placed under the compression in the die 15 and is held compressed therein to the desired thickness and density, and RF heating occurs between the live electrodes 18, 19, the binder that has been at least partially cured before entering the die 15 will have no effect on holding that part of the substrate in a bound compressed condition, because the binder had already been set, or cured, in the uncompressed condition prior to entering the compression zone of die or press 15.

The panels or boards made in this manner, tended to expand as again shown schematically (and in an exaggerated manner) at 13 in Fig. 2 and tend to be weakened and snap off in sections equal in length to the feed indexing length of the substrate 11 into the press 15.

According to the embodiment of the invention as shown in Fig. 3, particulate and resin mixture 21 is formed and deposited on a conveyor 23, which may be a continuous belt, made of RF permeable material (e.g. canvas or other fabric, synthetic or natural rubber, polymer material, etc.). The conveyor 23 conveys the mixture 21 into a press or die 25 that contains the live electrodes (plates) 28, 29. These constitute upper and lower die surfaces between which the mixture 21 is compressed e.g. by raising the upper die part 16 to increase the separation during introduction of mixture in the longitudinal direction X, followed by return movement of the die part 16 to compress the mixture to a desired density. The die parts 16, 17 are shown as planar, but could have other shapes of profiles e.g. corrugated in the direction X. Compression ratios between about 2:1 and 4:1 produce relatively open structured panels useful for acoustic or thermal insulation while compression ratios greater than about 4:1 produce higher density boards, like "craftwood", having more reflective properties and physical strength.

Between plates 28, 29 is the main curing zone 31 which is extended by an intake zone 32 upstream of the main curing zone 31 by intake guide portions 36, 37 composed of an insulating material. The intake zone 32 has opposing faces 33, 34 which are level with, and in the same plane as, the live electrodes 28, 29 and extends for a similar or preferably greater length B than the separation distance between the live electrodes 28, 29. Guide portions 36, 37 can be fixed to die parts 26, 27 so as to move therewith to open and close the die. The mixture or substrate 21 therefore will be held in the intake zone 32 in a compressed state the same as in the main curing zone 31 between the live electrodes 28, 29.

The mixture 21 is fed into the intake zone 32 through a mouth 30 which has progressively a narrowing shape in the direction of advance X of the mixture into the intake zone 32 so that the mixture is progressively compressed as it is fed through the mouth into the intake zone. Downstream of the mouth 30, the intake zone may have very slightly diverging faces in the direction of advance to promote release and advance of the mixture out of the intake zone into the main curing zone 31.

An RF field is selectively applied through the electrodes 28, 29 to dielectrically heat the water content of the binder in the mixture 21b held in compressed in the main

curing zone 31. In addition, because of some inductive or dielectric heating effect upstream of the entrance 31a and/or heat transfer through the mixture (e.g. by heated air or steam migrating through the mixture) some of the substrate 21a can be at least partially set or cured beyond and upstream of the live electrode area 31 but under the same compression conditions as the substrate 21 in the main curing zone 31 directly between the live electrodes 28, 29, although such curing will not occur in the total length B of the compressed substrate 21a held within the insulative extended press die section (the intake zone 32). This upstream compression to the same shape as the die shape provides an inventive and novel method of overcoming the problems of producing a continuous formed bound shape, using Radio Frequency as the heat source.

As panels of up to a thickness of 150mm and beyond can be made using Radio Frequency, the extended insulative die length B upstream of the live electrodes, can be anything up to 300mm long, or even longer.

When the top die member 26 of the die or press (and attached intake zone member 36) is raised, the portion 21a of substrate that was compressed and the binder therein was partially set or cured upstream of the main curing zone 31 under the same compression and thickness as was the portion 21b of substrate that was between the live electrodes 28, 29, is then moved forward into the main curing zone 31. This at least partially set or cured portion 21a of the substrate 21 that was in the intake zone 32 and upstream of the entrance 31a of main curing zone 31 will now be positioned between the live electrodes 28, 29 for ensuring complete curing. Preferably the portion 21a is moved to a position under, and most preferably a little before the exit 31b of the press die electrode area 31, (although effective binding may still be achieved if moved forward until a little after the exit 31b). Thus it will be possible to produce a continuous composite panel or board 22 using Radio Frequency field as heating source.

