This invention relates to a fuel injection pump governor for compression ignition engines and particularly to a combined mechanically and hydraulically actuated governor means for a fuel injection pump.

It is an object of this invention to provide a novel hydraulic and mechanical governor for a fuel injection pump which combines hydraulic and mechanical governing to effect improved injection pump performance.

It is a further object of this invention to provide an improved fuel injection pump governor which utilizes supply chamber pressure to effect increased fuel delivery at starting of the engine.

It is a further object of this invention to provide improved mechanism in a fuel injection pump governor for adjusting maximum fuel delivery.

These and other objects and advantages will be apparent to those familiar with the art when the following description is read in conjunction with the drawings in which:

FIG. 1 is a vertical section of a distributor type fuel injection pump and governor mechanism utilizing my invention;

FIG. 2 is a horizontal section of the pump and governor mechanism of FIG. 1;

FIG. 3 is a perspective view of components of the fuel pump shown in FIGS. 1 and 2;

FIG. 4 is a developed view of the internal bore of the fuel pump control sleeve;

FIGS. 5, 6, 7 and 8 are views illustrating axial adjustment of the control sleeve;

FIGS. 9 and 10 are views illustrating axial adjustment of the fuel control rod;

FIG. 11 is a perspective view of mechanical governor components;

FIGS. 12 and 13 are views illustrating adjustment of maximum fuel delivery; and

FIG. 14 is pump delivery v. engine speed curve.

As shown particularly in FIGS. 1 and 2 of the drawings, my invention is illustrated in an injection pump and governor assembly 21, the main components of which are a single plunger distributor type injection pump 22 and a governor 23 having a common housing 24. The pump plunger 26 is reciprocated through a cam 27 on the pump drive shaft 28 and is rotated through gears 29, 31 to sequentially deliver fuel, through port 49 in its distributing portion 30, to a plurality of delivery passages 51 opening at circumferentially spaced points into the plunger bore 35. A control sleeve 33 is rotatably and reciprocably mounted relative to the housing 22 and cooperatively encompasses an inlet portion 35 of plunger 26 to control the flow of fuel between supply chamber 34 and the pressure chamber, not shown, at the upper end or pumping portion of plunger 26. For a fuller understanding of the operation of the pump reference may be made to U.S. Patent 2,980,092. Fuel Injection Pump Issued to me and Louis G. Kaplan on April 18, 1961. A pair of gears 36, 37 comprise a gear type pump driving fuel from a reservoir, not shown, through conduit 38 and delivering it to supply chamber 34 by way of conduit 39. The gear 37 is connected through governor shaft 41, in driven relation to pump shaft 28 which in turn is adapted for connection to an engine. An annular plate 42 is likewise secured to shaft 25 by means, not shown, for rotation thereon.

OPERATION OF INJECTION PUMP

As the plunger 26 rotates, its equally spaced inlet ports 46 are cyclically blocked by lands 47 circumferentially spaced by equally spaced vertical slots 48. This blocking occurs during at least a portion of the upward, pumping stroke of plunger 26 with resulting delivery of fuel by way of delivery port 49 to one of the injector passages 51. Injection stops when the top inlet ports 46 pass above the top edge (spill edge) of the lands 47, thus connecting the high pressure pumping chamber at the top end of plunger 26 with the supply chamber 34 by way of central passage 52. On the down stroke of the plunger 26, the inlet ports 46 register with slots 48, thereby permitting fuel to flow to the high pressure pumping chamber to fill the space vacated by the plunger 26.

As shown in FIG. 3 as well as FIGS. 1 and 2, a single reciprocable control rod 56 is employed to rotate and axially shift the control sleeve 33 relative to the pump housing 24. The inner end of the rod 56 is furnished to receive a flattened end of a finger 57 which extends at one end into a transverse bore 58 in a vertical pin 59 and extends at its other end into a bore 60 in sleeve 33. Movement of the control rod 56 along its axis 61 effects rotation of control sleeve 33 to change the timing and quantity of injection.

In FIG. 4, showing a developed view of the internal bore of sleeve 33, the path of the center of inlet port 46 is shown schematically by curved dash line 62 in relation to lands 47 and slots 48 of sleeve 33 as the plunger simultaneously reciprocates and rotates. Thus it is seen that by shifting the rod outwardly, to the right as viewed in FIGS. 1, 2, and 3, the inlet port 46 will be closed earlier, that is at a lower point on curve 62 thereby advancing the beginning of injection and increasing the quantity of injection. Movement of the control rod 56 inwardly (to the left) rotiates the sleeve 33 in the direction of plunger rotation thus retarding inlet port closing and decreasing the quantity of fuel injection. Vertical displacement of control rod 56 moves the control sleeve 33 vertically relative to the housing 24 and plunger 26. The control rod 56 is supported in an axial bore 66 in a hydraulically actuated timing piston 67 axially and rotatably shiftable in a bore 68 in housing 24. The piston 67 is a primary component of the hydraulic governor means hereinafter described.

