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DESIGN CONSIDERATIONS FOR A ROLL CRUSHER/
SPLITTER FOR WOODY BIOMASS

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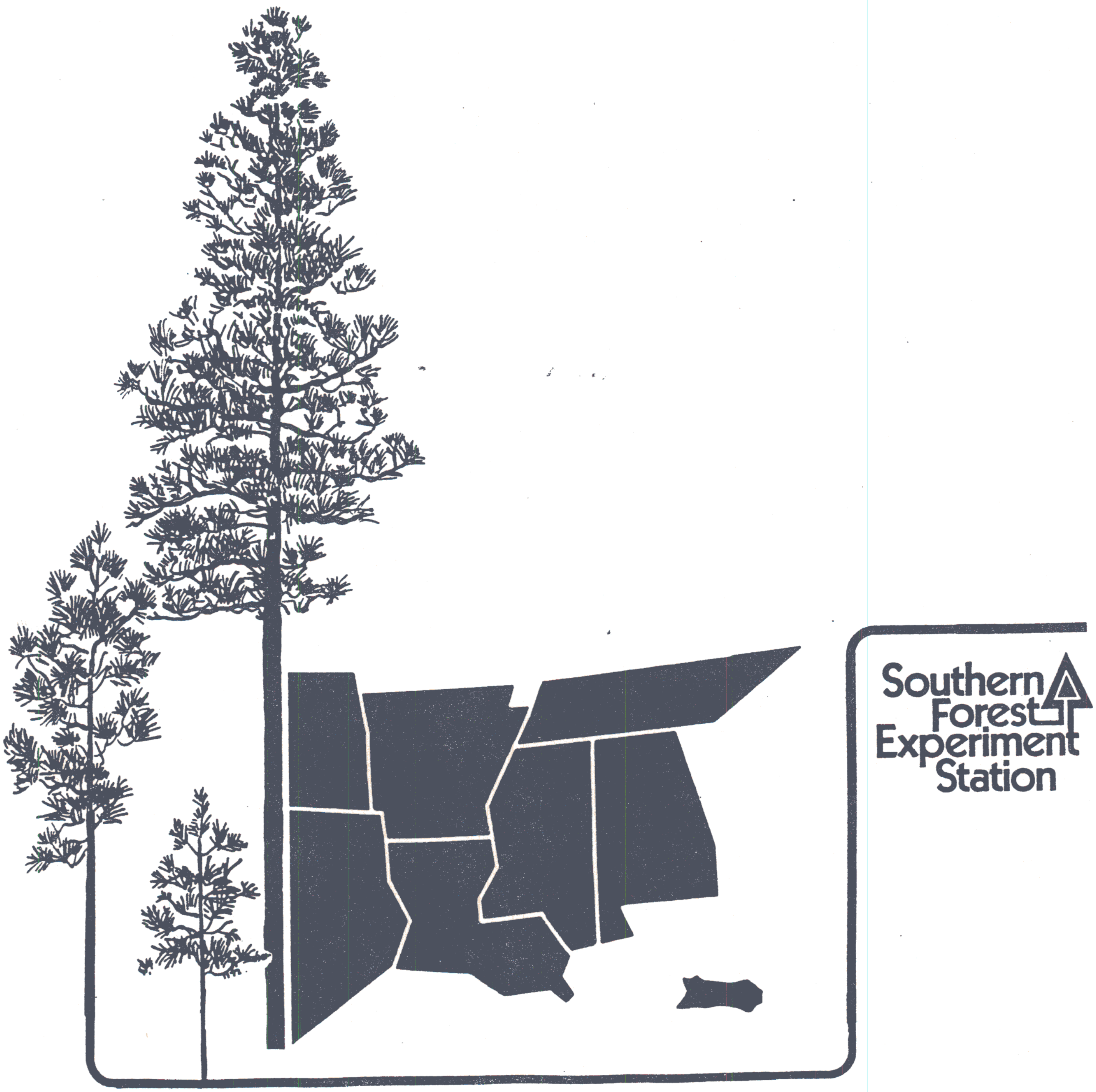

DESIGN CONSIDERATIONS FOR A ROLL CRUSHER/SPLITTER FOR WOODY BIOMASS

DONALD L. SIROIS and COLIN ASHMORE[1/]

INTRODUCTION

The principal focus of biomass harvesting in the past has been the use of chipping systems to reduce a wide variety of woody materials down to small pieces for easier handling and transporting. However, chipping systems have several short comings that limit their operational environments. For example, a conventional chipping system might not be applicable for harvesting small diameter trees growing in powerline rights-of-ways and energy wood plantations.