Heating in the main curing zone 31 may be to about 80°C for MDI and pMDI binders. Preferably the temperature is less than 100°C so steam is not formed which can migrate upstream of the die and dilute resin producing uncontrolled and non-uniform binding conditions.

It was also discovered that the sides of the substrate 21 desirably needed support to achieve a uniform substrate density at least within the main curing zone 31. This can be achieved by the apparatus in Fig. 4 having side walls parallel to the direction X along at least the length A of the curing zone 31 and preferably along substantially the

total length (A+B+C) of the die assemblies 36, 26, 46 and 37, 27, 47. These side walls 41, 42 can be moved out by suitable means 43 to allow substrate 21 to enter die area 31, then, when substrate forward indexing is complete, the side walls 41, 42 can be moved inward to the sides of the press electrodes 28, 29, holding substrate 21b level with side edges of the electrodes 28, 29, prior to compression, and therefore not allowing substrate to be squeezed laterally out of die area 31, and be of a lower density than the centre of substrate 21. As shown schematically in Fig. 4 the lower die part 27 is wider than upper die part 26 and the side walls 41, 42 remain above the upper surface of the lower die part to always confine mixture 21 within the walls 41, 42, but the upper die part 26 moves down to fit closely between the walls 41, 42.

The side walls 41, 42 can be moved laterally outward away from press die electrodes 28, 29 to allow the substrate 21b that has set to form board 22 to be indexed out through exit end 31b, e.g. into an exit zone 33 between insulating exit zone extension portions 46, 47 in which some residence time can allow curing, if not complete in zone 31, to progress further. The cycle then starts again. Instead of, or in addition to, lateral movement of the side walls 41, 42, the side walls may diverge in the direction X of advance of the product, e.g. by a few degrees such as 1°-5° or say 5mm over a die length A of 1200mm, to promote release and advance of the formed and bound product 22 out of the main curing zone 31.

The substrate moisture level may determine if the side walls 41, 42 are held in against the edges of the electrodes 28, 29, or slightly outwardly thereof, during the irradiation time. A slight outward positioning of the walls 41, 42 can reduce the risk of Flash Over at the sides of the die particularly if moist binder is used.

Instead of side walls 41, 42 shown as side panels, endless belts with upright planes can form side walls and can be indexed together with the movement of the substrate.

Face members 50, 55 are applied e.g. from rolls 51, 56, on the upper and lower surfaces of the mixture 21 being fed into the intake zone 31 and into the die 25 so that the face member 50, 55 are advanced through the intake zone and through the die. The face members 50, 55 remain attached to their associated upper and lower surfaces of the bound body 22 that emerges from the die after curing of the binder in the mixture within the die so that the face members 50, 55 form surface parts of the bound body. Alternatively however, one or both face members 50, 55 can be removed from the associated surfaces of the bound body after the bound body 22 emerges from the exit zone 33, as shown in

Fig. 4 with trailing portion 53 of the upper face member 50 being peeled off the top surface around roller 54. By removing one or both the face members, the mixture within the die can be prevented by the removable face members from contacting and fouling the facing surfaces of the die.

As shown, each face member 50, 55 comprises a flexible sheet material progressively fed from a roll 52, 56 so as to enter the intake zone 32 and progress to the die with the face sheet separating the mixture 21 of particulate material and binder from direct contact with the surfaces of the intake zone 32 and die 25. As shown in Fig. 3 for the upper face sheet 50, the flexible sheet can be wider than the final width of the bound body 22 that emerges from the die, and the flexible sheet 50 is shaped by its side edges contacting shaping members 58, e.g. resembling a mould board of a plough, to be folded down and form side members 59 for assisting to enclose the mixture 21b in the die against lateral expansion.

Fig. 4 shows schematically a wear sheet 48 located so as to extend completely through the intake zone 32 and continuously through the die 25 on a lower face thereof thereby providing a sacrificial wear member protecting the faces of the intake zone and the die from abrasion.

