

The invention relates to a hydraulic arrangement for a plastics injection moulding machine with a hydraulic cylinder, disposed in the axis of the mould locking unit, for building up the locking pressure for the injection mould whose cylinder chambers (high-pressure chamber, low-pressure chamber) defined by the pressure piston are connected to one another via overflow ducts of the pressure piston, said overflow ducts being closable by means of a hydraulically-operated valve, with a hydraulic drive cylinder with a stationary piston for closing the injection mould, whose actual cylinder is formed by the piston rod of the hydraulic pressure cylinder, with two piston-cylinder units (compensating cylinders) disposed diametrically relative to the hydraulic pressure cylinder and which may be pressurised at one side only, with pistons for receiving or delivering pressure oil coming from the pressure cylinder or to be delivered thereto, the low pressure chamber being in open connection with the cylinder chambers of the compensating cylinders, whose pistons as well as the pressure pistons are each connected via the associated piston rods to the mould carrier of the mould locking unit, and with a control valve regulating the opening and closing movements of the drive cylinder via a local voltage transformer in accordance with a rate program, said rate program having superimposed thereon a pressure control system via a pressure transducer.

A 'rate program' in the above sense controls the velocities of the drive cylinder on the basis of the instantaneous values provided by the local voltage transformer.

A pressure control system superimposed upon this velocity regulation in accordance with the heading means that, when the admissible pressure provided by the program is reached, a pressure control system comes into play automatically, this being effected on the basis of the instantaneous values provided by the associated pressure transducer.

By the term "control valve" is to be understood a valve with sliding function known per se (cf in this respect "Regelventile von Bosch" - 13, K 6/VKD 2-AKY 013/2 De (4.85) - 1987761302, pp. 3 - 50) which, in conjunction with a local voltage transformer and a pressure transducer, is capable of developing a controlled pressure both on the inlet and on the outlet sides.

A known hydraulic arrangement of this type (DE-PS 30 44 137) fulfils the requirements for an extremely short and yet high-performance mould locking unit, in which it is not necessary to pass all the displaced pressure oil back to the reservoir upon every opening or closing manoeuvre

of the mould locking unit. Moreover, the transition from the mould locking unit's closed phase into its locked phase is free of problems insofar as the closing manoeuvre is effected purely by a closing unit which is hydraulically shut off from the pressure cylinder, and the closing force of the drive cylinder continues to operate unaltered during the locked phase.

In a hydraulic arrangement of the type considered above, it is also known to control the flow cross-section of the connector ducts between the low-pressure chamber of the pressure cylinder and the cylinder chambers of the compensating cylinders by means of an electrically-displaceable throttle valve, in dependence on a predetermined working program. By means of such a further development, even heavy mould locking units may be operated at high speed without problems. On the other hand, should a low operative speed be required, a gentle, i.e. pressure-free operation of the mould carrier is guaranteed. In addition it is possible to use the mould locking device independently of its position. The velocities of the closing and opening movements, and the chronological dimensions of the braking phases can be undertaken according to a program. An injection mould which is difficult to open may be opened by increased force without an additional piston-cylinder unit being required for this purpose.

The throttle valve revealing the named advantages, and its incorporation into the mould locking unit are however relatively expensive, and also the connector ducts to be controlled must be passed across the valve, which is disposed outside the pressure cylinder. For this purpose duct bores must be provided in the assembly moulding carrying the hydraulic arrangement during casting of the same, with the help of cores. Experience has shown that such manufacturing processes are not easy to master.

Moreover, an electrohydraulic arrangement for controlling a double-action hydraulic motor is known, both of whose sides are respectively controllable independently of one another by means of an electrohydraulically-operated three-way continuous valve. The continuous valves are each triggered by a 4/4 proportional relay valve. The relay valves connect via separate electrical conductors with an electronic control apparatus, which produces control magnitudes at the hydraulic cylinder in accordance with the respective drive task at any moment.

Proceeding from this point, the object underlying the invention is further to develop a hydraulic arrangement of the type already mentioned in such a way that the advantages already considered (Patent 32 38 111) may be attained in terms of control technology with higher

precision and better adaptation to operational requirements at any moment, while avoiding the use of a throttle valve.

This object is fulfilled according to the invention by the features cited in the characterising part of Claim 1. In such a design manufacturing costs in comparison to the hydraulic arrangement named in DE-PS 32 38 111 can be considerably reduced, as the previously-required throttle valve is eliminated. A more precise method of operation and improved adaptability of the hydraulic arrangement result from the fact that all movements of the drive cylinder and if necessary the locking pressure (cf Claim 7) are provided by a hydraulic force resulting from the differential between opposed, controlled pressures in the drive cylinder or in the pressure cylinder. The design of the annular piston 43, which controls the overflow ducts in piston 25 of the pressure cylinder 20, 25, as a simple cylindrical sleeve according to Claims 9 and 10, ensures extremely high control speed. Further developments of the invention will be seen in the sub-Claims.

