Improvement of a processor and forwarders for collecting logging residues

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Abstract:
In Japan, bulk logging residues might be unutilized as a biomass resources and the collection and transportation of this resource is a major issue. Although a specialized biomass machine may not be worthwhile from a cost perspective, a combined machine should be, hence the forestry machines were improved and the logging residues collected. Processor-mounted excavators are frequently used in our country, but due to their higher productivity, have the longest waiting time, hence equipment to cut up the voluminous tops and branches was added. Using the waiting time after cutting the logs, these pieces were chopped and dropped into flexible containers, to facilitate drying and transportation. Conversely, forwarders with rubber crawlers are also popular, but although better for transporting round wood, they are less suitable for voluminous logging residues due to the limited loading space, hence the addition of equipment to expand the loading space and compress the loaded residues.

Keywords: logging residues, improvement, processor, forwarder

1 Introduction

In Japan, many energy plants have already been constructed to utilize woody biomass. Although almost all wood residue from construction and sawmills is used there, a significant volume of unused logging residue may still remain. To promote the utilization of logging residue as a biomass resource, a high-productivity and low-cost harvesting system for logging residues must be developed, and collecting round wood and logging residues simultaneously should be practical, considering the machine and labor costs. A harvesting system for round wood commonly used in steep trains in Japan is a cut-to-length system using a strip road network; felling by chainsaw, prehauling by a grapple loader with winch, processing by processor and forwarding by forwarder. Accordingly, a significant volume of logging residue is widely spread across the harvesting sites near the roads. The bulk density of logging residues is much lower than that of round wood, due to their form and quality. To collect efficiently and facilitate handling, the logging residues must be converted, but drying logging residues chipped in humid Japan is likely to be difficult. Although introducing a specialized machine for biomass such as a bundling machine might

resolve this issue, the harvesting cost is likely to be higher, while arranging many such machines on narrow strip roads is also difficult. In our other study, the bulk density and productivity of collecting logging residues was increased by crushing them roughly with a wood cutter (Yoshida *et.al*, 2011). Therefore, although a specialized machine for biomass may not be suitable, a combined machine should be, and for collecting logging residues we attempted to improve the forestry machines using today. The number of processors and forwarders peaked; 1,238 processors and 1,083 forwarders in 2009, accounting for almost half the total forestry machines in Japan, and these machines were intended for the improvement.

2 Processor

Processor-mounted excavators are frequently used in Japan and have longer waiting times than other machines, due to their higher productivity. Equipment to cut up the voluminous tops and branches with knives was added. Using the waiting time after cutting logs, these pieces were chopped and dropped into flexible and breathable containers as part of the development in our other study (Iwaoka *et al*., 2010), whereupon drying and transportation to energy plants are likely to be facilitated.

2.1 Specification

Figure 1 shows the improved processor and the cutting surface of a top. This processor head had a hydraulic excavator mounted, and was operated on a narrow strip road. Figure 2 shows the appearance of this processor head. To chop and hold tops and branches, the equipment included two knives, a telescopic boom and a grapple, with safety shields added to prevent dropping branches. Table 1 shows the specification of this processor head. Although it does not rotate through a full 360 degrees, it can be tilted between -35 to 75 degrees, and increases in weight by about 300 kg. Figure 3 shows an operating cycle for chopping tops and branches. Initially, this machine holds the top by the tongues, and chops using knives. Next the tongues open and release it, and close and hold it again after the boom lengthens and pulls it. Finally, the grapples open and release it, whereupon the boom shortens. A patent has been applied for this processor in Japan (patent application laid-open disclosure number 2011-130713).