It will be seen that in the preferred method and apparatus described herein the feeding of the mixture 21 in batches in an indexed manner from the intake zone 32 into the die 25 so that each batch of mixture 21a in the intake zone is a continuous extension of the preceding batch 21b now in the curing zone 31 of the die and so that the successive formed cured batches that are moved out of the die 25 form a continuous body 22 emerging in a stepped manner. In particular, the leading portion of the batch 21a in the intake zone 32 immediately upstream of the batch 21b in the die and which is subject to at least some heating during heating of the mixture in the die is, upon being advanced into the die, located in the die before the exit 31b of the die so that it is substantially entirely resident in the die for the heating cycle of its batch. That is, the longitudinal distance by which the mixture is fed in each batch or indexing movement along the path from the intake zone 32 into the die 25 is less than the longitudinal length A of the die in which heating of the mixture 21b occurs, whereby all of the mixture 21 will experience a residence time completely within the longitudinal boundaries of the die 25.

The output of the apparatus is a continuous sheet or panel 22 without weakness or deformation or other flaw at any zone where the mixture experienced some heating and curing outside of the die. Because of minor variations in composition or conditions in the

forming and curing processes, particularly for low density panels, the top surface of the final board can have some minor height variations, in the order of about 1mm, so the top may desirably be planed or sanded to produce a high quality flat surface finish.

The final products have been manufactured to satisfy safety standards e.g by having no free formaldehyde, and quality standards e.g. showing no swelling in both hot and cold water exposure tests, and no loss of internal bonding after water immersion tests.

CLAIMS

1. A manufacturing method for producing a bound body composed at least partially of particulate material, the method including the steps of:

providing a feed material which includes a substantial proportion of particulate material,

introducing to the feed material a binder which includes a heat curable or activated adhesive substance so that the binder contacts significant proportions of the surfaces of the particulate material,

feeding the mixture of feed material having the binder therein into a die so that it adopts substantially the shape of the body to be produced, and

heating the mixture in the die until the binder has cured sufficiently to enable further handling as an integral bound body comprising the bound particulate materials,

wherein the method includes the further step of feeding the mixture through an intake zone prior to entering the die where the mixture is shaped into substantially the same shape it adopts when subsequently fed into the die so that any progress of curing of the binder due to heating the mixture resident in the intake zone is effective in curing binder while the mixture is in the desired final shape.

2. A method as claimed in claim 1 wherein the mixture of feed material and binder formed into the desired shape is compressed in the die and is resident in a compressed condition in the die for a period of time for the binder to be cured sufficiently to enable removal of the compression and handling of the bound body.

3. A method as claimed in claim 1 or 2 wherein the intake zone is defined by intake guides composed of insulating material.

4. A method as claimed in claim 3 wherein the intake guides have substantially the same profile and separation as the die so that the die is effectively a continuation of the intake guides whereby mixture within the intake zone feeds smoothly into the die.

5. A method as claimed in claim 4 wherein the die is a continuous extension of the intake zone so that the mixture passes from the intake zone into the die without any intervening transition zone.

6. A method as claimed in claim 3, 4 or 5 wherein the heating comprises heating by RF energy applied through opposed conductive die plates between which the mixture is located and wherein the intake guides are composed of electrically insulating material.

7 A method as claimed in claim 6 wherein the length of the intake zone along which the mixture is fed before entering the die is at least equal to the separation of the die

plates, and is preferably in the range of about 2 to 3 times the separation of the die plates, whereby the length of mixture shaped and resident in the intake zone is substantially equal to or greater than the distance between the die plates.

8. A method as claimed in any preceding claim wherein the mixture is fed into the intake zone through a mouth which has progressively a narrowing shape in the direction of advance of the mixture into the intake zone so that the mixture is progressively compressed as it is fed through the mouth into the intake zone.

9. A method as claimed in any preceding claim wherein the step of feeding comprises feeding the mixture in batches in an indexed manner from the intake zone into the die so that each batch of mixture in the intake zone is a continuous extension of the preceding batch now in the die and so that the successive formed cured batches that are moved out of the die form a continuous body emerging in a stepped manner.

10. A method as claimed in claim 9 wherein a leading portion of the batch in the intake zone immediately upstream of the batch in the die and which is subject to at least some heating during heating of the mixture in the die is, upon being advanced into the die, located in the die before the exit of the die so that it is substantially entirely resident in the die for the heating cycle of its batch.

