PATENT SPECIFICATION (11) 1 573 665

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(21) Application No. 7924/77 (22) Filed 24 Feb. 1977
(31) Convention Application No. 20746 (32) Filed 2 Mar. 1976 in
(33) Italy (IT)
(44) Complete Specification Published 28 Aug. 1980
(51) INT. CL^3 B29H 5/02
(52) Index at Acceptance
B5A 1R3CX 1R403 T14P

(19)

(54) AN IMPROVED METHOD OF INJECTION MOULDING THE TREAD PORTION OF A PNEUMATIC TYRE

(71) We, INDUSTRIE PIRELLI SpA, an Italian Company of Centro Pirelli, Piazza Duca d'Aosta No 3, Milan 20100, Italy, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to a method of moulding pneumatic tyre tread portions and apparatus therefor.

It is well known to manufacture a tyre by forming a carcass of a tyre including side-walls, bead portions and breaker assembly and to attach a preformed tread portion, the whole assembly being cured in a mould. The separate formation of the tread portion is inconvenient and costly.

Previous proposals for injection moulding the tread portion have not been satisfactory due to lack of uniformity in the compound after it has been injected. This is mainly due to the formation of air pockets within the mould and dis-uniformities caused by localised hearing of the compound during injection.

It is an object of the present invention to obviate or mitigate the above disadvantages.

According to one aspect of the present invention there is provided a method of moulding a tread portion of a tyre by injection moulding a fluidised elastomeric compound into the cavity of a composite mould, the cavity having the shape of the tread portion to be formed, wherein the compound is introduced into the mould cavity through a plurality of injection openings all lying in an equatorial plane of the mould cavity and spaced from one another at intervals in the range 1/2 to 1/10 of the axial width of the cavity, the arrangement being such that compound entering the cavity through the openings initially radiates in all directions from each opening until the compound flows from two adjacent openings meet, after which said flows complete the filling of the cavity by expanding axially of the cavity.

According to another aspect of the present invention there is provided apparatus for carrying out the method of the preceding paragraph, the apparatus comprising a composite mould the cavity of which has the shape of a tyre tread portion to be moulded, the mould comprising a plurality of openings for the injection into the cavity of fluidized elastomic material, said openings all lying in an equatorial plane of the cavity and spaced from one another at intervals in the range 1/2 to 1/10 of the axial width of the cavity.

A preferred embodiment of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a partial, end-on view of a tyre having a tread portion moulded in accordance with the invention, part of the tread portion being removed to show the carcass ply or breaker 14 below the tread and injectin orifices 25 of a mould for the tread portion being shown in broken lines,

Figure 2 is a seciontal elevation of the tyre of Figure 1 enclosed in a mould, the section being taken in a radial plane of the tyre and the drawing showing only a right-hand half of the tyre and mould assembly.

Figure 3 is a view similar to Figure 1 illustrating the progressive filling of the mould tread cavity, the view being a flat projection of the curved surface represented by the line 2-2 of Figure 2.

Figure 4 is a diagram of the compound flows represented in Figure 3, and

Figure 5 is a diagram showing the pressure (upper part of the drawing) to which a given flow (lower part of the drawing) is subject during its movement from an injection opening through the various positions I-V illustrated in Figure 3.

In the drawings, 10 represents a tread provided with ribs 11 and grooves 12 according to any conventional design pattern. It should be observed that for performing the invention the ratio between actual tread total volume and the volume it would have if grooves 12 did not exist and said tread had at all positions the same radial thickness as in ribs 11, should preferably be in the range 60 to 90%.

In Figure 1 textile reinforcement 14 is shown, which can be of any kind, as for instance a part of a carcass or of an annular breaker, according to known tyre structures. In fact, the present invention is independent not only of the fact whether it is applied to the manufacture of a new tyre or to the retreading of a used tyre, but also of the particular tyre type one intends to manufacture or to retread.

As can be seen in Figure 2, the mould includes a male core 20 whose function is to support the tyre body. For the purpose of the present invention it is insignificant whether the core 20 was used for forming, by injection moulding or manufacture or any other manner, the tyre body, or whether it is only a support which is introduced into an already existent tyre body. Further, the mould includes a female portion generically indicated at 21 which can consist of any number of parts. In this case it consists of two axially spaced end parts 22 and of two annular peripheral parts 23 with holes 25 between them for compound injection; moreover holes 24 for air evacuation are bored between adjacent parts of the mould.

The equipment as necessary for making the compound, its fluidising, for bringing it under pressure, conveying it into the mould and for all of the preliminary steps, is not shown, for any known type thereof can be employed, and therefore forms no part of the present invention.

As can best be seen from Figure 1, the compound is conveyed into the mould through openings 25 which are formed between the peripheral parts 23. The tyre comprises a tread portion 10, and under it, an undertread 26 which extends to sidewalls 27 with which it forms the body of the tyre which, too, can be of any known structure.

