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(72) Inventor JACK LENDYMORE RILEY



(54) METHOD OF FORMING PIPE

(71) We, YORKSHIRE IMPERIAL PLASTICS LIMITED, a British Company, of Haigh Park Road, Stourton, Leeds LS1 1RD 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:—

10 This invention relates to a method of forming sockets and joints in a plastics pipe.

In the manufacture of plastics pipe having a portion of enlarged internal diameter, usually referred to as a socket, for engagement with another pipe, there are problems involved in the provision of a socket of adequate strength. Previous proposals for forming sockets on the ends of pipes have involved taking a straight constant diameter pipe and forcing out one end of the pipe to form the socket. The socket, which conventionally includes a groove or recess for a sealing ring, is consequently reduced in wall thickness when compared to the remainder of the pipe. Clearly the socket has to be of adequate strength for the internal pressures, usually water pressures, which the plastics pipe has to withstand. If the wall thickness of the socket and groove is such that it can withstand the maximum required pressures, then the remainder of the pipe has a thickness greater than that necessary to withstand the pressures. This redundant thickness of material adds to the price of the pipe and is, therefore, disadvantageous.

To provide the minimum wall thickness in the finished socket, two main proposals have been made heretofore. The first proposal has been to thicken the pipe locally at the position where the socket is to be made by reducing the draw-off speed during the extrusion of the pipe and consequently to increase the wall thickness. The

alternative system has been to use a reinforcing plastics sleeve locally where the socket is to be formed to increase the wall thickness. Both of these systems seem to work very well but they both require extra material and consequently extra cost for the socket.

The provision of the extra wall thickness also complicates the process of manufacture.

By the present invention, there is provided a method of forming a pipe of orientable thermoplastic polymeric material with an integral first portion of enlarged internal and external diameters which comprises the steps of placing at least part of the length of the pipe into a female mould having internal dimensions substantially corresponding to the external dimensions to be formed on the pipe part, heating said part of the pipe to a temperature at which deformation of the material induces orientation of the polymer molecules, applying internal pressure into the pipe to force out said part of the pipe radially against the female mould and orientate the polymer molecules, the first portion of the pipe being forced out to a greater internal and external diameter than a second portion of the pipe, the first portion being further forced out in a part thereof to provide a groove therein for the accommodation of a sealing member, cooling the material to a rigid condition and removing the applied pressure.

The pipe may be formed originally of an unoriented or a partially oriented polymeric material. The pipe may be heated by means of a fluid, preferably hot water. The pipe may be forced out by means of a compressed gas or pressurised liquid.

The first portion may be at one end or there may be a first portion at both ends of the pipe. The first portion may be at a position along the length of the pipe, and

may be provided with two grooves, subsequently to which the first portion may be severed transversely to form two ends, each with a groove.

5 The first portion after having been forced out into the female mould may be shrunk onto a mandrel, the male mandrel corresponding to the exact internal dimensions required of the first portion by heating to a temperature at which some shrinkage occurs, but at which temperature not all of the orientation in the polymeric material is lost, the first portion being cooled to a rigid state after shrinking, and the mandrel 15 then removed.

The pipe may be bent subsequent to being forced out at a temperature which permits bending, and at which elastic deformation can occur. The pipe may be filled 20 with a particulate material prior to bending to prevent reversion and kinking.

The present invention further provides a method of manufacturing a pipe of orientable thermoplastic polymeric material with 25 an integral first portion of enlarged internal and external diameters which comprises the steps of placing at least part of the length of the pipe into a female mould having at least two internal cross-sectional areas, a larger one of which being greater than the required external diameter of the first portion, heating said part of the pipe to a temperature at which deformation of the material induces orientation of the polymer 35 molecules, applying internal pressure into the pipe to force out said part of the pipe radially against the female mould and orientate the polymer molecules, the first portion of the pipe being forced out to a greater internal and external diameter than 40 a second portion of the pipe, cooling the material to a rigid condition, removing the applied pressure, inserting a male mandrel into the first portion and shrinking the first portion onto the male mandrel by heating said portion to a temperature at which some shrinkage occurs but at which temperature not all of the orientation in the polymeric material is lost, the first portion 45 being cooled to a rigid state after shrinking, and then removing the mandrel, which has an outwardly directed annular projection to form a groove in the inner surface of the first portion and which corresponds to the exact internal dimensions required of 55 the first portion.

The mould may have a non-straight central axis, the pipe being expanded into the mould to form a bent pipe.

