

PROPOSAL OF MULTI-FUNCTIONAL MATERIAL HANDLING MACHINE APPLYING HYDRAULIC SYSTEM OF EXCAVATOR

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ABSTRACT

Recently, excavator is used for not only civil engineering but also building demolition, scrap recycling and so on. The reason is thought that it has a general-purpose power supply system and is able to move by itself. In other words, it could be considered a kind of high-powered robot. As a whole, it consists of several modules. Divided roughly by each function, power module such as an engine and pumps, working module such as front structures and hydraulic actuators, traveling module such as crawlers or wheels, operation module such as control levers and pedals. In this time, to gather and carry lots of objectives in scrap yard or somewhere, both a fork grapple and a loader bucket are equipped as a working module. And to carry the objectives quickly to destination, wheeled traveling system is equipped. As a result, we have produced a multi-functional handling machine which has double front attachments and wheels. Then if operators cooperate the modules effectively, they will be able to handle their work more efficiently.

KEY WORDS

Excavator, Hydraulic, Robot, Material, Handling

INTRODUCTION

Recently, excavator is used for not only civil engineering but also building demolition, scrap recycling and so on. For example, Figure 1 shows a car demolisher, which demolishes the body and sorts the parts of scrapped cars. Then the operator is able to control the grapple for the objects delicately because of the control ability of excavator's actuators. I think the reason of the multi use is that it has a general-purpose power supply system and is able to move by itself. In other words, it could be considered a kind of boarding-type high-powered robot.



Figure 1 Car demolisher

As a whole, an excavator consists of several function modules. Divided roughly, power module such as an engine and pumps, working module such as front attachments and hydraulic actuators, traveling module such as crawlers or wheels and operation module such as control levers and pedals. Figure 2 shows the example of the function modules of Hitachi mini excavator Zaxis40UR.

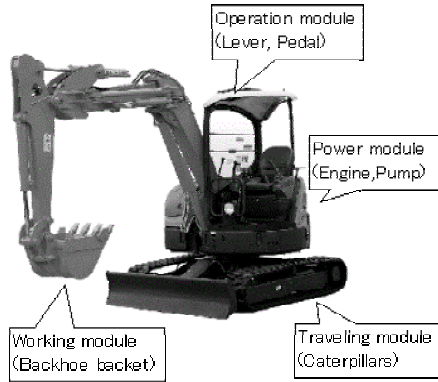


Figure 2 Hitachi mini excavator Zaxis40UR

APPLICATION EXAMPLE

In this time, applying the excavator, we have investigated a multi-functional handling machine, which could gather and carry lots of objects in scrap yards or the other places. For example of works Figure 3 shows the situation of industrial waste yard and Figure 4 shows the situation of disaster area in Sumatra Island.



Figure 3 Industrial waste yard



Figure 4 Disaster area in Sumatra Island (2004)

Usually an excavator and a truck are necessary for the works. Of course, two operators are also necessary at least. So if the works could be done by one machine efficiently, the job efficiency goes up and the energy of machines is saved. Then both a fork grapple and a loader bucket are used to sort and gather the objects. And a wheel traveling system is suitable to carry them quickly to the destination.

SYSTEM OF THE MACHINE

Figure 5 shows a picture of the developed machine. As you guess, the base machine is Zaxis40UR of figure 2. Power module is common with it. But traveling module is changed to wheel type and two different type fronts are used as working modules. Using upper fork grapple, we can do delicate works such as object sorting. And using lower loader bucket and wheel, we can gather and carry them to the destination efficiently.

Table 1 shows the specifications of the machine. The travel speed is not so fast but is enough to travel in a yard. The hydraulic circuit (Figure 6) is based on the load-sensing system of Zaxis40UR. It's easy to add the optional systems by connecting the pressure line in common.

