Product Introduction

Development of Control Valve for Wood-Splitting Machine

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1 Introduction

KYB Engineering & Service Co., Ltd delivers hydraulic equipment products including agricultural machinery and construction equipment to many different customers.

The company was requested by HONDA-WALK CO., LTD., which imports and sells wood-splitting machines, to offer a hydraulic system for a new wood-splitting machine to be developed.

To set up the specifications of the hydraulic system, both companies began joint survey and measurement of the existing wood splitting machines.

Prior to describing the control valve, the following explains wood-splitting machines.

2 Wood-Splitting Machines

General wood-splitting machines have a power source to move a splitter blade or log so as to split it into smaller pieces. Wood-splitting machines can be divided into stationary and portable types (Photo 1).

Photo 1 Example of wood-splitting machine
(Source: HONDA-WALK CO.,LTD. Catalog)

The blade of the wood-splitting machine has a tapered shape and is used to literally split a log rather than cut it. The machine is also called a log splitter machine. People throughout time usually swing an axe down onto a log to split it into pieces. This work requires physical strength and skill, which has driven the mechanization of wood splitting work. Currently many different types of wood-splitting machines utilizing gravity, mechanical, electrical or hydraulic power to split wood are manufactured and sold, instead of using an axe by hand.

The target wood-splitting machine in this development project is supposed to be equipped with a hydraulic system that uses an engine to drive a hydraulic pump, controls the hydraulic oil with a control valve, and pushes a blade through a log with a hydraulic cylinder. The machine also has a crawler or tires to enable movability. This configuration is the most popular and sold most.

3 Hydraulic Properties of Wood-Splitting Machines

3.1 2-stage Pumps

A series of work to split a log can be roughly divided into two processes.

The first is a process requiring not so much power.

All that is needed in this process is to move the blade. Travel speed, rather than power, is essential. For this process a low-pressure high-capacity pump is needed.

The second process is to split a log.

This process requires hydraulic power rather than speed. Hydraulic power will be the source of splitting logs. For this process a high-pressure low-capacity pump should be used.

Thus the first speed-oriented process, using a low-pressure high-capacity pump, and the second power-oriented process, using a high-pressure low-capacity pump, should be automatically switched over to implement a wood-splitting machine.

Almost every wood-splitting machines use this switching system to allow log splitting, even with a low output engine in a short time cycle.

3.2 Control Valve Operation

The control valve has the following three operation modes selected by the lever position (Fig. 1).

① Neutral

The lever remains in neutral position until it is operated. The hydraulic oil flows from the hydraulic pump to a tank. The hydraulic cylinder is stopped.

② Pull (Hydraulic cylinder: Expand)

When the lever is pulled, the hydraulic cylinder expands to start splitting the log. When the lever is released, it returns to neutral position and the cylinder comes to a stop.

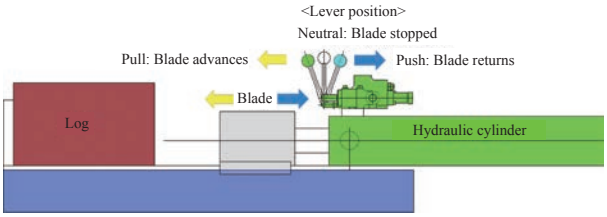

Fig. 1 Lever position and hydraulic cylinder motion

③ Push (Hydraulic cylinder: Contract)

After the log has been split, pushing the lever will fix the lever in the current position. Even if the lever is released, the hydraulic cylinder continues contracting.

During this time, the operator can set up another log. This function is probably used in almost all wood-splitting machines.

Fig. 2 gives the hydraulic circuit diagram including the series of motion above. Fig.3 shows the motion of wood-splitting machines along with pressure and flow rate measurements.