11. A method as claimed in claim 9 wherein the longitudinal distance by which the mixture is fed in each batch or indexing movement along the path from the intake zone into the die is less than the longitudinal length of the die in which heating of the mixture occurs, whereby all of the mixture will experience a residence time completely within the longitudinal boundaries of the die.

12. A method as claimed in any preceding claim wherein the die has side walls which confine the mixture laterally within the die during the heating of the mixture in the die.

13. A method as claimed in claim 12 wherein the side walls of the die slightly diverge in the direction of advance of the mixture through the die so as to promote the release of the bound body from the die at the end of each operation to cure the binder within the mixture in the die.

14. A method as claimed in claim 12 or 13 wherein the side walls of the die are movable towards each other to laterally confine the mixture in the die before commencement of the step of heating the mixture in the die and are movable apart to release the bound body formed by curing of the binder in the die.

15. A method as claimed in any preceding claim and further including locating a face member on at least one of the upper and lower surfaces of the mixture being fed into the

intake zone and into the die whereby the face member is advanced through the intake zone and through the die.

16. A method as claimed in claim 15 wherein the face member remains attached to its associated surface of the bound body that emerges from the die after curing of the binder in the mixture within the die so that the face member forms a surface part of the bound body.

17. A method as claimed in claim 15 wherein the face member is removed from the associated surface of the bound body after the bound body emerges from the die whereby the mixture within the die can be prevented by the removable face member from contacting and fouling the surfaces of the die.

18. A method as claimed in any one of claims 15 to 17 wherein the face member comprises a flexible sheet material progressively fed from a roll so as to enter the intake zone and progress to the die with the face sheet separating the mixture of particulate material and binder from direct contact with the surfaces of the intake zone and die.

19. A method as claimed in claim 18 wherein the flexible sheet is wider than the final width of the bound body that emerges from the die, and wherein the flexible sheet is shaped at its side edges to form side members for assisting to enclose the mixture in the die against lateral expansion.

20. A method as claimed in any preceding claim wherein a selectively replaceable wear sheet is provided and located so as to extend completely through the intake zone and continuously through the die on a lower face thereof thereby providing a sacrificial wear member protecting the faces of the intake zone and the die from abrasion and adhesion.

21 A bound body composed at least partially of particulate material when manufactured by a method as claimed in any one of the preceding claims.

22. Apparatus for manufacturing a bound body composed at least partially of particulate material, the apparatus comprising means operative to perform the steps of a method as claimed in any one of claims 1 to 20.

23. Apparatus for manufacturing a bound body composed at least partially of particulate material, the apparatus comprising:

means for introducing to a feed material which includes a substantial proportion of particulate material a binder which includes a heat curable or activated adhesive substance so that the binder contacts significant proportions of the surfaces of the particulate material,

a die having substantially the shape of a body to be produced and means for feeding the mixture of feed material having the binder therein into a die so that it adopts substantially the shape of the body to be produced,

means for heating the mixture in the die until the binder has cured sufficiently to enable further handling of the integral bound body comprising the bound particulate materials, and

an intake zone into and through which the mixture is fed prior to entering the die and wherein the mixture is shaped into substantially the same shape it adopts when subsequently fed into the die so that any progress of curing of the binder due to heating the mixture resident in the intake zone is effective in curing binder while the mixture is in the desired final shape.