60 The pipe may be formed of unplasticised polyvinyl chloride, the temperature of orientation being in that case in the range 80 to 110°C, or more specifically in the range 82 to 86°C or 88 to 92°C for compounds with Vicat softening points of 75

and 82°C respectively (British Standard Specification 2782, Part 192J).

By way of example, embodiments of the present invention will now be described with reference to the accompanying drawings, of 70 which:

Figure 1 is a cross-section of a mould and pipe;

Figure 2 is an end elevation along arrow II of Figure 1;

Figure 3 is a cross-section of a further mould and pipe, and

Figure 4 is a cross-section of an enlarged end and internal mandrel.

Referring to Figures 1 and 2, a plastics 85 pipe 1 of an unplasticised PVC having a vicat softening point of 82°C is located inside a split mould having an upper half 2 and a lower half 3. The pipe is sealed into the mould by means of external seals 4. 90 The annular interior space 5 of the mould can be filled with hot water via an inlet pipe 6 and drained by an outlet pipe 7. The two mould halves are clamped together by bolts (not shown) located and 95 screwed into the stud-ways 8. The internal surface of the mould is provided with an annular recess 9 having a pair of annular grooves 11. Internal seals, not shown, are located inside the pipe prior to its expansion. 100

To operate the equipment, the unoriented PVC pipe is inserted into the mould which is split open along the line 10 to receive it. The mould is then clamped onto the 105 pipe, internal seals are inserted into the pipe at both ends, and hot water at a temperature of 92°C is circulated through the chamber 5 for sufficient time to heat the pipe to soften it and to bring it to a temperature at which expansion of the pipe 110 results in orientation of the polymer molecules. The effect of the orientation is to give a greater hoop strength to the final product when compared with the unoriented material. Once the pipe is at the requisite temperature, the hot water supply is fed to the bore of the pipe, is pressurised and forces out the pipe to make it conform to the internal shape of the mould. 120 In so forcing out the pipe the PVC is oriented and as the amount of orientation and consequent increase in strength depends on the amount of enlargement, the effect is as follows. The material forced into the 125 grooves 11 is more oriented and stronger than a material forced into the recess 9, and the material forced into the recess 9 is stronger and more oriented than the bulk of the pipe. 130

Once the forcing out stage is complete, the mould is cooled with pressurised cold water which forces out the hot water remaining and cools the pipe. As soon as the pipe is rigid it is removed from the mould, the internal pressure is removed and the internal seal is removed. The enlarged section is then cut along the dotted line to form two socket ends, typically the cut would be made with a power operated circular saw. With blow up ratios of the order of 2:1 for the bulk of the pipe, the increase in strength in the socket and grooves compensates for the reduction in wall thickness so that the final product has sufficient strength to be used safely.

If it is required to manufacture a pipe with a socket at one end only, then the mould illustrated in Figure 3 having upper and lower portions 13 and 14 respectively can be used. It may be seen from Figure 3 that there is only a single socket 15 with a single groove 16 formed at one end only of the pipe.

In many circumstances, the internal dimensions of the socket are sufficiently accurate. However, they are not controlled directly, but merely result from the original dimensions of the pipe, the amount of enlargement, the geometry of the mould and the manner in which the enlargement occurs. The situation can arise in which the internal dimension cannot be formed sufficiently accurately using this method. In such circumstances the pipe can be initially forced out into a mould similar to that shown in Figure 3, except that the socket portion 15 and groove portion 16 are oversized. A shaped mandrel 17 can then be inserted into the socket end as illustrated in Figure 4. The end is heated by any suitable means to a temperature at which the oriented socket begins to soften and shrinks onto the mandrel from the position shown solid at 18 to the position shown dotted at 19. The mandrel, which is an exactly known external shape, then gives the inside of the socket an exact internal shape. The temperature to which the end 14 is heated is so chosen that not all of the orientation is lost during the shrinking operation. A suitable temperature for unplasticised polyvinyl chloride would be 78 to 110°C.

The mandrel illustrated has an annular projection 20 and this is made collapsible to aid removal of the mandrel from the socket. The mandrel may be collapsed in any suitable manner.

In a further example, a length of PVC pipe having a vicat softening temperature

of 82°C and of 1.90 inch diameter, 0.25 inch wall thickness is concentrically located inside a tubular steel mould of 3.5 inches internal diameter with an enlarged portion at one end, the size and shape conforming to a pipe jointing socket. The PVC pipe is sealed at one end and at the other end is connected to a source of compressed nitrogen. Metal end pieces which support the pipe in the mould have ports through which heating or cooling water can enter the mould and come into direct contact with the PVC.