In Figure 3 some injection openings in a limited arc of the mould annular crown are shown. The shown injection openings are circular, for this is their most natural shape, but they could be of any other preferred shape, for instance square, provided the conditions as set by the present invention are met. Let us now consider in Figure 3 the adjacent openings 25_1 and 25_2. At the start of injection the compound will spread out from both said openings in a substantially uniform manner in all directions, and initially it will therefore distribute with a circular configuration. At the beginning the flow of compound is free and the two compound flows as coming out through two adjacent openings do not interfere with each other, wherefore the two circles indicated (I) are obtained, which are spaced and which represent the edges of the areas occupied by the compound a short time after injection begins.

As injection goes on, areas occupied by compound and therefore circles delimiting same widen and at a certain moment the situation is as shown by the circles (II) - (II), which are partially in contact.

Up to the moment when the circles touch compound flow has taken place through each orifice 25_1 and 25_2, as if the other one did not exist. However, as injection progresses, while the compound can freely flow from both orifices in the direction parallel with the axis of the tyre in the circumferential direction, compound progress is no longer uninhibited because two compound flows come into contact with each other. As they tend to advance in opposite directions, they give rise at their contact surfaces, to a certain pressure and the latter gives rise to rolling movements of the compound flows on each other and a mixing thereof, which phenomena are difficult exactly to define, but which can be said to be accompanied by an enlargement of the contact area between the compound flows and by an increase in pressure. After a further time period, the compound will occupy the areas indicated (III) - (III) which have not a circular form but a roughly elliptical one. The areas occupied by the compound tend steadily to widen axially of the tread, without widening circumferentially of the tread, giving rise successively to limit curves (IV) - (IV) and (V) - (V). When this last stage is attained, compound comes in contact with the mould walls, i.e. it has reached the limits of the tread width, in radial planes containing the tyre axis and intersecting the injection opening axes. As will be understood, the air contained in the mould is swept towards its axial ends with no possibility o the formation of bubbles, and when the compound has reached the limit of areas (V) - (V) only small pockets 28 remain against the mould walls.

In coincidence with the zones of the mould, where the pockets 28 will be formed, orifices 24 for air evacuation are formed. The total volume of compound injected is measured so that when the areas of the small pockets 28 have also been filled with compound flow, a low pressure will exist in the mould of the order of 10 atmospheres. Greater pressures, such as are normally used in known injection processes, are for the process according to the present invention not only unnecessary, but also detrimental.

What has been said about the orifices 25_1 - 25_2 applies of course for any pair of adjacent orifices, and thus the compound coming through orifice 25_1 interacts with that coming through orifices 25_0, and that coming through orifice 25_2 interacts with that coming through orifices 25_3.

Figure 4 shows flow lines of the various compound flows coming through the orifices, based on the phenomenon illustrated in Figure 3. Of course these are not exactly drawn, precisely determined flow lines; the purpose of Figure 4 is only to further illustrate the directions which the compound flows follow.

In similar manner, also Figure 5 should be understood as merely illustrative, indicating how the pressure varies with progress of the injection.

In other words, Figures 4 and 5 show in a very schematical manner what is believed in principle, to occur when fluidised material is introduced into the mould through adjacent openings at successive time intervals of said material distribution process. These successive time intervals are represented approximately by the sets of small arrows in Figure 4. Figure 4 is visually suggestive of the interdiffusion which occurs between compound flows entering through adjacent openings, during their progress towards the mould sides.

Figure 5 (whose lower part reproduces half of one of the two diagrams in Figure 3) represents in its upper part and with a first approximation the values of both pressure and resistance as encountered by compound, due to its interaction with compound entering through an adjacent opening. It should be noted that this pressure progressively attains its maximum value as the space of the mould is filled by the compound; but said pressure reduces when the advancing front (V) of the compound flow is in contact with the mould side, and this is due to the fact that the quantity of compound injected is measured. Of course, after completion of the injection vulcanisation of the compound is carried out, which is a well-known technique and therefore requires no description; and this is conveniently performed while the tyre is still in the mould, so that it can be taken out from the mould in its vulcanised condition. Tyres having treads thus provided have been found to be perfectly uniform and to have, in use, good behaviour and wear characteristics.

This high quality of tread is both unexpected and surprising. Above all, one would have supposed that the multiplicity of injection openings, according to the invention, would have an adverse effect, as it multiplies the areas of welding between the various injection flows and goes, therefore, in an opposite direction to technical opinion, which wants the injection to take place in such a manner that a homogeneous body is obtained. Further, high final pressures are not attained, which so far has been considered as necessary for obtaining the complete filling of the mould, and also the homogenizing of welding areas of different injection flows.

It has been found that the moulding apparatus gives the best results when the injection openings 25 are spaced apart a distance within the range 1/2 to 1/10th of the axial width of the tread and preferably lie within the range 1/4 to 1/7th of the tread width.

WHAT WE CLAIM IS:-

1. A method of moulding a tread portion of a tyre by injection moulding a fluidised elastomeric compound into the cavity of a composite mould, the cavity having the shape of the tread portion to be formed, wherein the compound is introduced into the mould cavity through a plurality of injection openings all lying in an equatorial plane of the mould cavity and spaced from one another at intervals in the range $\frac{1}{2}$ to 1/10 of the axial width of the cavity, the arrangement being such that compound entering the cavity through the openings initially radiates in all directions from each opening until the compound flows from two adjacent openings meet after which said flows complete the filling of the cavity by expanding axially of the cavity.

