The MUNCASTER steam-engine models – 8

Continued from 16 May 1957, pages 700 to 702

In this instalment EDGAR T. WESTBURY discusses governors and control gear

Several of the engine designs in this series have included governor gear, which is a necessary fitting for engines which have to maintain a fairly constant speed under varying load conditions and, in fact, practically any engine which is not under the constant supervision of the driver.

Nearly all steam-engine governors are of the centrifugal type, based on the original pendulum governor of James Watt, and, in the earlier engines at least, were usually made as a self-contained unit, located at a convenient position on the engine to be driven by belt or gears, and for connecting up to a throttle control valve. I have described governor mechanism in connection with the Unicorn and Tangye engines as well as in a separate article [MODEL ENGINEER, 27 October 1955] dealing with a governor unit suitable for the Vulcan beam engine or other early types.

Although the basic principle of the governor is very easy to grasp—indeed, it is obvious to anyone who has observed the forces exerted in rotating masses—a full explanation of the theoretical considerations involved in its design would take up far more space than could be spared here. Advanced text books on mechanics usually devote one or two pages of mathematical formulae to the phenomena of centrifugal force (for example, see Ganot’s Physics, para. 55), but I propose to deal only with simple practical applications of the governor in the examples illustrated by Muncaster.

As first designed by James Watt, the rotating ball weights of the governor not only produced the positive operating effort, under the effect of centrifugal force, but also the negative or restoring effort, under the effect of gravity; no extra weights or springs were used, and the vertical shaft arrangement was essential for its operation. Muncaster states that in this form it cannot be recommended for small engines, and my own experience supports this view; the reason of course is that in a small size, the gravitational effect is reduced to a much greater extent than the friction in the working parts.

The action of a governor relying on the weight of the balls alone to restore the control on reduction of speed would be very erratic or "sticky." Some governors, such as the Porter type, have an additional moving weight, which slides on the centre shaft and supplements the restoring force, but even this is limited in its effects and has been found inadequate in small sizes. It is also necessary in most cases to increase the positive effort by running small governors at higher speed than the full-size types.

To transmit the movement of the sliding yoke to the governor lever with the minimum friction, a horse-shoe-shaped thrust collar is fitted to the groove, with extended pivots engaging the eyes of short arms which straddle the yoke and are pinned to the lever shaft. These details are illustrated in Fig. 39. The governor shaft runs in a long vertical bearing, in a bracket mounted on the engine frame, and is bevel-gear to the
drive shaft which runs in a long horizontal bearing.

For high-speed engines, such as those used for driving electrical generators, it is often found convenient to fit the governor directly on the end of the main shaft, thus avoiding the necessity for either belt or gear drive, and making a compact arrangement. In this case spring return is an obvious necessity, and it is also desirable to reduce the number of working parts in the mechanism, thus cutting down wear, friction and any tendency to rattle. The governor (Fig. 40) fulfills these conditions, as it entails the use of only two pivoted joints and a single sliding member, with a totally-enclosed central compression spring. This type is suitable for the engine shown in Fig. 28.

It will be seen that as the balls move outwards under the effect of centrifugal force, the bell crank levers to which they are attached press against a fixed thrust washer, causing the entire governor assembly to move bodily to the left. The grooved collar on the sleeve operates the governor lever through a thrust collar, as in the previous example, though this is not shown. In the drawing, the shaft extension which carries the governor is shown as screwed into the end of the main engine shaft, but there are practical objections to this arrangement, and I would suggest modifying it. Apart from the risk of the extension unscrewing if the shaft ran in a clockwise direction or in the event of sudden acceleration or stopping, there might be difficulty in ensuring true running of the extension shaft. It would be better to make this integral with the shaft or devise some more positive scheme of fixing and alignment. It is hardly necessary to add that the governor assembly should be symmetrical and in balance at all speeds; this is of special importance not only when it is fitted on a shaft extension as in this case, but also where it projects a long way above a single vertical bearing as in the previous example.

THROTTLE VALVES

The design of the control gear which regulates engine speed under the influence of the governor is of equal importance to that of the governor itself. The simplest method of governing is by means of a throttle or restricting valve, which may be of any type so long as it is capable of being operated with the minimum effort; it does not need to be capable of shutting completely, as it is generally a supplement to the main engine stop-valve, which should be quite steamtight when closed. The type of throttle valve shown in Fig. 41 is commonly used in full-size practice and is recommended by
MUNCASTER MODELS

Muncaster for small engines. It is similar to that specified for the Tangye engine, but I have found it more employ successfully than types which have a rotary movement, such as barrel or butterfly valves. The reason for this is that it takes less effort to rotate a shaft in a packed gland than to slide it bodily through the gland, as in this case.