OPERATION OF HYDRAULIC GOVERNOR MEANS

Supply pump 36, 37, driven by the governor shaft 41 delivers fuel to the fuel supply chamber 34 in which the inlet portion of plunger 26 and metering sleeve 33 are disposed. Fuel pressure in supply chamber 34 is regulated by regulating valve 69. As the speed of the supply pump 36, 37 increases, a larger flow of fuel must be bypassed through valve 69, resulting in a pressure increase in chamber 34. For a given injection pump delivery per stroke, supply chamber pressure is solely a function of speed. This, therefore, enables the use of supply chamber pressure as a speed sensing device.

When the engine is at rest fuel pressure is substantially zero. Hydraulic governor piston 67 is pushed to the left toward the supply chamber 34, as shown in FIGS. 5 and 6, under the action of spring 71 through lever 72 having a fulcrum contact with fixed abutment 73. Due to this positioning of the piston 67, the control sleeve 33 is shifted axially to a raised position thereby retarding inlet port opening, thus delaying the ending of injection and increasing the quantity injected. This increased initial injection aids in starting the engine. The upward transposition of control rod 56 is accomplished by cooperation of the spherical head 74 of timing screw 75 with the side walls of helical slot 76 in piston 67. The engagement of
finger 57 with bore 60 of sleeve 33 prevents the control rod 56 from rotating about its axis.

The relationship between the cross sectional area of piston 67, the spring rate of spring 71 and lever ratio of lever 72 is arranged so that at a supply chamber pressure of some desirable engine idling speed, the timing piston 67 is pushed to the right to the position shown in dash lines 67* in FIGS. 5 and 6. As the timing piston 67 moves to the right, to its advanced injection ending position 67*, the spherical head 74 of timing screw 75 cooperates with eccentric slot 76 causing the piston 67 to rotate clockwise, as viewed in FIG. 7, through an angle whereby moving control rod 56 downwardly to its position 56* and sleeve 33 to its advanced injection ending position 33*. As seen in FIG. 8, on the upward injection stroke of plunger 26, the inlet port 46 will rise above the spill edge 40 of sleeve 33 at a lower point on the upward portion of its path when the sleeve is lowered to its position 33*.

From the foregoing it is evident that the piston 67 and control rod 56, screw 75, and spring 71 are primary parts of the means for reciprocating the sleeve 33 in response to pressure changes in supply chamber 34.

OPERATION OF MECHANICAL GOVERNOR MEANS

FIG. 9 shows the parts of mechanical governor 23 in solid lines at an intermediate speed and under full load. The position of the inlet port 46 in relation to the slots 48 and lands 47 of the control sleeve 33 at the beginning of injection (port closing) is shown in FIG. 10. As load is taken off the engine, engine speed will increase, centrifugal force on the balls 81 will increase and the balls will move radially outwardly from the centerline of the governor shaft 41, causing the governor parts to move to the positions shown in dash lines. This movement will push the governor cup member 82 to the right against the governor springs 83, 84 until a new position of equilibrium is obtained. As cup member 82 is shifted axially to the right the governor control lever 85 is pivoted about its axis 86 moving its upper end to the left, thus shifting control rod 56 to the left to reduce the quantity of fuel delivered by the pump. The dash lines 133 in FIG. 10 indicate the resulting reduced fuel position of the control sleeve 33.

Referring to FIG. 11, it is seen that the torque arm assembly 91, supporting lever 85, can be oscillated about axis 92 of the throttle shaft assembly 93. A torque pin 94 in torque shaft 97 and a slot 98 in sleeve 99 of throttle arm assembly 91 provide a rotational lost motion connection between the assemblies 91 and 93. A torque spring 96 with its ends connected to assemblies 91, 93, urges relative rotation of the assemblies 91, 93 so that normally the torque pin 94 is in contact with side 95 of slot 98.