The invention will be explained in the following with reference to an embodiment given by way of example and illustrated in the drawings.

Shown are:

Fig. 1: the hydraulic arrangement incorporated in the mould locking unit of the plastics injection-moulding machine,

Fig. 2: a horizontal section on an enlarged scale through the axis of the mould locking unit of the hydraulic arrangement (movable mould carrier in retracted position),

Fig. 3: the drive arrangement according to Fig. 2, in section through the axis of the mould locking unit,

Fig. 4: a diagrammatic view of the hydraulic circuit of the drive arrangement, and

Figs. 5-8: the circuits of the hydraulic arrangement.

A stationary mould carrier 11 and a mounting plate 12 are attached to the machine base, and connected together via pillars 16 to form a rigid frame. For this purpose attachment means 17 are provided on the free ends of the pillars 16. A movable mould carrier 13 with a frontal pressure exchange wall 13a, a posterior pressure absorption wall 13b, and with reinforcing ribs 13c, is displaceably mounted on the pillars 16. The mould carrier

13 is supported by means of sliding blocks 15 on slide rails on the machine base 10. The hydraulic arrangement comprises a hydraulic pressure cylinder 20, 25, disposed in the axis a - a of the mould locking unit, for building up the locking pressure for the injection mould 78. The cylinder chambers (high-pressure chamber 52, low-pressure chamber 50) defined by the pressure piston 25 are connected to one another via overflow ducts 42 of the pressure piston 25. The overflow ducts 42 are closable by means of a hydraulically-operated valve, which will be described in detail later. A hydraulic drive cylinder 27, 47b, lying in the axis a - a of the mould locking unit, with a stationary piston 47b, enables closing and opening of the injection mould 78. The actual cylinder of this drive cylinder 27, 47b is formed by the piston-rod 27 of the hydraulic pressure cylinder 20, 25. Two piston-cylinder units, disposed diametrically relative to the hydraulic pressure cylinder 20, 25 serve as compensating cylinders 21, 26. Their pistons 26 can be pressurised at one side only. The compensating cylinders 21, 26 serve to receive or deliver pressure oil arriving from, or to be delivered to, the pressure cylinder 20, 25. The low-pressure chamber 50 is in open connection with the cylinder chambers 51 of the compensating cylinders 21, 26. The pistons 26 of the compensating cylinders 21, 26 and the pressure piston 25 are each connected via their associated piston rods 28, 27 to the mould carrier 13.

Thus the the piston rod 27 bears via a central distributor plate 14 on the pressure absorption wall 13b of the mould carrier 13.

The piston 47b of the drive cylinder 27, 47b is in the form of a piston which can be pressurised on both sides. The drive speed of the drive cylinder is determined according to a program by a synchronous pressure control system, in the connector ducts 48c, 68, each equipped with a pressure transducer 74, 74', said connector ducts leading from a control valve 64 of the hydraulic arrangement to both cylinder chambers 48, 80 of the drive cylinder 27, 47b.

As is particularly apparent from Fig. 3, both a portion of the connector duct 48c leading to the cylinder chamber 48, on the mould side, of the drive cylinder 27, 47b, and also a portion of the connector duct 63 leading to the high-pressure chamber 52 are in the form of a sleeve 48d or 63a. This sleeve 48d or 63a connects a duct bore 48c or 63 in the stationary mounting plate 12, which carries the hydraulic arrangement and is formed by a cast part, with a duct bore 48c" or 53" in a rear-side cylinder flange 22. The actual cylinders 20 and 21 of the pressure cylinder 20, 25 and of the compensating cylinders 21, 26 are formed by steel sleeves, which are received on the mould side by the mounting plate 12, and on the posterior

side by a cylinder flange 22, each in a centred manner. This results in an extremely compact structure for the hydraulic arrangement, whose structure and method of operation will be explained in detail later; 29 and 30 are the covers of the pressure and compensating cylinders respectively.