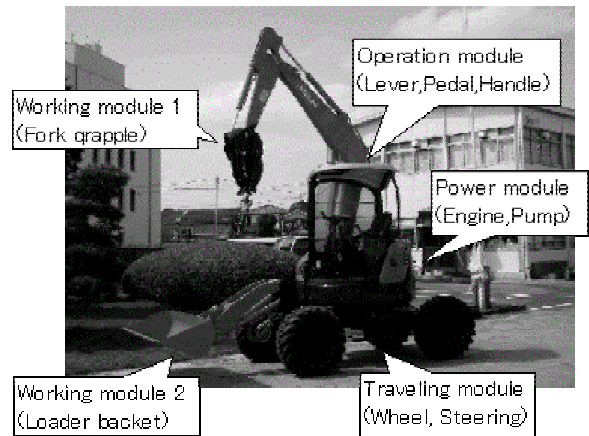


Figure 5 Developed machine

Table 1 Specification of the machine

Item	unit	Value
Machine weight	kg	3957
Engine output	kW	20.6
Travel speed	km/h	10
Weelbase	mm	2000

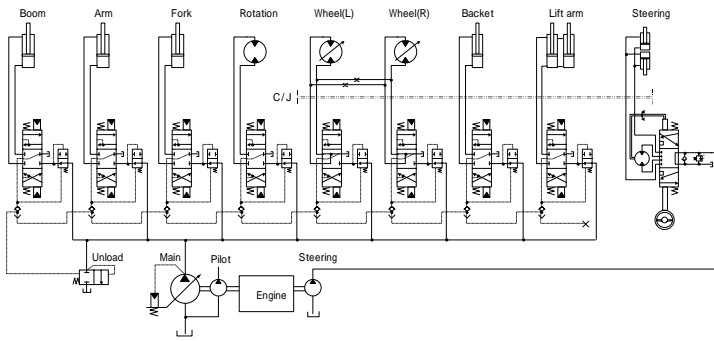


Figure 6 Hydraulic circuit

SPECIFICATION OF MODULES

Front Attachments

Figure 7 shows front working range of the machine. Wide working range is necessary as a backhoe front to deal various objects. And high dumping height is necessary to dump them to a loading platform of truck. Using both fronts like broom and dustpan, we can gather objects efficiently.

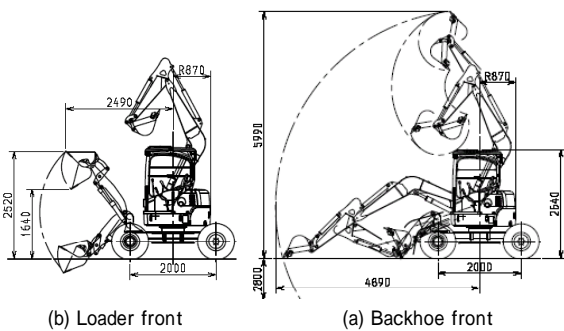


Figure 7 Front working range

Traveling System

The main hydraulic circuit of the wheel system is the same as the original open circuit for crawlers, not using HST system. The reason is to simplify the system and to cut down the cost and term of development. Then the travel performance might be not so high compared with HST. So I planned simulation to certify the performance and investigate the parameters in advance.

Figure 8 shows the simulation model and Table 2 shows the specifications. The counter valance valve is to prevent body falling in slope. The travel feeling depends on the characteristics of valves. So we tuned the size of valve chokes and the set pressure of relief valve by simulation to realize desired acceleration and deceleration feeling. As a result, the acceleration is good and the shock is about under 0.2G (Figure 9). Well, the drift of experiment speed is caused by the indirect calculation with acceleration.