2. A method as claimed in claim 1, wherein the volume of compound injected is measured so that when the cavity is full the compound is subject to a pressure of the order of 10 atmospheres.

3. A method as claimed in claim 1 or claim 2, wherein during the injection of compound air originally occupying the cavity is allowed to escape through a plurality of passages positioned in zones of the cavity which will be reached last by compound spreading from the injection openings.

4. A method as claimed in claim 3, wherein the air originally occupying the cavity is allowed to escape through passages which open into the axial ends of the mould cavity, each at a position equidistant from planes containing the cavity axis and respectively intersecting two adjacent injection openings.

5. A method as claimed in any one of the preceding claims, wherein the total volume of compound necessary to fill the cavity is divided into equal, measured quantities of compound injected through the respective openings.

6. A method as claimed in any one of the preceding claims, wherein the injection

openings are spaced from one another at intervals in the range $\frac{1}{4}$ to 1/7 of the axial width of the cavity.

7. Apparatus for carrying out the method claimed in any one of the preceding claims, comprising a composite mould the cavity of which has the shape of a tyre tread portion to be moulded, the mould comprising a plurality of openings for the injection into the cavity of fluidised elastomeric material, said openings all lying in an equatorial plane of the cavity and spaced from one another at intervals in the range $\frac{1}{2}$ to 1/10 of the axial width of the cavity.

8. Apparatus as claimed in claim 7, wherein said openings are spaced from one another at intervals in the range $\frac{1}{4}$ to 1/7 of the axial width of the cavity.

9. A method of moulding a tread portion of a tyre substantially as hereinbefore described with reference to the accompanying drawings.

10. Apparatus for carrying out the method claimed in any one of claims 1-6 and 9 substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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Printed for Her Majesty's Stationery Office,
by Croydon Printing Company Limited, Croydon, Surrey, 1980.
Published by The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.

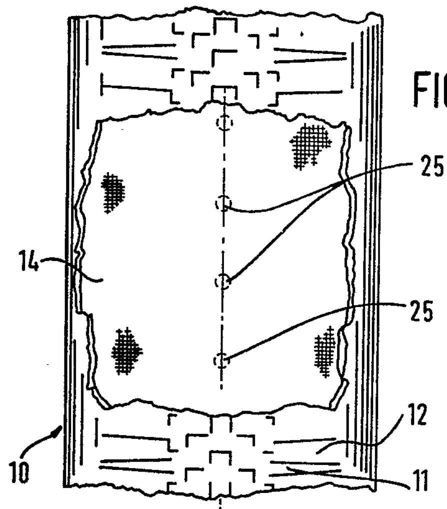

FIG.1

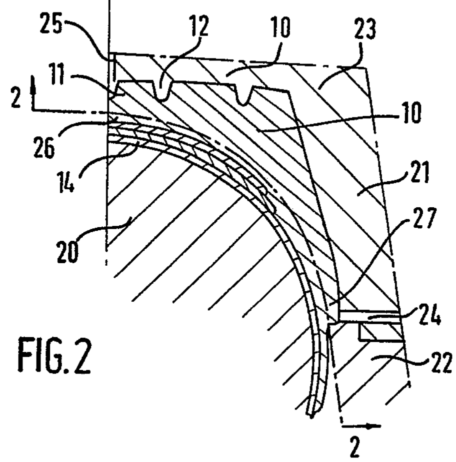

FIG.2

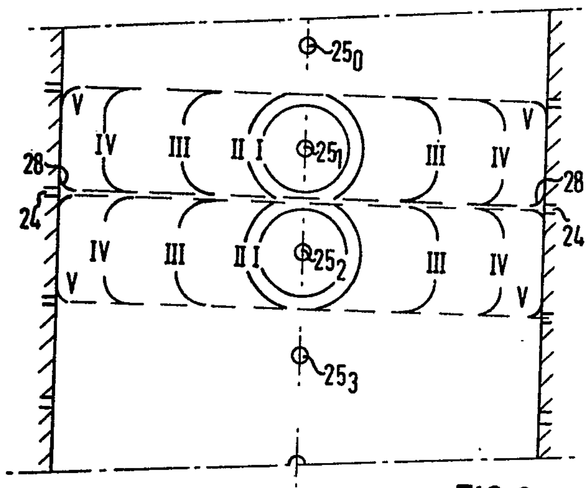

FIG.3

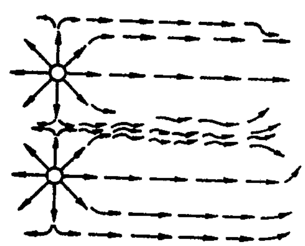

FIG.4

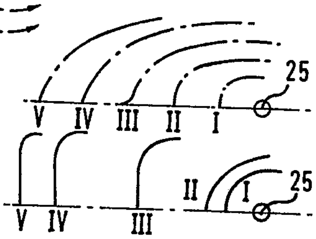

FIG.5