The whole assembly is spaced in a water bath maintained at 91 to 92°C and after a delay of about 15 minutes, compressed nitrogen is led into the PVC pipe to give a rate of increase of pressure of 20 psi per minute until a maximum pressure of about 300 psi is obtained. This causes the PVC pipe to be forced out, forcing the water out of the surrounding annulus in the process, until it conforms to the shape of the mould. While still maintaining the pressure, the mould is then transferred to a second bath containing cold water. After a few minutes the pressure is released, the mould end pieces removed, and the pipe pushed out of the mould. The enlarged portion is fed to the cutting device for end trimming of the formed socket.

For PVC having a vicat softening temperature of 75°C, the orientating is performed at a temperature of 84 to 86°C.

It will be appreciated that sockets may be formed at both ends of the pipe and if an extremely short length of pipe can be used, a double socketed end will effectively form a double coupler. The sockets may have different sizes in which case the coupler will be an adaptor.

Although the above description has related to the production of a pipe having a straight central axis, if the mould has curved or otherwise bent central axes, the forcing out of the pipe into the mould will produce a bent product.

In an alternative method of forming the bends, an oriented pipe and socket is filled with a filler medium such as a sand and heated locally to a temperature in the range 100 to 110°C and bent in the heated region of the pipe plane. The internal packing prevents reversion and kinking and the amount of wall thinning resulting from the bending is compensated by the further orientation of the pipe at the bend. Examples of bending temperatures are set out in the following table.

120

	Starting Stock Temperature of Orientation °C	Filler Medium	Heating Medium	Temperature of Bending °C	Comments
5	91	Centizorb ¹	Mobiltherm 603	122	Split longitudinally
	91		Ethylene Glycol	116	Split longitudinally
	91.5		Mobiltherm 603	112	Acceptable
	91.5			112	Acceptable
	92			112	Acceptable
10	92	Ethylene Glycol		114	Acceptable
	92			112	Split longitudinally
	91.5			112	Accepted
	92			110	Split longitudinally
	92			104	Acceptable
15	91.5	Oil-Dri ²		104	Acceptable
	91.5			104	Acceptable
	91.5			104	Acceptable
	91.5			104	Acceptable
	91.5			104	Acceptable
20					Difficult to bend — overpacked filler
	91	Centizorb	Ethylene Glycon	103	Acceptable
	92			102	Acceptable
	91			100	Stress marks and dimensional problems
25	91			100	
30	1 "Centizorb" is an absorbent granular material used for absorbing waste oil and available from Labap, Elm Grove, Manchester, England				2 "Oil-Dri" is also an absorbent granular material available from Oil-Dri SA, Fribourg-2.

Spigot and sockets with 'O' ring sealing members were tested as though they were a straight pipe. The test was a hydrostatic one using a constant pressure designed to give (a) bursting in the time range 1 to 10 hours, and (b) bursting in the time range 100 to 1000 hours. Using two pipe samples, both having an outside diameter of 3.5 inches and blow-up ratios of 2.03 for the pipe and 2.13 for the socket, the following results were obtained:

	Sample No.	Minimum Wall Thickness	Test Pressure	Hoop Stress	Time to Fail	Reason for Failure
45	1	0.111"	626 psi	9560	2.5 hrs	('O' ring sealing member became displaced
	2	0.115"	522 psi	7690	910.2 hrs	

A regression line can be prepared from the information in British Standard 3505 for non-oriented plastic pipe of the same class. From this it is possible to interpolate the stresses for failure at the times at which failure occurred on the oriented pipe and socket of the present invention. Comparing these two, the following information can be deduced:

	Sample No.	Time to Fail	Stress for Failure in Oriented Pipe	BS Stress for Same Time	Ratio of Stresses
60	1	2.5 hrs	9560	5500	1.75*
	2	910.2 hrs	7690	4450	1.73*

* As samples failed by displacement of the 'O' ring sealing member the pipe and socket strength is greater than shown and hence these ratios are at a minimum. This shows that the straight pipes and sockets are extremely satisfactory in practice and exceed the British Standard specification by a considerable amount.

Hydrostatic burst tests on the bent pipe

at 20° show that the pipes are as strong as straight pipes. Reversion of the pipe by heating to 150°C shows a minimum 96% reversion, the pipe straightening, going back to its original size and the socket and groove going back to their original sizes.