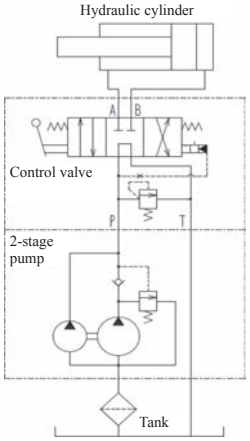

Fig. 2 Hydraulic circuit diagram of wood-splitting machine

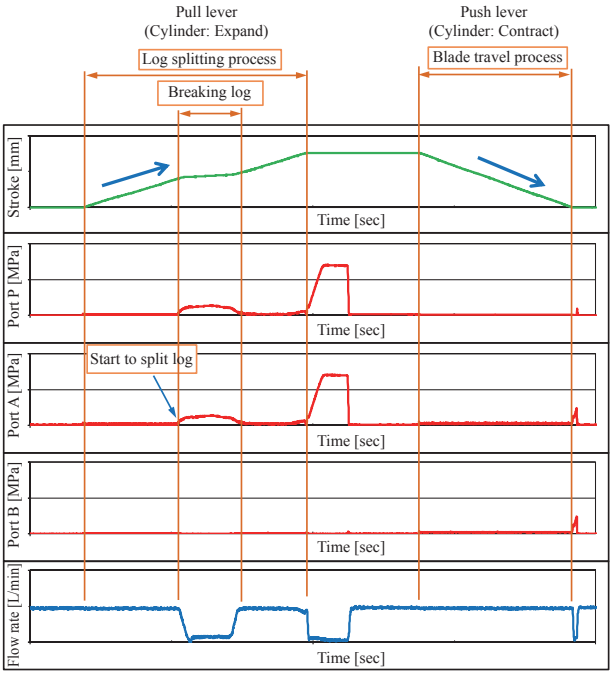

Fig. 3 Wood-splitting machine motion and pressure measurements

4 Development of Control Valve

4.1 Specifications

The control valve specifications (Table 1) were determined based on actual measurement of existing machines as well as customer demands.

The control valve of the wood-splitting machine needs to have the following functions:

Table 1 Control valve specifications

Item	Specifications
Maximum operating pressure	20.6MPa
Service flow rate	30L/min
Allowable back pressure	1.5MPa
Relief valve pressure setting	20.6MPa at 6.5L/min
Hydraulic oil	Oil equivalent to ISO VG32
Oil temperature range	-20°C to 80°C
Cylinder port leakage	6 to 60 cm^3/min at 6.9MPa
Product mass	4.5kgf

① Neutral: P-T open
② Pull: Spring return
③ Push: Holding by detent mechanism
These functions have been already described in section 3.2.
④ Push: Auto return upon full stroke

The auto return function refers to a mechanism that, when the cylinder has gone through a full stroke, automatically returns the lever to neutral position with a higher pump pressure. This mechanism had never been implemented with traditional technology and has been successfully developed by making use of the pressure receiving area of the spool. Note that the lever and relief valve share proven parts to ensure higher reliability and lower cost, reducing the number of new parts to be introduced.

4.2 Improvements after Prototype Test

(1) Increasing the holding force of the detent mechanism

For the conventional design, the spool was fixed with the detent mechanism to hold the lever position during the contraction stroke of the hydraulic cylinder. However, the spool accidentally returned to neutral position. This problem occurred because the detent mechanism could only provide a weak holding force and was released at a low pressure. To solve the problem, the spool diameter was changed to diminish the difference in area between the sections. The spool length was also changed to be compatible with standard parts and seals. In addition, the groove angle and spring force were increased to raise the holding force, eventually satisfying the target (Fig. 4).

(2) Reducing the lever operating force

Operator was likely to be tired from continual lever manipulation with the existing machine. Then the development team tried to reduce the lever operating force from the existing level. To prevent return failures, the return spring load has been reduced as far as possible

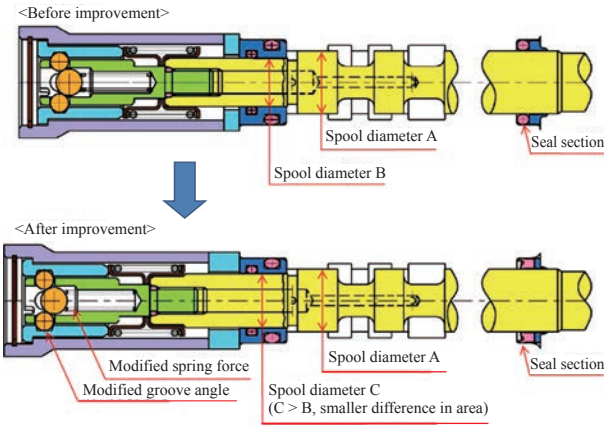

Fig. 4 Higher holding force of detent mechanism

within the range of the operating conditions.

(3) Durability of the seal section

The seal section externally leaked during the operation durability test. It was revealed that the detent mechanism returned from the holding state to neutral too quickly due to poor seal performance. Therefore the seal has been replaced with one with good following performance, satisfying the durability target (Fig. 5).

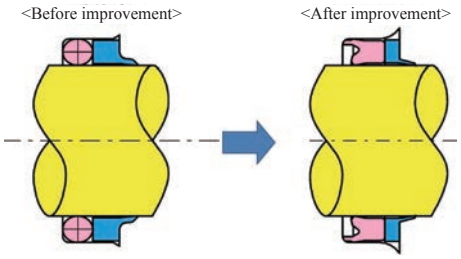

Fig. 5 Seal improvement

4.3 Using a Cast Body

The control valve body was conventionally fabricated by shaving. In the prototyping of the new control valve, the manufacturing method was changed from shaving to casting. The method of mounting the valve body onto the hydraulic cylinder was also changed from conventional screwing to fastening with bolts.

This change reduced the piping part cost and installation fee, and also eliminated oil leakage due to loose screwed-in piping (Fig. 6).

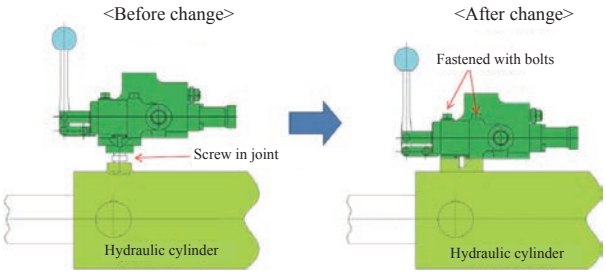

Fig. 6 Valve installation

These improvements have been successfully introduced before the launch of mass production. Photo 2 shows the appearance of the control valve, and Fig. 7 gives the outline drawing.

Photo 2 Appearance of control valve

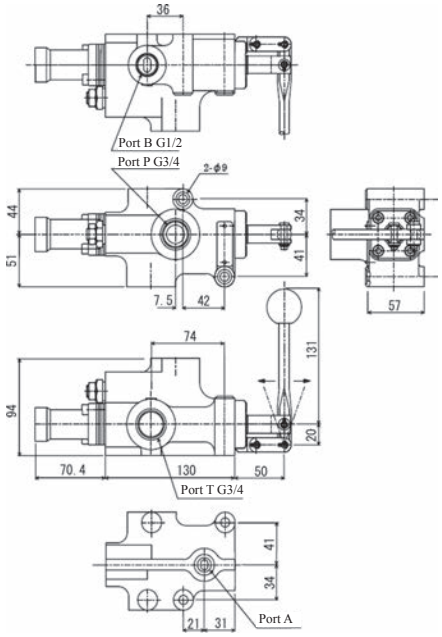

Fig. 7 Outline drawing of control valve

5 Future Development

This section introduces the wood-splitting machine MS4000J jointly developed by HONDA-WALK CO., LTD. and KYB (Table 2, Photo 3).

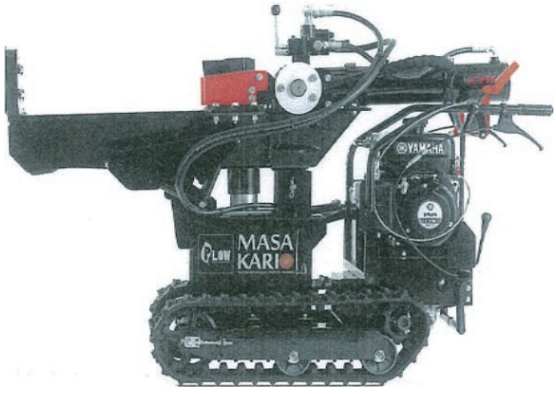

Photo 3 Appearance of wood-splitting machine MS4000J (Source: HONDA-WALK CO.,LTD. Catalog)

Table 2 Major specifications of wood-splitting machine MS4000J (Source: Hondawalk Inc. Catalog)

Major specifications		
Model		MS4000J
Engine	Manufacturer	Yamaha
	Type	Air-cooled four-cycle inclined type OHV gasoline engine
	Engine model	MZ175
	Displacement	171cc
	Fuel tank capacity	4.5 l
	Engine oil capacity	0.6 l
	Plug	NGK BPR4ES
Cylinder thrust		20 ton
Breakdown force		40 ton
Dimensions	Length (horizontal version)	1,850 mm
	Height (horizontal version)	1,150 mm
	Width	690 mm
	Length (vertical version)	1,800 mm
	Height (vertical version)	1,730 mm
Dry mass		310kgf
Hydraulic oil tank capacity		16 l (hydraulic oil #32)
Maximum splittable size		630 mm
Drive		Two forward gears, one backward gear
Cycle time		21 sec (12-sec advance, 9-sec retract)

Following the domestication of imported models, the companies will continue to develop cost-oriented models and those with a modified hydraulic system. Hondawalk plans to use KYB's control valve as a common part of these models.

6 In Closing

Wood-splitting machines equipped with the developed product have just begun to be manufactured and sold.

Experienced wood splitters and purchasers seemed to have various opinions and demands for improving the conventional machine.

I believe Hondawalks would enjoy the benefits from the machine equipped with the developed product in satisfying those demands.

Recently the value of wood as woody biomass has been reconsidered in power generation applications since chips or pellets of woody biomass are more readily burned than firewood. This application definitely requires mass production of chips or pellets. Briquettes produced by solidifying sawdust (artificial firewood) and other woody biomass products have also become available, but seem to be inferior to firewood in cost.

Thus, the demand for wood-splitting machines will probably still continue.

KYB would like to continue developing products satisfying customer demands.

Finally, I would like to take this opportunity to thank those concerned inside and outside KYB who have supported the development of the control valve for wood-splitting machines.

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