An alternative to conventional methods of harvesting small diameter trees for energy use is roll crushing/splitting (Du Sault 1984, Barnett and Sirois 1985, and Barnett et al. 1985). The concept involves the crushing and splitting of small diameter stems to expedite field drying and to facilitate handling by producing a uniform material for baling or modulating (fig. 1). Jenkins (1983) reports on several concepts for modulating agricultural biomass in California. Fridley and Burkhardt (1984) showed that a modified round-bale hay baler would bale small diameter forest biomass to a density of 8.8 to 20.7 lb/ft^3. The bales had good integrity and were easily handled.

Jones (1982) reported on the development of a test bench machine used for crushing and splitting trees. Jones designed a prototype machine for the Forest Engineering Research Institute of Canada (FERIC) to demonstrate the crushing and splitting of forest biomass under Canadian conditions. The Southern Forest Experiment Station acquired FERIC's roll crusher/splitter to determine horsepower requirements; operating restraints; and efficiencies of different roll designs; and to compare drying efficiencies between crushed and whole tree biomass typical of the Southern United States. The design considerations determined from these tests are discussed.

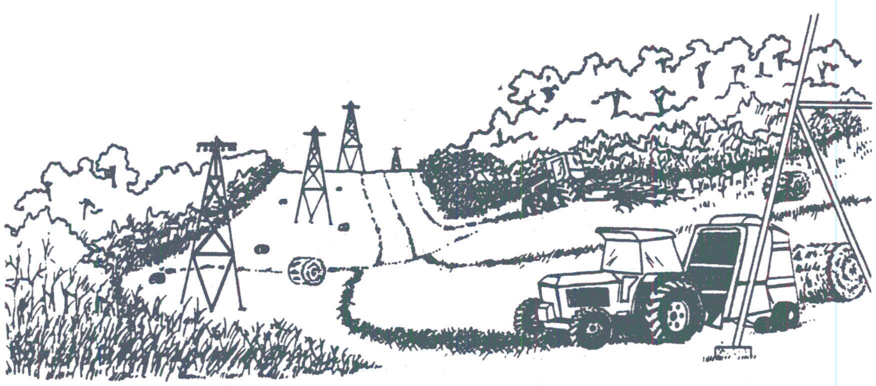

Figure 1. Conceptual crusher/splitter biomass harvesting system.

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DESCRIPTION OF MACHINE

The test bench roll crusher/splitter (fig. 2) consists of two sets of 20-inch diameter steel rolls mounted in two vertical, fixed stanchions. A 175 Hp, gasoline engine furnishes power to 3 hydraulic pumps. Two separate hydraulic motors, with speed-reducing gear drives, power the bottom roll of each set. Crushing or compression force is provided by four hydraulic cylinders (4-inch diameter) mounted on the movable upper rolls of each set. The upper rolls can be manipulated up and down, and the compression force is controlled using the hydraulic cylinders and relief valves. The vertical set of rolls that first feed the material are termed herein as the primary rolls; and the second set, the secondary rolls. The control valves on the test bench are designed to control hydraulic flow and pressure to each set of rolls and to the hydraulic cylinders.

DESIGN CONSIDERATIONS

Four different roll surface designs were evaluated on the test bench roll crusher/splitter to determine feeding and crushing efficiencies. The designs considered were (1) serrated bars, (2) spikes, (3) a combination of serrated and smooth-angled bars, and (4) tapered, angle-edged bars. For each design, different gap settings for the primary and secondary rolls were tested at two hydraulic cylinder pressures on the primary crush roll to determine their ability to crush and/or feed tree bolts. Seven different diameter classes 1-7 inches) and two southern species, loblolly pine (*Pinus taeda*) and sweetgum (*Liquidambar styraciflua*), were used for the tests. The results of the test combinations showed that a 1/2-inch primary roll gap and a 500-psi cylinder compression pressure, combined with a 1-inch secondary roll gap, allowed the greatest range of material to feed through the system. A roll design with a combination of serrated and smooth-angled bars was the best overall feed roll surface (fig. 3).

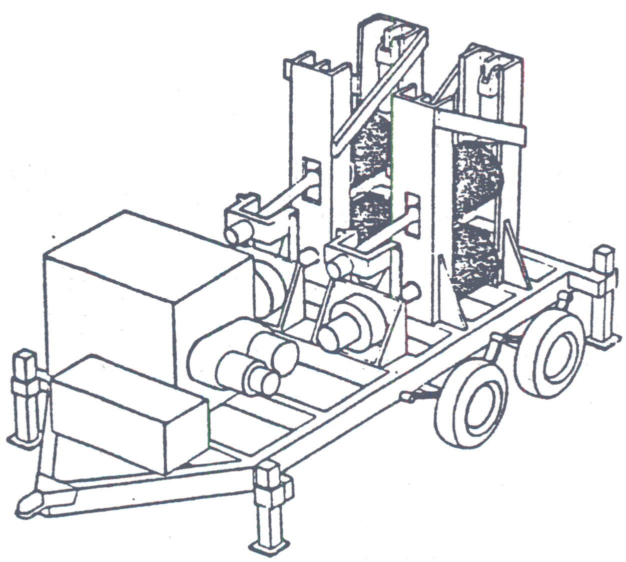

Figure 2. Test bench crusher/splitter (Du Sault 1984).