Figure 1: Processor with chopping equipment and the cutting surface of a top

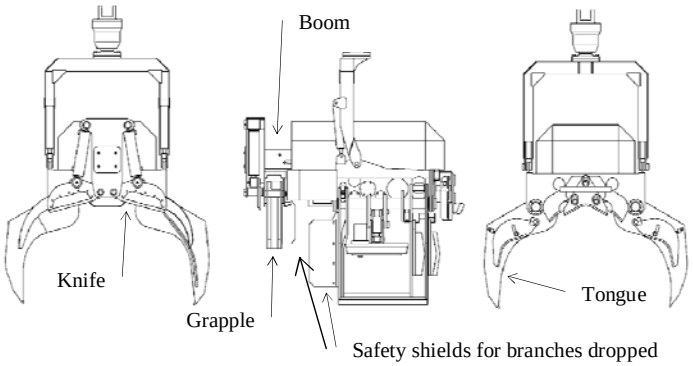

Figure 2: Appearance of the processor head

Table 1: Specification of the processor heads

	Improved head	**Base head (Nansei Machine CM-40ZN)**
Weight (kg)	1,200	900
Dimensions (mm)	1,653×1,000×1,766	1,350×1,000×1,220
Circling	Limited (< 360 degrees)	Full
Tilting	-35 to 75 degrees	None
Maximum cutting diameter (cm)	48	48
Maximum opening tongues (mm)	1,270	1,270
Maximum feeding diameter (cm)	3～35	3～35
Based hydraulic shovel	Caterpillar 314CCR	Bucket capacity over 0.45m^3

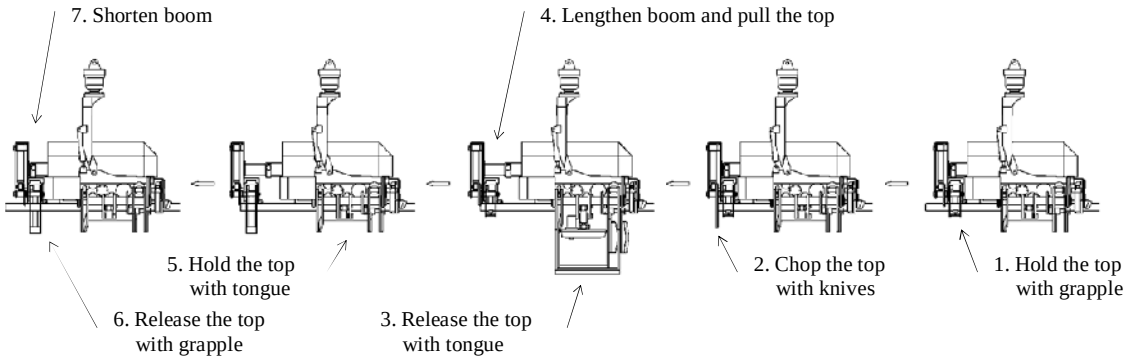

Figure 3: Chopping operation cycle

2.2 Performance

The telescopic boom can be extended to a maximum 30 cm, altered between 10 and 30 cm, and chop over 30 cm by repeatedly lengthening and shortening the boom. This machine can also chop tops at set lengths such as 10, 15, 20, 30 and 40 cm. The maximum diameters of tops chopped were up to 17cm for sugi (*Cryptomeria japonica*) and 16 cm for hinoki (*Chamaecyparis obtuse*) (see Figure 1).

3 Forwarder

Forwarders with rubber crawler are also frequently used in Japan. This machine is better for transporting round wood, but less so for transporting voluminous logging residues due to its limited loading space, hence the addition of equipment to expand the loading space and compress the laden residues.

3.1 Specification

Figure 4 shows the forwarder improved by expanding and dumping the loading space (type 1), and the grapple crane type (type 2). The telescopic length of the crane (Cranab FC45DT) is 8m. Figure 5 shows the appearance of the forwarder of type 1, while figure 6 shows type 2. Table 2 shows the specification of the forwarders for types 1 and 2. The loading widths of both types can be extended by up to 800 mm on each side, whereupon the loading volumes can expand over three times around 20 m^3. The objective bulk density is 0.3 t-wet/m^3, which is the density of a bundle made by a bundling machine.