The hydraulically passive chambers 53, at atmospheric pressure, of the compensating cylinders 21, 26 are defined at the rear by air-permeable covers 55 in the cylinder flange 22. The numeral 53a refers to openings for an oil leakage outlet. A local voltage transformer 81, detecting the movements of the piston rod, is disposed on an arch-shaped mounting clamp 82 for the protective hood of the mould locking unit. The drive cylinder is covered by a cup-shaped cover 44, through which the piston rod 47 passes centrally in a sealed manner. Here an annular flange 44a, which penetrates in a sealed manner from the posterior into the bore of the piston rod 27 serving as a cylinder, defines the cylinder chamber 80. An axial annular flange 44b of the cover 44 surrounds the posterior end of the piston rod and defines a cylinder chamber 61, which is formed by an axial annular recess in the axial annular flange 44b. An internal cylindrical surface shell of the axial annular flange 44b in the region of the recess serves as an external slide bearing for an annular piston of the valve

controlling the overflow ducts 42 at the pressure piston 25. The annular piston 43 is in the form of a simple sleeve with a cylindrical inner and outer shell surfaces. This sleeve is slidably supported on an end portion of the piston rod 27, said end portion extending from the pressure piston 25 towards the rear. The valve seat of the said valve is formed by an annular rim of the pressure piston, as Figs. 2 and 3 show. The control valve controls the flows of pressure oil under its control equally on the inlet and outlet sides. The connector ducts leading from and to the cylinder chambers 61, 80, 52, 48 and the cylinder chambers 50, 51 communicating with one another are to be described in more detail as follows:

The annular cylinder chamber 61 may be connected, by means of a slide 66, via the connector duct 58, with the pressure line P, which comprises an axial bore in the piston rod 27 and a duct bore 58a in the pressure plate 14 (valve control).

The cylinder chamber 80 may be connected with the pressure line P and the control valve 64 via the connector pipe 68, said connector pipe comprising one axial bore in the piston rod 27 and the duct bore 68a in the distributor plate 14. As Figs. 4 and 6 show, the high-pressure chamber 52 may be connected, by means of

the multiway slide 65 and via a connector duct 63, with the connector duct 48c, which is connected upon closure of the injection mould 78 to pressure line P, said connector duct 63 comprising duct bores 63', 63" in the mounting plate 12 and in the cylinder flange 22, and a sleeve 63a connecting the said duct bores; said connector duct 63 branches off from the connector duct 48c.

The cylinder chamber 48, on the mould side, of the drive cylinder 27, 47b may be connected via the connector duct 48c with the pressure line P by means of the control valve 64 (Figs. 4 and 7), said connector duct 48c comprising an axial bore in the piston rod 47, an annular duct 48b in the cylinder flange 22, and duct bores 48c' and 48c" in the mounting plate 12 and in the cylinder flange 22 respectively, as well as a sleeve 48d, which connects the said duct bores with one another.

As is particularly visible from Figs. 4 and 8, the two interconnecting cylinder chambers 50, 51 of the pressure cylinder 20, 25 and of the compensating cylinders 21, 26 may be connected with the pressure line P by means of the control valve 64 and the slide 67 via a connector duct 68b, which comprises a duct bore (68b in Fig. 3) in the mounting plate.

The cylinder chamber 48 of the drive cylinder 27, 47b is

defined on the mould side by a cup-shaped casting 27a' sealingly inserted into the hollow piston rod 27. A piston 33 is guided in this casting 27a'. The casting 27a' forms with the piston 33 a hydraulic ejector cylinder 27a, by means of which the finished injection-moulded parts may be ejected from the open injection mould 78. The piston rod 34 of the piston 33 may be coupled by means of a coupling 34a with a connecting rod (not shown in the drawing) leading to the ejector members of the injection mould 78. The cylinder chambers 32, 32' of the hydraulic ejector cylinder 27a may be supplied with pressure medium via duct bores 57, 73, as Fig. 2 shows. The diagram in Figs 4 and 8 shows that the connector duct 68 leading from the control valve 64 to the cylinder chamber 80 of the drive cylinder 27, 47b may be connected, via a branching connector duct 68b with the help of slide 67, with the pressure line P (opening of the injection mould 68 with large cylinder area).

The connector duct 48c leading from the control valve 64 to the cylinder chamber 48 of the drive cylinder 27, 47b may be connected, via a branching connector duct (63 in Fig. 3), with the high-pressure chamber 52, said connector duct 63 being controlled by the multiway slide 65. Figs. 5 to 8 show the flow paths of the pressure oil during opening of the injection mould with low power (Fig. 5), during opening of the injection mould with high

power (Fig. 8), during closing of the injection mould (Fig. 7) and during locking of the injection mould (Fig. 6). In this case the pipes connected to the pressure line P are shown by a complete line, and the pipes connected to the reservoir by a dotted line. It should be noted in this respect that, during opening and closing of the injection mould (and also during travel of the displaceable mould carrier 13), the valve controlling the overflow ducts 42 in the pressure piston 25 is open so that, during closure of the injection mould, the pressure oil can overflow out of the cylinder chambers 50, 51 into the high-pressure chamber 52 which at this stage is not under pressure, and that, during opening of the injection mould, the pressure oil can overflow out of the high-pressure chamber into the cylinder chambers 50, 51. This means that at least the predominant part of the pressure oil only needs to travel short distances within the hydraulic arrangement during opening and closing of the injection mould, and in any case need not be passed through the reservoir 71, 72.