Referring now to FIG. 12, I show, in solid lines, the governor lever 85 when the engine is running at rated speed and under full load. The operator has rotated the throttle shaft assembly 93 counterclockwise as viewed in FIGS. 1 and 11 to its full load position. In this position the upper part of the governor control lever 85 is abut-ting against the torque cam 101. If the load on the engine is now increased, the engine will start slowing down due to its inability to maintain speed under such an overload. As the speed goes down, the centrifugal force on the balls 81 decrease, the governor springs 83, 84 move the cup member 82 to the left until a new position of equilibrium is obtained, as shown in dash lines. The lower end of control lever 85 will be moved to the left, however, since the upper end of the lever is abutting torque cam 101, the control lever 85 cannot swing about axis 92. Instead, the force of governor springs 83, 84 is transmitted through the control lever 85 and overcomes the force of the torque spring 94 to move the torque arm assembly 91 clockwise about axis 92 until the pin 94 engages side 116 of slot 98. When this occurs, the upper end of control lever 85 assumes the dashed line position shown in FIG. 12, the torque cam 101 acting as a fulcrum. The control rod 56 is thus moved to the right, increasing the quantity of fuel delivered to the engine.

The new position of the control sleeve is shown by dash lines 233 in FIG. 13. This ability of increasing the fuel delivery at lower speeds is referred to as torque control. As shown in FIGS. 1, 2 and 11, the torque cam 101 is threaded on a torque screw 102 and, as seen in FIG. 2, the axis of the cam 101 is offset from the axis of torque screw 102. The torque screw 102 has a cylindrical bottom end 107 piloted in a bore 106 of the horizontally extending bottom leg 108 of bracket 109 which is secured to housing 24 by screw 111 and nut 112. The upper threaded portion of torque screw 102 is in threaded engagement with a threaded opening 110 in the horizontally extending upper leg 113.

By loosening the lock nuts 103, 104 on the torque screw 102 and rotating the latter one full turn or a multiple of full turns, the torque cam 101 can be positioned at a higher or lower point. For the same drop in full load engine speed, a different displacement of the upper end of the control lever will result from differential axial positions of cam 101, in turn effecting a larger or smaller fuel delivery. In other words it will change the shape of the fuel pump torque curve.

Small relative adjustments of the torque screw 102 will result in the control lever 85 touching a different point on the eccentric abutment surface 114 of torque cam 101. This results in a variation of full load injected fuel quantity.

COMBINED OPERATION OF MECHANICAL AND HYDRAULIC GOVERNOR MEANS

FIG. 14 shows a pump delivery curve over the usual engine speed range which can be obtained by using my combined mechanical and hydraulic governor. Point A represents the full load fuel quantity which the pump delivers at the rated engine speed. As the speed is decreased under full load conditions, the torque control increases the fuel quantity to its peak value at point B, by control lever 85 pivoting about torque cam 101 as illustrated in FIG. 12. At this point, the left hand edge 116 of the slot 98 in the throttle arm sleeve 99 contacts the torque pin 94 and control lever 85 does not move any more as engine speed decreases. As the engine speed decreases further, pump delivery follows its natural curve to point C. Between points B and C the combined governor means does not change the position of control sleeve 33. At speeds below point C, due to decreasing pressure in the pump chamber 34, the timing plunger 67 starts moving inwardly under the influence of the timing spring 71 retarding the end of injection by raising control sleeve 33. This causes an increase in pump delivery until at zero speed the available pump delivery has been increased to D and the opening of inlet port 46 is fully retarded.

It is obvious from the foregoing description that point C and point B can be moved up or down along the natural speed range curve segment. Also the slope of the delivery curve from A to B can be changed by moving the torque cam 101 up or down on the torque screw 102. The embodiments of the invention for which an exclusive property or privilege is claimed are defined as follows:

1. A fuel injection pump and governor comprising: a housing including walls defining a supply chamber, and a plunger bore opening at one end into said supply chamber, a pump plunger reciprocably and rotatably mounted in said bore and having a fuel inlet portion in said supply chamber,
a control sleeve receiving said plunger in surrounding and controlling relation to said inlet portion and reciprocally and pivotally mounted in said housing for pivotal and reciprocal movements relative to said housing,
means for rotating and reciprocating said plunger relative to said sleeve and said housing including a drive shaft,
mechanical means operating said control sleeve for effecting one of said pivotal and reciprocal movements of said control sleeve in response to changes in speed of rotation of said shaft,
said means supplying fuel to said supply chamber and causing the pressure therein to increase with increasing rotary speed of said shaft, and
hydraulic means for effecting the other of said pivotal and reciprocal movements of said control sleeve in response to pressure changes in said supply chamber.

The structure set forth in claim 2 wherein said means for effecting reciprocal movement of said control sleeve is operative to reciprocate said control sleeve to one extreme of its reciprocal movement, wherein a decrease in delivery results, upon said drive shaft reaching a predetermined idling speed.

The structure set forth in claim 2 wherein said means for effecting reciprocal movement of said control sleeve includes a reciprocable piston in said housing resiliently biased axially in one direction and urged axially in the opposite direction by the pressurized fuel in said supply chamber.