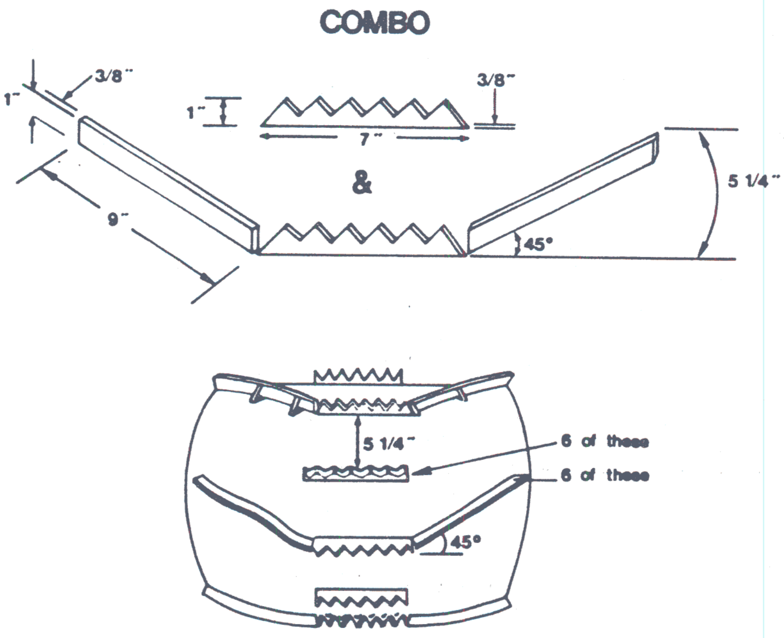

Figure 3. Best overall feed roll surface.

Splitting (producing the greatest number strands), not crushing (changing the cross section diameter), has the greatest effect on increasing rate of wood moisture loss. However, the higher degrees of splitting also provides the greatest opportunity for moisture uptake for material drying in the field subjected to rain and high relative humidities.

The test bench machine was instrumented to obtain hydraulic pressures and flow rates for the determination of horsepower requirements. For these tests, seven different diameter classes (1-7 inches) and four southern species, loblolly pine (Pinus taeda), sweetgum (Liquidambar styraciflua), hybrid poplar, and oak (Quercus spp.) were used. Good correlation was found between the primary roll horsepower and stem diameter for the four species. For example, Figure 4 shows a comparison between the actual data and the regressed horsepower for loblolly pine plotted against diameter for the primary roll. The same trends were not true for the secondary roll, probably because the original diameter was destroyed by the primary set of rolls. Figure 5 shows the regressed lines of total horsepower (primary horsepower and secondary horsepower) versus diameter for the four species tested. This graph indicates that minimal power is required to crush and split small diameter biomass.