If the injection mould 78 is difficult to open, it is in a primary phase slightly opened, with overflow ducts 42 closed in accordance with Fig. 8, over a large surface area, in order then to be moved into the open position with low power in accordance with Fig. 5.

All the functions which can be effected by the hydraulic arrangement may be controlled according to a program, with the aid of the control valve 64 and the slide 65-67. It should be noted here that, upon opening (Fig. 5) and closing (Fig. 7) of the injection mould, the piston 47b of the drive cylinder 27, 47b is as a rule in each case pressurised on both sides, and that thus the opening or closing movements each result from the differential between the hydraulic forces acting on the frontal and posterior faces of piston 47b. In this way the opening and closing movements may be adapted by programmed regulation to the numerous requirements arising from the respective type of moulding to be manufactured, or from the type of plastics material being processed.

Figs. 5 and 7 show respectively only those flow paths of the pressure oil which exert the hydraulic force on the piston 47b of the drive cylinder 27, 47b.

During an injection cycle on the injection-moulding machine the hydraulic arrangement operates as follows, with the closed injection mould 78 as a starting point: the injection mould is firstly opened with low cylinder area according to Fig. 5, and then, according to Fig. 8, with large cylinder area, the latter in such a way that the hydraulic arrangement according to Fig. 8, after a slight separation of the halves of the mould, moves into

a circuit according to Fig. 5. Then the finished injection-moulded parts are ejected with the aid of the ejector cylinder 27a from the open injection mould 78. Thereafter the injection mould is closed according to Fig. 7. During injection of the plastics material into the injection mould 78, and during a 'pressure dwell phase' until the plastics material in the injection mould has hardened, the injection mould is held closed according to Fig. 6 with high power.

A further not inconsiderable advantage of the hydraulic arrangement is seen in the fact that controlled locking of the injection mould is thereby guaranteed. The piston rod is secured on the cylinder flange 22 by means of the pin 47a and nut 24, said cylinder flange being braced by means of stay bars 23 on the mounting plate 12. The numeral 23 indicates the heads of these stay bars 23.

Fig. 6 shows that the connector duct 48c leading from the control valve 64 to the cylinder chamber 48 of the drive cylinder 27, 47b is connected by multiway slide 65 via a branching connector duct 63 with the high-pressure chamber, and thus the locking pressure, measured by the pressure transducer 74 and thus controlled, is built up, the low-pressure chamber 50 being switched to the reservoir 71 by means of multiway slide 67. On the other hand the control valve 64 enables a pressure to be

developed and controlled on its outlet side, and thus via the connector duct 68 in cylinder chamber 80 of the drive cylinder 27, 47b. This controlled pressure may be taken from the connector duct 68 with the aid of the branching connector duct 68b with the aid of the multiway slide 67, and also delivered to the low-pressure chamber 50. Thus, during locking of the injection mould, both the pressure piston 25 may be hydraulically influenced from the low-pressure chamber 50, and also the piston 47b of the drive cylinder 27, 47b from the cylinder chamber 80, during a controlled pressure cycle. There therefore results from the differential of hydraulic influence on the pressure piston 25 and on the piston 47b a controlled locking pressure, with measurement of the pressure differential by the pressure transducers 74, 74'.

Patent Claims

1. A hydraulic arrangement for a plastics injection moulding machine with a hydraulic cylinder (20,25), disposed in the axis (a - a) of the mould locking unit, for building up the locking pressure for the injection mould (78) whose cylinder chambers (high-pressure chamber 52, low-pressure chamber 50) defined by the pressure piston (25) are connected to one another via overflow ducts (42) of the pressure piston (25), said overflow ducts (42) being closable by means of a hydraulically-operated valve, with a hydraulic drive cylinder (27, 47b) with a stationary piston (47b) for closing the injection mould (78), whose actual cylinder is formed by the piston rod (27) of the hydraulic pressure cylinder (20, 25), with two piston-cylinder units (compensating cylinders 21, 26) disposed diametrically relative to the hydraulic pressure cylinder (20, 25) and which may be pressurised at one side only, with pistons (26) for receiving or delivering pressure oil coming from the pressure cylinder (20,25) or to be delivered thereto, the low pressure chamber (50) being in open connection with the cylinder chambers (51) of the compensating cylinders (21, 26) , whose pistons (26) as well as the pressure pistons (25) are each connected via the associated piston rods (28; 27) to the mould carrier (13) of the mould locking unit, and with a control valve (64) regulating the opening and