Figure 4: Forwarders with compression equipment (right; type 1, left; type 2)

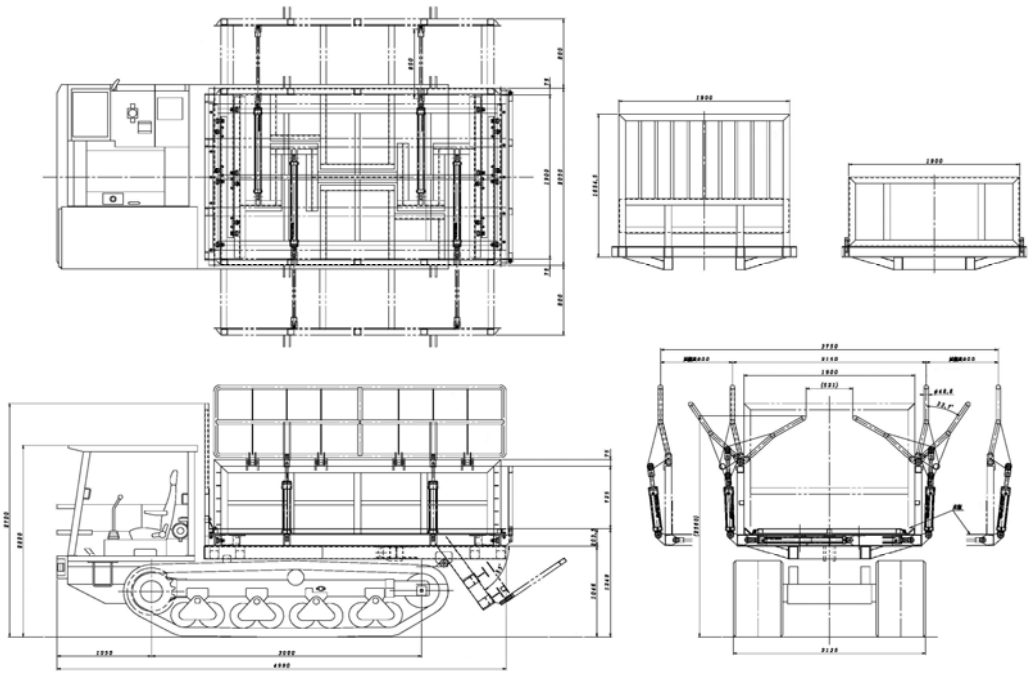

Figure 5: Appearance of the forwarder for type 1

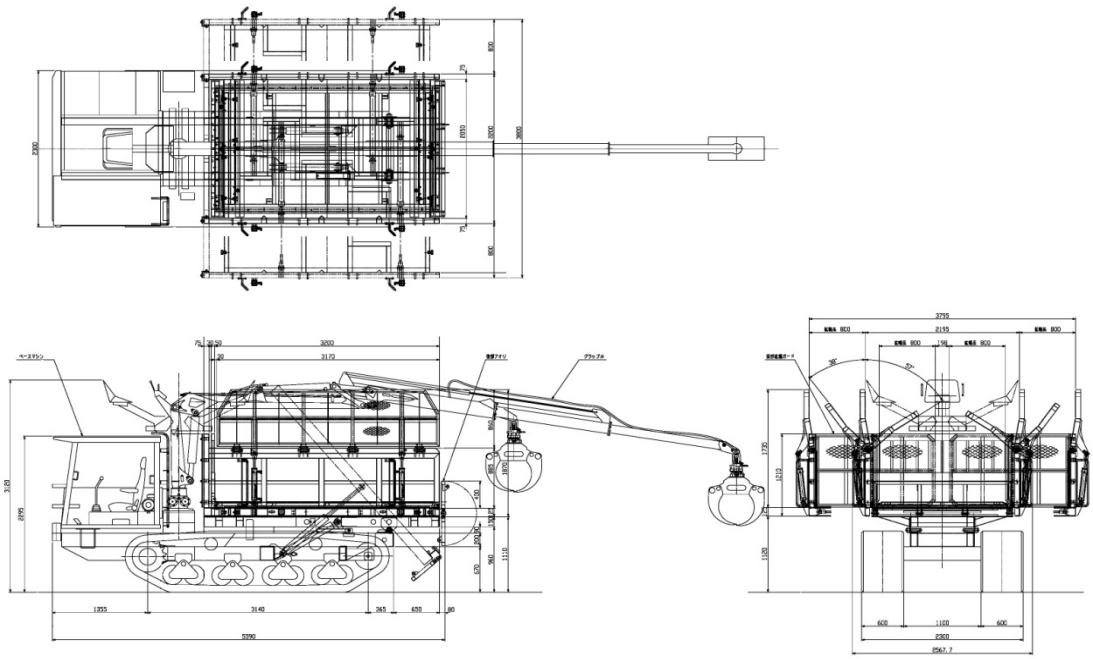

Figure 6: Appearance of the forwarder for type 2

Table 2: Specifications of the forwarders

		Type 1	Type 2
Base machine		MST-650VDL	MST-800VDL
Weight	(kg)	7,420	9,700
Declared power	(kw/min^{-1})	66.2/2100 (90PS)	81.0/2200 (110PS)
Length	(mm)	5,043	5,590
Width	(mm)	2,418	2,568
Height	(mm)	2,700	2,980
Loading space length	(mm)	3,280	3,200
Loading space width	(mm)	1,900	2,050
Loading space width expanded	(mm)	800	800
Loading space height			
Front wall	(mm)	1,650	1,220
Side wall	(mm)	800	800
Rear wall	(mm)	900	400
Loading space volume expanded	(m^3)	19.15	20.26

3.2 Performance

Figure 7 shows the weight when loaded with branches only, and branches and short logs cut of hinoki for type 2. “Usual load” means loading with the height of the side wall expanded, and “Full load” means maximum loading over the side wall expanded, while leaving the drive untouched. This forwarder could load about 2 t-wet by once expanding and