The advantages of the provision of the socket by the above methods are that a reduced amount of material is required for a given socket by the above methods

and that a reduced amount of material is required for a given socket of a given strength when compared with an un-oriented socket of the same strength. This

5 leads to a reduction in the amount of material needed for a given joint and hence to a cost saving. Also, when compared to sockets which required enhanced thick-
10 ness of material for the starting pipe at the points to be formed into a socket, there is a two-way saving: (i) from the reduced material used, and (ii) from the reduction of the process step previously necessary to prepare the enhanced thickness.

15 It will be appreciated that the present method of manufacturing an oriented pipe and socket is only limited by the length of the female mould needed. Since nothing has to be inserted into the pipe, there is no
20 problem of friction with the pipe surface as there would be if a male mandrel were to be used internally of the pipe to expand the pipe as opposed to the use of a female mould of the present invention. It will be
25 appreciated that although male mandrels can be used for short pieces of pipe to expand them radially, it would not really be very easy to expand long lengths of pipe up to, for example, 30 feet by the use
30 of an expanding male mandrel.

Comparing the method of the invention with the production of an oriented pipe socket and groove by expanding the pipe with an internal male mandrel, it can be
35 appreciated that the latter method would not really be very easy for long pipes of up to 30 feet in length.

Although PVC has been specifically described above, chlorinated PVC, high or
40 low density polythene, polypropylene or ABS could also, amongst other suitable orientable polymers, be used.

WHAT WE CLAIM IS:—

1. A method of forming a pipe of
45 orientable thermoplastic polymeric material with an integral first portion of enlarged internal and external diameters which comprises the steps of placing at least part of the length of the pipe into a female mould
50 having internal dimensions substantially corresponding to the external dimensions to be formed on the pipe part, heating said part of the pipe to a temperature at which deformation of the material induces
55 orientation of the polymer molecules, applying internal pressure into the pipe to force out said part of the pipe radially against the female mould and orientate the polymer molecules, the first portion
60 of the pipe being forced out to a greater internal and external diameter than a second portion of the pipe, the first portion being further forced out in a part thereof to provide a groove therein for the accom-
65 modation of a sealing member, cooling the

material to a rigid condition and removing the applied pressure.

2. A method as claimed in claim 1 in which the pipe is originally of an unoriented or partially oriented polymeric material. 70

3. A method as claimed in claim 1 or 2 in which the pipe is heated by means of a fluid, preferably hot water.

4. A method as claimed in any one of claims 1 to 3 in which the pipe is forced
75 out by means of a compressed gas or pressurised liquid.

5. A method as claimed in any one of claims 1 to 4 in which the first portion is at one end or at a position along the length
80 of the pipe, or there is a first portion at both ends of the pipe.

6. A method as claimed in claim 5 in which the first portion is along the length of the pipe, and is provided with two
85 grooves, subsequently to which the first portion is severed transversely to form two ends each with a groove.

7. A method as claimed in claim 1 in which the first portion, after having been
90 forced out into the female mould is shrunk onto a male mandrel, the male mandrel corresponding to the exact internal dimensions required of the first portion by heating said portion to a temperature at which
95 some shrinkage occurs, but at which temperature not all of the orientation in the polymeric material is lost, the first portion being cooled to a rigid state after shrinking, and the mandrel then removed. 100

8. A method as claimed in any one of claims 1 to 7 in which the pipe is bent subsequent to being forced out at a temperature which permits bending, but which
105 does not completely destroy the orientation of the material.

9. A method as claimed in claim 8 in which the pipe is filled with a particulate material prior to bending to prevent re-
110 version and kinking.

10. A method as claimed in any one of claims 1 to 7 in which the mould has a non-straight central axis, the pipe being expanded into the mould to form a bent
115 pipe.

11. A method of manufacturing a pipe of orientable thermoplastic polymeric material with an integral first portion of enlarged internal and external diameters which comprises the steps of placing at
120 least part of the length of the pipe into a female mould having at least two internal cross-sectional areas, a larger one of which being greater than the required external diameter of the first portion, heating said
125 part of the pipe to a temperature at which deformation of the material induces orientation of the polymer molecules, applying internal pressure into the pipe to force out said part of the pipe radially 130

and that a reduced amount of material is required for a given socket of a given strength when compared with an un-oriented socket of the same strength. This

leads to a reduction in the amount of material needed for a given joint and hence to a cost saving. Also, when compared to sockets which required enhanced thickness of material for the starting pipe at the points to be formed into a socket, there is a two-way saving: (i) from the reduced material used, and (ii) from the reduction of the process step previously necessary to prepare the enhanced thickness.