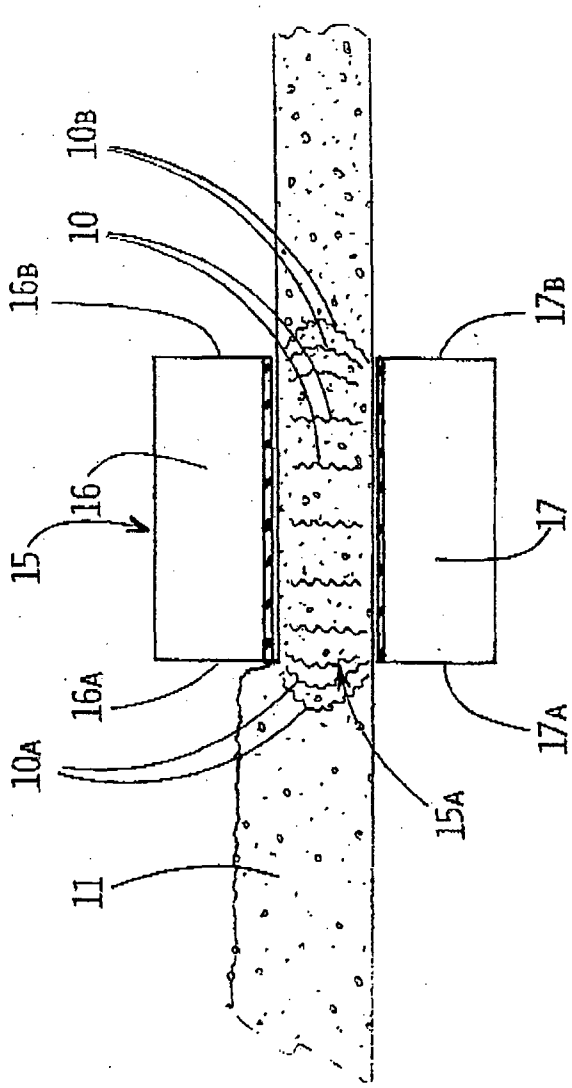

Fig. 1

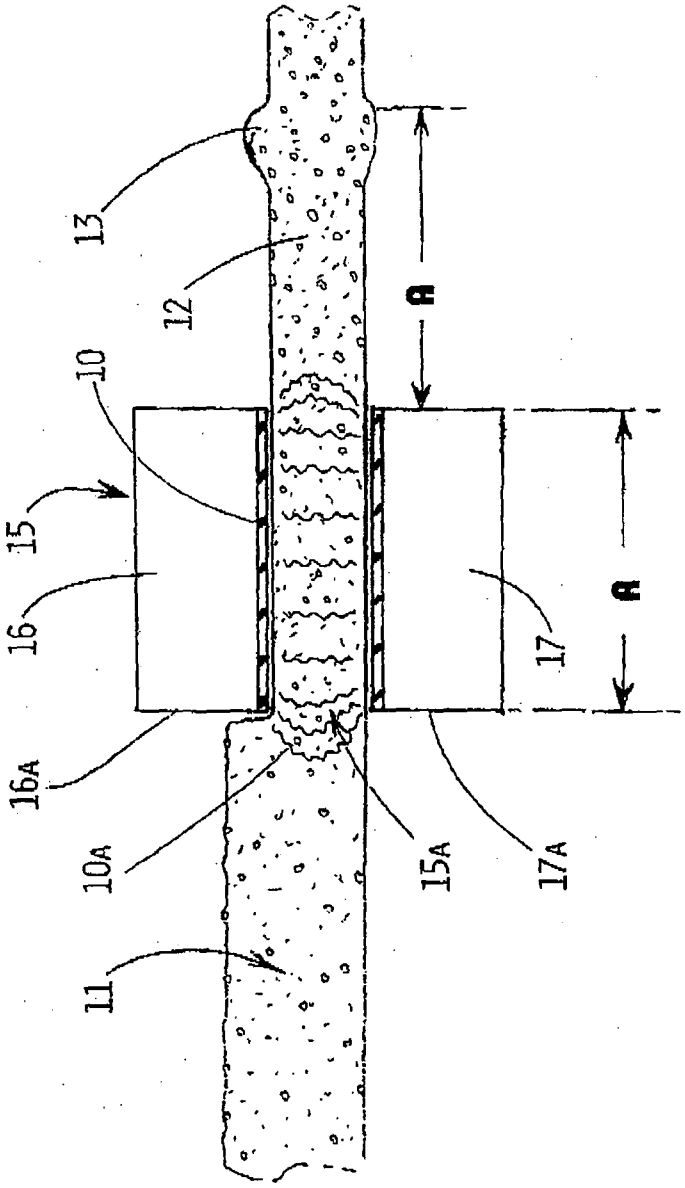

Fig. 2