compressing logging residues, and a maximum of near 4 t-wet by increasing the number of compressions. Moreover, the loading weights of branches and short logs were higher than that of only branches.

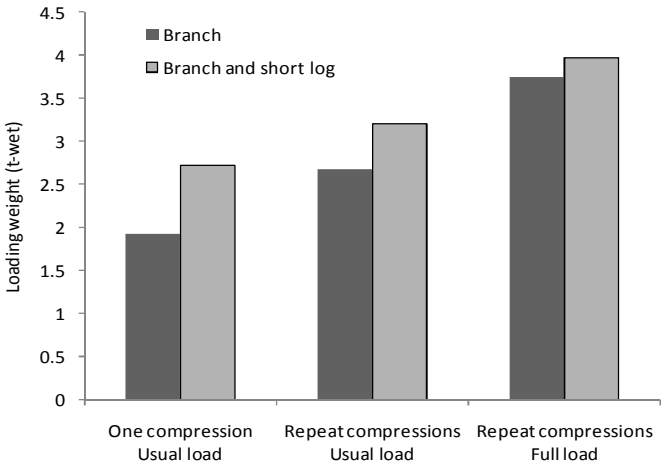

Figure 7: Loading weight for type 2

Figure 8 shows the bulk density for types 1 and 2, both of which also rose, increasing the number of compressions, and that of branches and short logs exceeded that of only branches. The density for each type peaked at about 0.15 t-dry/m3, with branches and short logs compressed repeatedly, allowing us to meet the objective density as the water content was 100% on a dry basis.

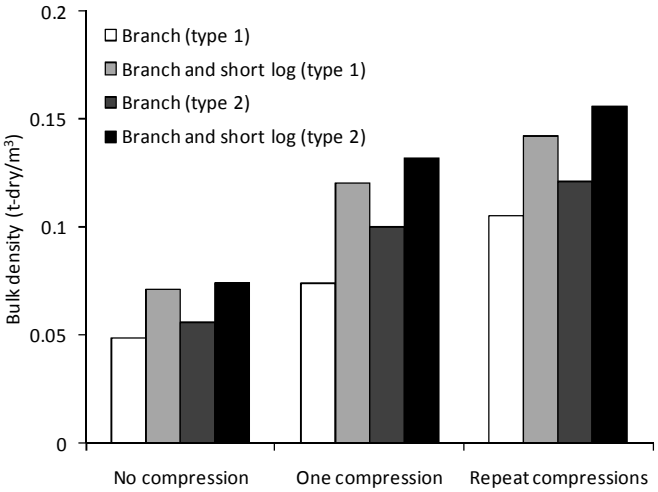

Figure 8: Bulk density for types 1 and 2

4 Discussion

In this report, the processor and forwarders were improved for collecting logging residues, and the specification and performance for these machines were shown. The productivity and cost of collecting both round wood and residues must be researched in actual operating sites, and a total harvesting system developed.

5 References

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