However, the example illustrated is certainly capable of working successfully on the larger models for which it is obviously intended, having a bore diameter of 3/8in. Steam must be admitted from the left-hand (horizontal) branch, the vertical passage being connected to the engine. It is fitted with a liner having three ports which open into an annular passage, so that pressure is even all round the valve and there is no tendency to press it against one side of the liner. The sliding piston should be a smooth, easy fit in the liner, the two parts preferably being of dissimilar metals, such as steel and cast iron, or brass and hard bronze, to give good wearing properties. A hole must be drilled through the piston to balance the pressure on the upper surface, otherwise it will be difficult to move owing to inequalities in this respect or through the trapping of steam or water. Care must be taken to fit the cover, with its central gland, in exact concentric register with the liner, and the piston and rod also concentric with each other.

GOVERNOR CONTROLLING POWER

The "power" of a governor may be defined as the positive effort which it is capable of exerting on the control valve. It must obviously be capable of overcoming any frictional or other resistance encountered in the control gear, and it is desirable to have a margin of power in hand to ensure reliable action. The power can be increased in two ways: by increasing the weight of the balls, and by increasing the rotational speed. Large slow-speed engines call for heavy governor weights unless the governor is geared up. But in high-speed engines a governor which appears much too small may be just as effective.

It should be noted that the force available to operate the control gear is influenced by the means by which motion is transmitted from the governor. Sometimes, in order to obtain sufficient amplitude of movement at the valve rod or spindle from a relatively small governor, multiplying levers are used in the connecting mechanism, and the effective force is, therefore, reduced in inverse ratio to the increased movement. Thus the governor power must be adequate to cope with this.

If, however, the effective weight or speed of a governor is increased, it will come into operation at a lower speed and thus, if the engine speed is to remain the same, equilibrium must be restored by increasing the strength of the return spring or counterweight. Erratic action or "hunting" (alternate rise and fall of engine speed) may be caused by friction in the control gear or by faulty governor design—which includes too great a multiplication of lever and control valve movement—so that it moves over too great a range with a slight increase of speed. Steadiness of control is sometimes improved by fitting a damping device, such as an air or liquid dashpot. Speed range can be adjusted by varying the spring tension, or fitting an external spring which can be adjusted while running.

ACCURACY OF CONTROL

Although a governor is often assumed to be capable of keeping the engine speed exactly constant, this is not so in practice because the governor cannot effect any change in the throttle position until some change of speed has taken place. There must obviously be some margin of error in any type of governor, depending on its design and control linkage, but more still on workmanship and elimination of friction. For most stationary engines of small size, a margin of five per cent. deviation from the set speed is fairly reasonable, but for special purposes, such as generating electricity, closer accuracy is necessary, and the permissible variation may be less than one per cent. in some cases.

Geared or positively-coupled governors are preferred for accurate control, as belt-driven governors may be liable to variable slip and their reliability may be open to question. Cases have occurred where broken governor belts have caused serious accidents, sometimes with loss of life. Nevertheless belt driven governors gave good results on steam-engines for many years.

EXPANSION GOVERNORS

While throttle governing is effective, and is probably the most satisfactory method on small engines where rigid steam economy is not the first consideration, it tends to waste steam by the biwearding effect of the throttle valve, which results in lowering the working pressure of the steam before it enters the engine cylinder. To obtain the best efficiency the steam should be admitted to the engine but cut off earlier in the piston stroke so that it can be used expansively and its energy utilised to the best effect. This is done in most large engines by using governors which vary the timing of the valve gear.

The governors themselves may be of normal type though they are sometimes of special design; they may operate on the normal slide or piston valve through linkage comparable to that of reversing gear, or on "track" valves with elaborate porting arrangements. Corliss and drop-valve engines have trip devices which close the steam admission valve suddenly at different cut-off points under governor control.

A very simple and effective expansion governor is that fitted directly on the engine shaft—often in the flywheel—and controlling a movable eccentric, not only by reducing the throw but also advancing the timing. If only the throw and, consequently, the valve travel, were reduced, it would certainly result in earlier cut-off, of steam, and, therefore, be effective in speed control; but it would be uneconomical because the admission point would be retarded, or, in other words, lead reduced in the same proportion. To compensate for this, therefore, the eccentric is advanced as its stroke is reduced.

As expansion governors are a specialised type in which only a limited number of readers are likely to be interested, I do not propose to describe them further. But for the benefit of those seeking further information: it may be noted that they were fully dealt with by Muncaster in a series of articles in Vol. XXVI (January to June 1912) of Model Engineer.

* To be concluded

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