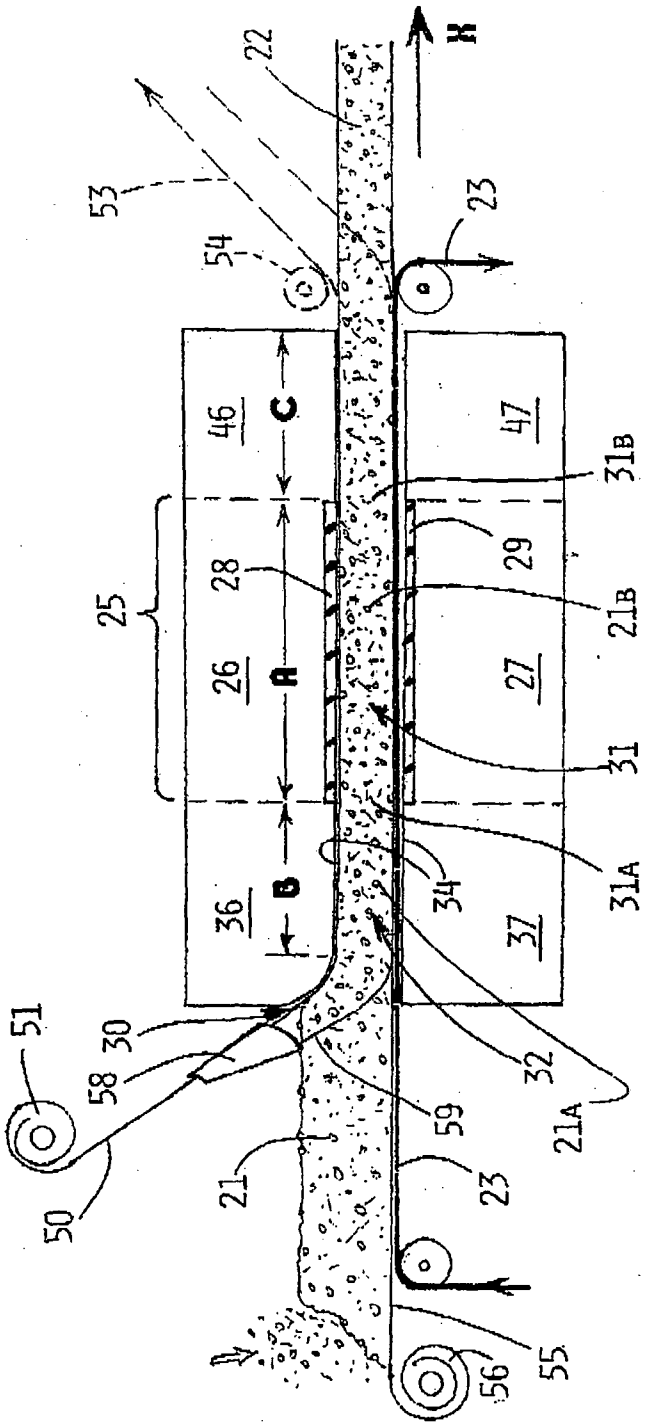
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Fig. 3