closing movements of the drive cylinder (27, 47b) via a local voltage transformer (81) in accordance with a rate program, said rate program having superimposed thereon a pressure control system via a pressure transducer (74, 74'), characterised in that the stationary piston (47b) of the drive cylinder (27, 47b) is a piston capable of receiving pressure on both sides, and the control valve (64) is designed as a valve regulating both the inlet and the outlet sides, by means of which the drive velocities of the drive cylinder (27, 47b) may be determined in the closing and opening directions, in each case with simultaneous pressure influence on both sides of the piston (47b) in accordance with the rate program via the local voltage transformer (81) which detects the movements of the displaceable mould carrier (13), a pressure transducer (74, 74') being provided in both connector ducts (48, 68) leading to the cylinder chambers (48, 80) of the drive cylinder (27, 47b), in order to provide a superimposed system of pressure control.

2. A hydraulic arrangement according to Claim 1, characterised in that both one portion of the connector duct (48c) to the cylinder chamber (48) of the drive cylinder (27, 47b), on the same side as the mould, and one portion of the connector duct (63) to the high-pressure chamber (53) is in the form of a sleeve (48d; 63a), which in each case connects a respective duct bore



(48c', 63') in a stationary mounting plate (12) carrying a hydraulic arrangement, with a duct bore (48c", 63") in a rear-side cylinder flange (22).

3. A hydraulic arrangement according to Claim 2, characterised in that all the connector ducts (48a; 58; 63; 68; 68b) of the hydraulic arrangement pass through duct bores (48c'; 58a; 63'; 68a; 68b) of the mounting plate (12) or of a distributor plate (14) on the displaceable mould carrier (13).

4. A hydraulic arrangement according to one of the foregoing Claims, characterised in that the cylinder chamber (48) of the drive cylinder (27, 47b) is defined on the same side as the mould by a can-shaped moulding (27a') inserted sealingly into the hollow piston rod (27), and that there is guided in this moulding a piston (33), which forms along with moulding (27a') a hydraulic ejector cylinder (27a).

5. A hydraulic arrangement according to one of the foregoing Claims, characterised in that the connector duct (68) leading from the control valve (64) to the cylinder chamber (80) of the drive cylinder (27, 47b) can be made to connect with the low-pressure chamber (50) by means of a multiple-way slide (67) via a branching connector duct (68b) (opening of injector mould with



large cylinder surface).

6. A hydraulic arrangement according to one of Claims 1 to 4, characterised in that the connector duct (48c), leading from the inlet side of the control valve (64) to the cylinder chamber (48) of the drive cylinder (27, 47b), and provided with pressure transducers (74) can be made to connect, by means of a multiple-way slide (65) and via a branching connector duct (63), with the high-pressure chamber (52), and the low-pressure chamber (50) may be connected by means of a multiple-way slide (67) with the reservoir (71). (Regulated locking of the injector mould with pressure measurement on one side by means of the pressure transducer).

7. A hydraulic arrangement according to one of the foregoing Claims, characterised in that the inlet side, regulated by means of pressure transducers (74), of the control valve (64) may be made to connect via the connector duct (48c) with the cylinder chamber (48) of the drive cylinder (27, 47b), and simultaneously may be made to connect, via a branching connector duct (63) and by means of the multiple-way slide (65), with the high-pressure chamber (52), the outlet side, controlled by a pressure transducer (74'), of the control valve (64) is connected via the connector duct (68) with the cylinder chamber (80) of the drive cylinder (27, 27b), and is in



connection with the low-pressure chamber (50) by means of the multiple-way slide (67) via the branching connector duct (68b).

8. A hydraulic arrangement according to one of the foregoing Claims, characterised in that the local voltage transformer (81) is disposed on a mounting clamp (82) of the mould locking unit.

9. A hydraulic arrangement according to one of the foregoing Claims, characterised in that the annular piston (43) controlling the overflow ducts (42) in the piston (25) of the pressure cylinder (20, 25) is in the form of a simple cylindrical sleeve.

10. A hydraulic arrangement according to Claim 9, characterised in that the sleeve forming the annular piston (43) has extending over it an axial annular flange (44b) of a cover (44) which encloses the rear cylinder chamber (80) of the drive cylinder (piston rod 27 and piston 27b) at the back.