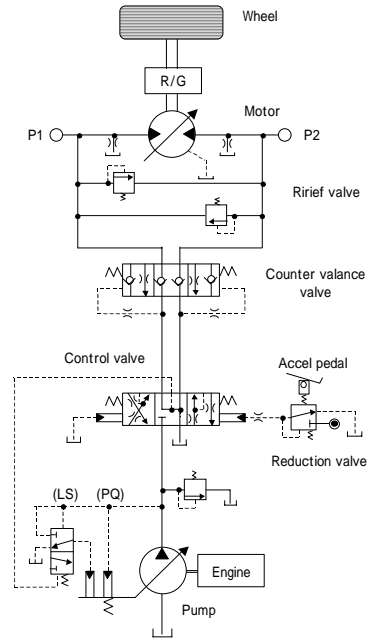


Figure 8 Simulation model of traveling system

Table 2 Specification of traveling system

Item	Unit	Value
Wheel diameter	mm	860
Equivalent inertia	kg·m ²	370
Gear ratio		1/48.636
Motor volume	cm ³	11.6 ~ 18.0
Pump volume	cm ³	8.5 ~ 38
Ririef Pressure	MPa	27
Engine speed	min ⁻¹	1175 ~ 2500

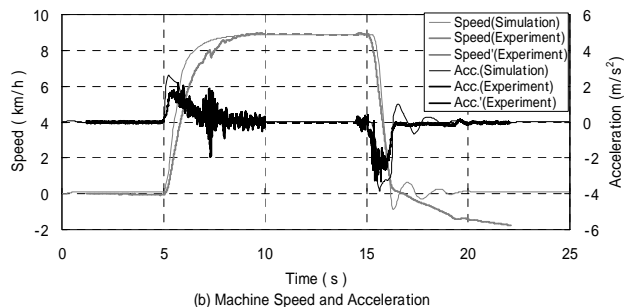
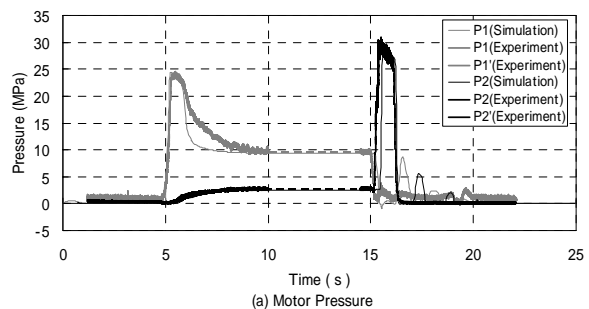


Figure 9 Simulation and experiment result

Operating System

At present we still apply combination of usual operating systems for it (Figure 10). Handle and pedals are used to operate the traveling system. Forward right lever is for Loader bucket. They are the same as usual ones of wheel type machine like a wheel loader. And two levers at seat side are common with excavator's ones.

Figure 11 shows a working situation in industrial waste yard. Professional operators could control this machine very well using the operating system in a few hours. And they didn't complain the control ability especially. But now I think that farther advanced mechatronic system will become necessary for more cooperative motion in the future [1]. For example figure 12 shows master-slave control system of excavator, which was developed several years ago and called one-lever system by us [2]. Usually this technology is used to control manipulators [3].

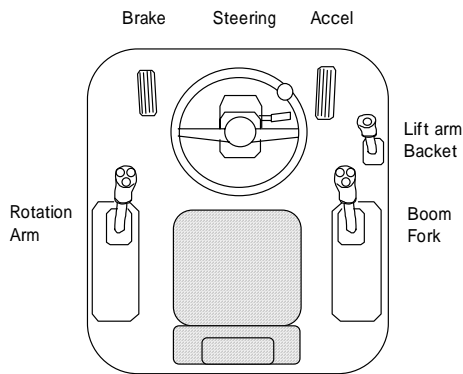


Figure 10 Operating system



Figure 12 One-lever system



(a) Sorting



(b) Traveling



(c) Dumping

Figure 11 Example of working situation

CONCLUSION

Now we proposed a multi-functional handling machine as a kind of high-powered robot. The feature is the working ability by double front attachments and the mobility by wheel traveling system. From now on such multi-functional machines will be developed more and more with low cost and high reliability, applying the hydraulic system of excavators.

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