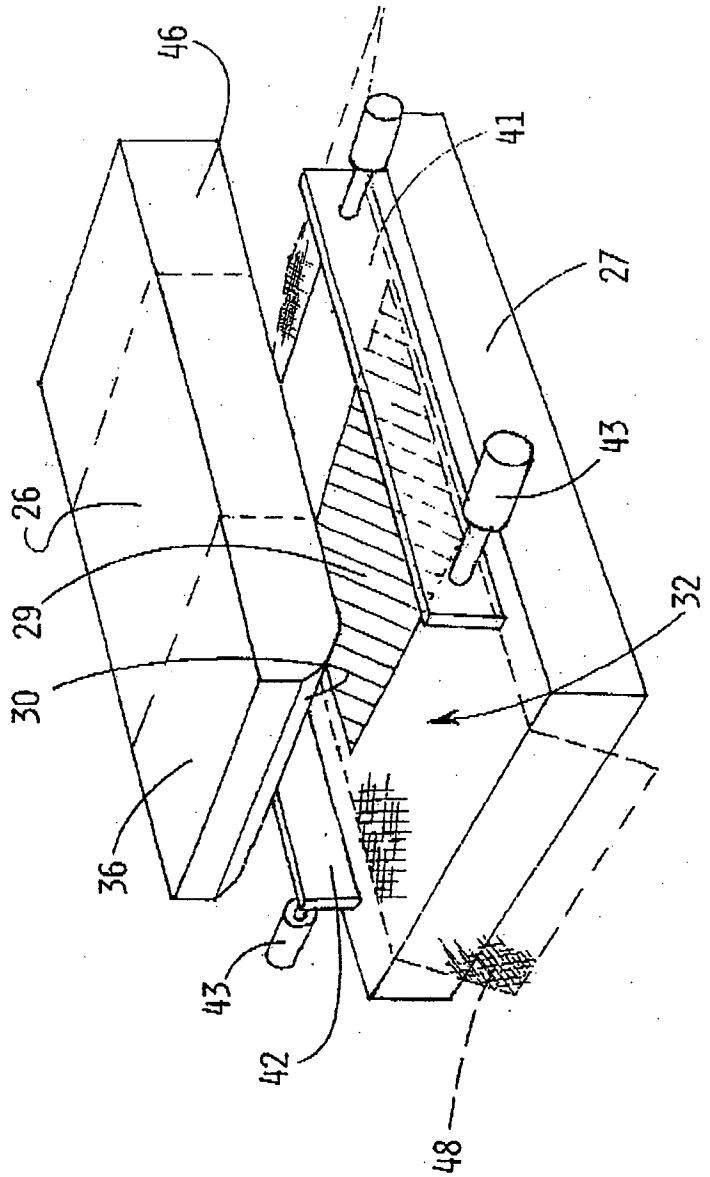

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2009/000650

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

B29C 31/08 (2006.01) ***B29C 31/00*** (2006.01) ***B29C 67/00*** (2006.01) ***B27N 1/00*** (2006.01) ***B29C 31/04*** (2006.01) ***B29C 71/00*** (2006.01) ***B27N 1/02*** (2006.01) ***B29C 35/00*** (2006.01) ***D21J 1/00*** (2006.01) ***B27N 3/00*** (2006.01) ***B29C 35/02*** (2006.01) ***D21J 3/00*** (2006.01) ***B27N 3/08*** (2006.01) ***B29C 39/00*** (2006.01) *B29K 103/00* (2006.01) ***B27N 5/00*** (2006.01) ***B29C 39/24*** (2006.01) ***B27N 7/00*** (2006.01) ***B29C 39/38*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI; EPODOC B29C 31/08, 31/00, 67/00, 31/04, 71/00, 35/00, 35/02, 39/00, 39/24, 39/38 or B27N 1/00, 1/02, 3/00, 3/08, 5/00, 7/00 or D21J 1/00, 1/02 and keywords (mold+ or mould+ or die+) and (bind+ or bound or adhesive+) and particul+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4401615 A (GERHARDSON) 30 August 1983 Abstract, column 1, lines 9-15, column 1, line 33-column 3, line 15, figures, claims	1-5, 8, 9, 12, 23
Y		6
X	US 5882462 A (DONECKER ET AL) 16 March 1999 Abstract, column 1, line 51- column 2, line 13, column 2, lines 58-67, column 4, lines 8-34, column 4, lines 57-60, figures, claims 1 and 6	1, 23
X	US 6024905 A (DORIS) 15 February 2000 Abstract, column 1, lines 31-60, column 2, line 15- column 4, line 50, figures 1-8, claims 1, 5, 6, 10	1, 23

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 July 2009	29 JUL 2009
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **GREGORY DIVEN** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6283 2992

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5130072 A (HEMELS ET AL) 14 July 1992 Abstract, column 1, lines 39-65, column 2 lines 7-19, column 5 line 20-column 6 line 19, claims	1, 23
X	EP 074325 A1 (THE GOODYEAR TIRE & RUBBER COMPANY) 16 March 1983 Abstract, page 1, lines 2-6, page 1, line 24- page 2, line 26, claim 1	1, 23
Y	US 6187249 B1 (LEWELLIN) 13 February 2001 Abstract, column 1, lines 23-38, column 2, lines 53-61, column 3, lines 9-25, column 3, line 52-column 4 line 3, claims	6

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2009/000650

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	4401615	CA	1154926	DE	2909526	FI	790819
		SE	7802873				
US	5882462	NONE					
US	6024905	CZ	9801480	EP	0909619		
US	5130072	AU	57171/90	CA	2018987	DE	3919756
		EP	0402785	JP	3055203	NO	902667
EP	0074325	CA	1204909	JP	58059067		
US	6187249	AU	70802/96	BR	9610873	CN	1202851
		EP	0874719	JP	2007112137	WO	9713629

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX