

The leading edge of compact technology

Abstract

A constantly growing market and a considerable increase in quality standards has led suppliers of hydraulic units for mini-excavators to carrying out constant improvements in terms of quality, cost reduction and project engineering, in order to meet the demands of manufacturers.

The main hydraulic component used on a mini-excavator is without doubt the control valve: it has to handle every machine function in terms of movement and control quality.

Control valves for these applications have undergone very noticeable innovation during recent years, also thanks to the Japanese, who have introduced quite a few novelties in this field: we are not speaking only about the number of functions which are incorporated in a single valve, but also about continuous “compacting” which they have undergone in order to apply the typical philosophy of manufacturers, who need machines which are more and more compact but have more and more functions.

Actually, control valves are undergoing an integration of functions which were initially assigned to outside valves or to blocks connected to them: this is forcing manufacturers to redesign the “heart” of the machine, on the basis of these new needs.

It is in the name of integration that the new battle is going to be fought by suppliers of control valves: integration of everything associated with it, and which therefore interacts with its operation.

From this point of view, there are many advantages for manufacturers. We refer to the reduction, in terms of numbers, of the items installed on the machine, to simplification of the piping, to a reduction in the possibility of leakage towards the outside and, last but not least, to the convergence of functions (and hence of any problems) in a single nucleus recognized as the first element to be diagnosed in case of faults.

We shall now see in detail which basic functions must be included in a control valve for mini-excavators, which are the special functions which can be integrated inside a control valve and what is the state of the art of the market.

Basic functions

In most cases, a control valve for mini-excavators controls 9 functions, and makes use of a three-pump hydraulic system, which can be gear based, piston based or a combination of both. These functions are as follows:

- 1) Shift to the right
- 2) Rotation
- 3) Angle of the dipperstick
- 4) Blade
- 5) Preboom
- 6) Dipperstick
- 7) Bucket
- 8) Auxiliary
- 9) Shift to the left

The quality of the machines currently on the market forces the manufacturer to heavily optimise the control of all these functions: the manufacturer hands this task over to the supplier of the unit, helping to assess the results. It is the latter who, on the basis of his experience and taking into account the customer's requests, will develop the stems and hydraulic circuit (we do not want to open a technical discussion on the operation of control valves, but we would like to remind the reader that the hydraulic cylinders are driven by spools which move inside the various banks and establish how the oil handles the functions). Fine tuning however is preceded by a definition of the hydraulic circuit in order to decide

which functions the machine must be provided with and the kind of drive this function must have (manual or hydraulic).

As we can see, the basic configuration of a control valve is quite simple in terms of functions; however this is something which is quite hard to find on the market, except on machines which have passed their prime and need to be updated.

Special functions

These include all the functions involving special operations the manufacturer needs, or auxiliary functions required to improve the performance of the machine. Following is a detailed analysis:

- 1) Doubling of the flow rate on the preboom: used to increase the upward speed, this requires the addition of an extra bank. It can be added inside the control valve (the most sophisticated solution) or else outside, employing the lay-out of the pipes.
- 2) Doubling of the flow rate on the dipperstick: used in this case too in order to increase the speed. It can be applied both when closing and when opening the dipperstick. In this case too, an extra bank must be provided. It can be applied either outside or inside: an especially sophisticated solution calls for cutting off the doubling when a certain pressure is reached, through an auxiliary circuit inside the control valve.
- 3) Regenerating circuit: this too has the purpose of

increasing the digging speed of the dipperstick, but only with a closing function (supplying the bottom). This avoids the use of the extra bank as provided for under the previous item, and helps increase speed by about 70 % (the speed of regeneration can be changed on demand by the customer).

4) Straight shift: this allows the machine to move along a straight line even while other functions are being activated at the same time. This is especially useful during laying operations.

5) Lock valve on the preboom with the stem in idle position: this makes it possible to cut down leakage during descent of the preboom to 1 cc/min. Medium sized machines can in certain cases also be used as loaders, so it will be of basic importance in these cases to cut down the load.

6) Automatic reduction of engine revs to a minimum: a signal line inside the control valve controls the electronic accelerator which brings the engine to a minimum number of revs when the spools are in an idle position. As soon as one of them is moved, even by a very small distance, the closure of the signal will raise the running speed to the pre-set value.

7) Priority of the preboom: if the preboom and the bucket are activated simultaneously, this will grant the movement of the preboom priority over the movement of the bucket, so the movements take place simultaneously.

8) Automatic relief of the pumps P1 and P2 (feeding both shifts). This way any unintentional activation of any function associated with these two pumps will be ineffective.

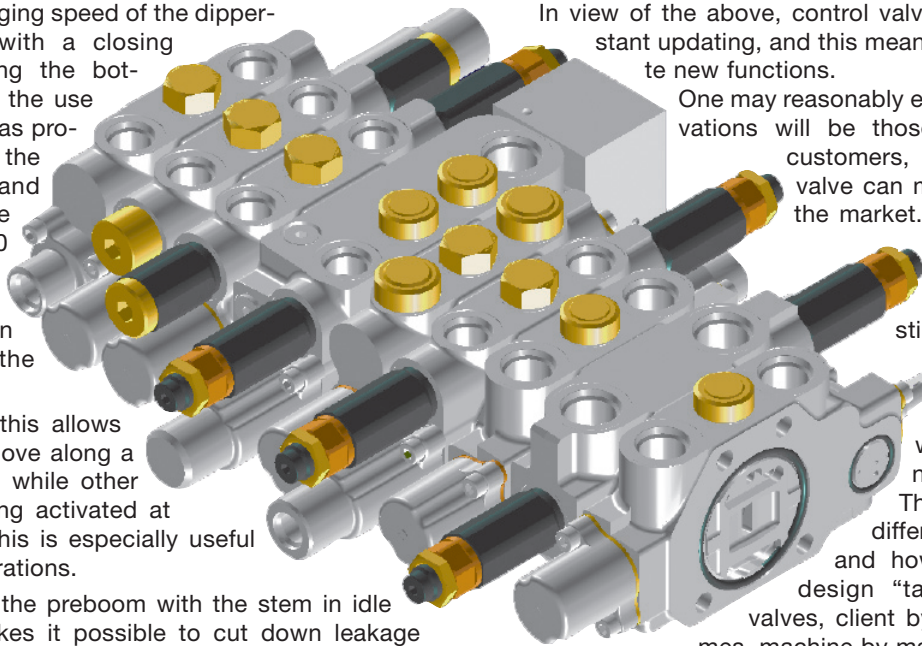
These functions, which we have called special, were initially applied on medium sized machines; however, at present these functions are being moved towards smaller sized machines.

State of the art

The current situation of the market reveals a certain unevenness in terms of the functions present on the machines.

While Japanese OEMs tend to use many of the solutions described above on their machines, European OEMs seem to concentrate more on designing more "cost-effective" machines featuring a more rational use of the functions of the latest generation, used only where they are really needed.

The major battle which is going on now on the marketplace, and which involves machines weighing between 1.5 tons and 3.5 tons, leads of course to the need for an excellent quality/price ratio which cannot be achieved using functions which would not only have a considerable intrinsic cost but would in certain cases require equally expensive auxiliary accessories (electronic accelerators, pressure switches, etc.).



In view of the above, control valves will undergo constant updating, and this means they will incorporate new functions.

One may reasonably expect that such innovations will be those requested by the customers, so that the control valve can meet the demands of the market. What makes it difficult, is that some OEM's consider some characteristics fundamental, and strongly recommend their introduction, other OEMs, just want to reduce the number of functions. This demonstrates how different the OEMs can be and how important it is to design "tailor made" control valves, client by client and, sometimes, machine by machine.

Future developments

Since the market for mini-excavators is very dynamic and constantly changing, an analysis of this segment must include some considerations about its future.

The main discussion concerns the use of open centre vs closed centre control valves. Currently, nearly all valves in the mini-excavator range are open centre, and we feel that things will stay the same during the next generation.

Load Sensing systems are however being increasingly used along the line dividing mini-excavators from mid-excavators (5/6 tons).

Technical advantages deriving from the use of Load Sensing systems on machines measuring up to 4/5 tons are not very interesting: it is easy to show that such a solution costs more; indeed, there seem to be more commercial than technical reasons behind its application.

Often, what some people may see as good reasons for using closed centre systems turn out to be disadvantages for others.

The main advantage of Load Sensing systems is to be found in the better – or rather smoother – control of various functions: the system of internal compensators which divides the oil according to the actual working flow rate of the utilities ensures that every function is always provided with a minimum quantity of oil, preventing any movement from coming to a stop.

No comparison between open centre control valves and Load Sensing control valves (equipped with anti-saturation) can avoid an analysis of the heat balance equation: whatever some may claim, this in most cases is favourable to an open centre solution, because of less heat dissipation in the pump/control valve system.

Actually, the most modern control valves for open centre mini-excavators are highly controllable; so much so that they compete seriously with the qualities of closed centre systems: these imply high costs both in terms of the pump and the control valve.

Another system which is meeting with more and more success on medium/large machines (it is hard to say whether it will also be used on smaller machines) is the so-called "Negative control".

At present, this system enjoys a certain level of application on quite large machines (10/12 tons), but if we want to explore every aspect of the issue, it is only fair to consider it among possible future control systems for smaller machines as well.

Discussion about the actual need to use Load Sensing systems on small machines is not over, and if we consider the quantity of machines which this system currently employs, open centre control valves hardly seem to be something to worry about for the future.

Moreover, there seems to be an objective limitation to the use of Load Sensing control valves on small machines, due to the fact that below a certain size, any benefit due to greater controllability disappears, since the excavator due to its light weight presents no such problem. It remains to be seen whether the manufacturer – in view of commercial reasons or other considerations, – will find it useful to apply the same philosophy already used on heavy machines to lighter ones as well.