A combined mechanical and hydraulic governor for an engine driven fuel pump of the type having a supply chamber, a rotatable and reciprocable pump plunger with an inlet port in the supply chamber and a pivotal and axially shiftable control sleeve in the supply chamber presenting a cylindrical control surface interrupted by axial slots for cyclically opening and closing the inlet port as the pump plunger is rotated and reciprocated, said governor comprising:
a housing,
said means supplying fuel to said supply chamber and causing the pressure therein to increase with increasing engine speed,
a centrifugal mechanism mounted in said housing for rotation about a first axis including radially shiftable weights, and an axially shiftable member resiliently biased axially in one direction and urged in the opposite direction by said weights under the influence of centrifugal force,
a control lever,
means mounted on said housing for pivotally supporting said control lever for pivotal movement about a second axis spaced from and transverse to said first axis,
an axial thrust transmitting connection between one end of said lever and said member,
means for pivotally and control sleeve in response to changes in pressure in said supply chamber.

The structure set forth in claim 5 wherein said means for axially shifting said control sleeve includes a piston in said housing resiliently biased in one direction and biased in the opposite direction by the fuel pressure in said supply chamber.

The structure set forth in claim 6 wherein said means for pivoting and axially shifting said control sleeve include a control rod having a finger at one end connected to said sleeve and its other end in motion transmitting relation with the other end of said lever and wherein said piston is operatively connected to an intermediate portion of said control rod.

The structure set forth in claim 7 wherein said piston includes an axial opening therethrough and said control rod extends through said opening in axially shiftable relation to said piston.

A governor for an engine driven fuel injection pump of the type having a plunger with inlet, distributing and returning portions and an axially shiftable and rotatable control sleeve encompassing said inlet portion of said plunger, said governor comprising:
a housing including a supply chamber in which said sleeve is disposed,
a control rod connected to said control sleeve to rotate the latter upon reciprocation of said rod,
a centrifugal mechanism mounted in said housing for rotation about a first axis and adapted for connection in driven relation to an engine including radially shiftable weights, an axially shiftable member urged in one direction by said weights upon centrifugal force acting upon the latter, and spring means biasing said member axially in the opposite direction,
a throttle shaft mounted on said housing for pivotal movement about a second axis spaced from and transverse to said first axis,
a torque arm mounted in said housing for pivotal movement on said second axis and having a radially extending arm,
means forming a rotational lost motion connection between said throttle shaft and torque arm, means resiliently biasing said throttle shaft and torque arm to rotate relative to one another in one direction,
a throttle lever connected intermediate its ends to said arm for relative pivotal movement about a third axis parallel to said second axis and spaced from said first axis,
means connecting one end of said lever to said member for movement therewith in the direction of said first axis,
an abutment surface on the other end of said lever in axial thrust transmitting engagement with said control rod,
a torque control element adjustable mounted in said housing and having an abutment surface engageable with said lever intermediate said abutment surface and said third axis to provide a fulcrum point for said lever,
means for shifting the position of said torque control element radially relative to said third axis, means for shifting said torque control element in the direction of movement of said other end of said lever, and
means for axially shifting said control sleeve in response to changes in fuel pressure in said supply chamber.

The structure set forth in claim 9 wherein said means for axially shifting said control sleeve includes a piston resiliently biased in one axial direction and biased in the opposite axial direction by the fuel pressure in said supply chamber.

A governor for an engine driven fuel injection pump of the type having a reciprocable control rod, comprising:
a housing,
a centrifugal mechanism mounted in said housing for rotation about a first axis and adapted for connection in driven relation to an engine including radially shiftable weights, an axially shiftable member urged in one direction by said weights upon centrifugal force acting upon the latter, and
spring means biasing said member axially in the opposite direction,
a throttle shaft mounted on said housing for pivotal movement about a second axis spaced from and transverse to said first axis,
a torque arm mounted in said housing for pivotal movement on said second axis and having a radially extending arm,
means forming a rotational lost motion connection between said throttle shaft and torque arm,
means resiliently biasing said throttle shaft and torque arm to rotate relative to one another in a first direction,
a throttle lever connected intermediate its ends to said arm for relative pivotal movement about a third axis parallel to said second axis and spaced from said first axis,
means connecting one end of said lever to said member for movement therewith in the direction of said first axis,
an abutment surface on the other end of said lever in axial thrust transmitting engagement with said control rod,
a torque control element adjustably mounted in said housing and having an abutment surface engageable with said lever intermediate said abutment surface and said third axis to provide a fulcrum point for said lever,
means for shifting the position of said torque control element radially relative to said third axis and means for shifting said torque control element in the direction of movement of said other end of said lever.

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