It will be appreciated that the present method of manufacturing an oriented pipe and socket is only limited by the length of the female mould needed. Since nothing has to be inserted into the pipe, there is no problem of friction with the pipe surface as there would be if a male mandrel were to be used internally of the pipe to expand the pipe as opposed to the use of a female mould of the present invention. It will be appreciated that although male mandrels can be used for short pieces of pipe to expand them radially, it would not really be very easy to expand long lengths of pipe up to, for example, 30 feet by the use of an expanding male mandrel.

Comparing the method of the invention with the production of an oriented pipe socket and groove by expanding the pipe with an internal male mandrel, it can be appreciated that the latter method would not really be very easy for long pipes of up to 30 feet in length.

Although PVC has been specifically described above, chlorinated PVC, high or low density polythene, polypropylene or ABS could also, amongst other suitable orientable polymers, be used.

WHAT WE CLAIM IS:—

1. A method of forming a pipe of orientable thermoplastic polymeric material with an integral first portion of enlarged internal and external diameters which comprises the steps of placing at least part of the length of the pipe into a female mould having internal dimensions substantially corresponding to the external dimensions to be formed on the pipe part, heating said part of the pipe to a temperature at which deformation of the material induces orientation of the polymer molecules, applying internal pressure into the pipe to force out said part of the pipe radially against the female mould and orientate the polymer molecules, the first portion of the pipe being forced out to a greater internal and external diameter than a second portion of the pipe, the first portion being further forced out in a part thereof to provide a groove therein for the accommodation of a sealing member, cooling the

material to a rigid condition and removing the applied pressure.

2. A method as claimed in claim 1 in which the pipe is originally of an unoriented or partially oriented polymeric material.

3. A method as claimed in claim 1 or 2 in which the pipe is heated by means of a fluid, preferably hot water.

4. A method as claimed in any one of claims 1 to 3 in which the pipe is forced out by means of a compressed gas or pressurised liquid.

5. A method as claimed in any one of claims 1 to 4 in which the first portion is at one end or at a position along the length of the pipe, or there is a first portion at both ends of the pipe.

6. A method as claimed in claim 5 in which the first portion is along the length of the pipe, and is provided with two grooves, subsequently to which the first portion is severed transversely to form two ends each with a groove.

7. A method as claimed in claim 1 in which the first portion, after having been forced out into the female mould is shrunk onto a male mandrel, the male mandrel corresponding to the exact internal dimensions required of the first portion by heating said portion to a temperature at which some shrinkage occurs, but at which temperature not all of the orientation in the polymeric material is lost, the first portion being cooled to a rigid state after shrinking, and the mandrel then removed.

8. A method as claimed in any one of claims 1 to 7 in which the pipe is bent subsequent to being forced out at a temperature which permits bending, but which does not completely destroy the orientation of the material.

9. A method as claimed in claim 8 in which the pipe is filled with a particulate material prior to bending to prevent reversion and kinking.

10. A method as claimed in any one of claims 1 to 7 in which the mould has a non-straight central axis, the pipe being expanded into the mould to form a bent pipe.

11. A method of manufacturing a pipe of orientable thermoplastic polymeric material with an integral first portion of enlarged internal and external diameters which comprises the steps of placing at least part of the length of the pipe into a female mould having at least two internal cross-sectional areas, a larger one of which being greater than the required external diameter of the first portion, heating said part of the pipe to a temperature at which deformation of the material induces orientation of the polymer molecules, applying internal pressure into the pipe to force out said part of the pipe radially



against the female mould and orientate the polymer molecules, the first portion of the pipe being forced out to a greater internal and external diameter than a second portion
 5 of the pipe, cooling the material to a rigid condition, removing the applied pressure, inserting a male mandrel into the first portion and shrinking the first portion onto the male mandrel by heating said portion
 10 to a temperature at which some shrinkage occurs but at which temperature not all of the orientation in the polymeric material is lost, the first portion being cooled to a rigid state after shrinking, and then removing the mandrel, which has an outwardly directed annular projection to form

a groove in the inner surface of the first portion and which corresponds to the exact internal dimensions required of the first portion.

12. A pipe manufactured by the method as claimed in any one of claims 1 to 11.

13. A pipe as claimed in claim 12 formed of polyvinyl chloride.

14. A method of manufacturing a pipe substantially as herein described with reference to and as illustrated by figures 1, 2 and 4 or figures 3 and 4 of the accompanying drawings.

R. F. LEE,

Agent for the Applicants.

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