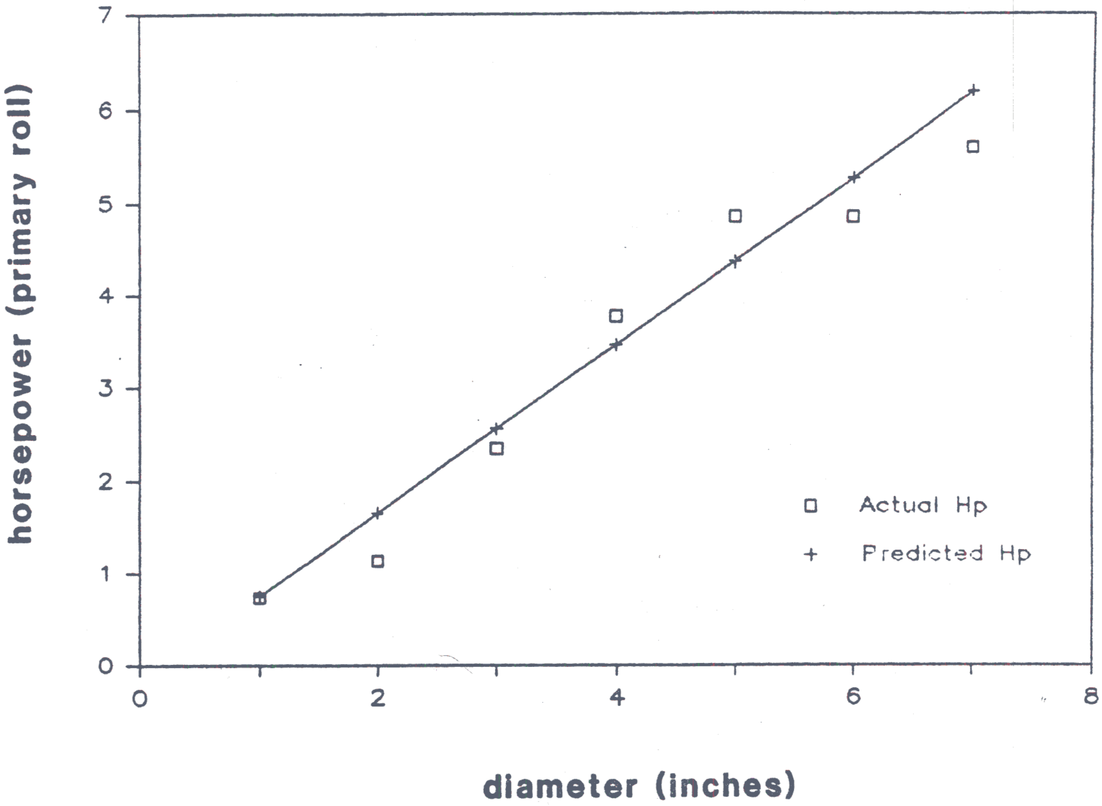

Figure 4. Primary roll horsepower versus diameter (loblolly pine).

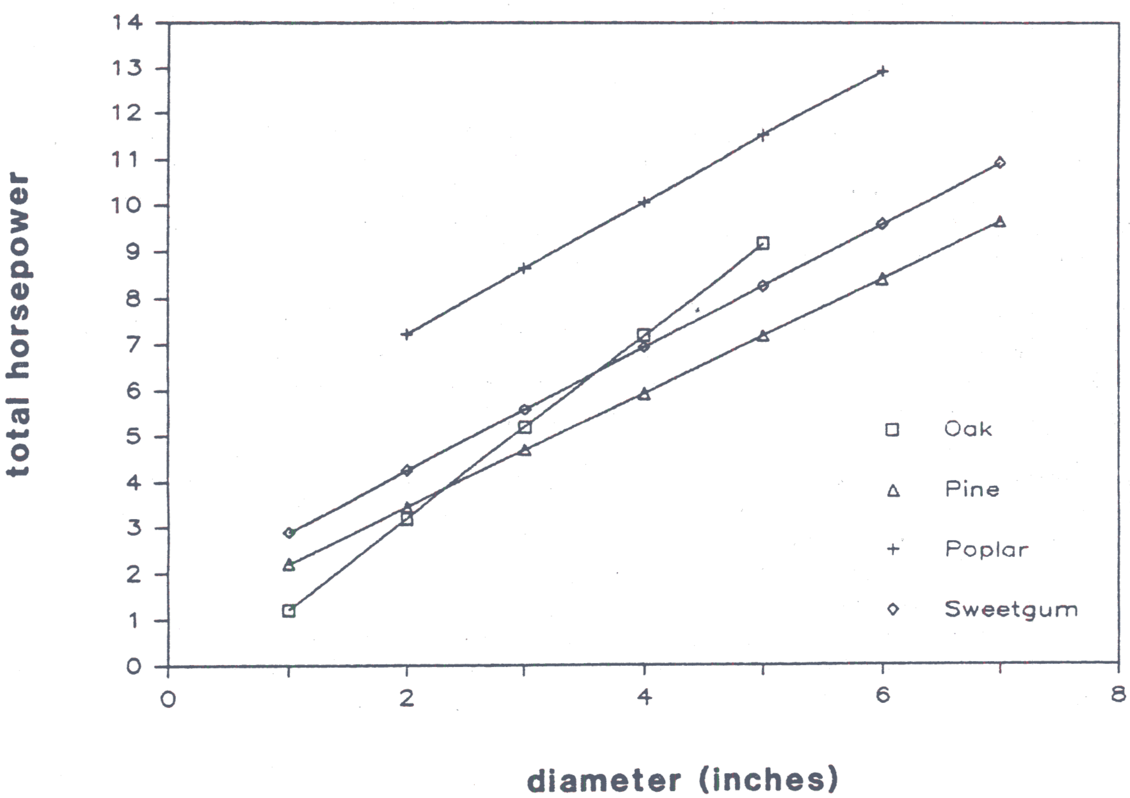

Figure 5. Total horsepower versus diameter for the four species tested.

SUMMARY

Although all factors have not been considered in this abstract, the principal design considerations indicate:

1) That with proper roll surface designs, forest biomass will self feed through a set of crush/split rolls.

2) Narrow gaps can be used between a vertical set of rolls to provide a high degree of crushing/splitting.

3) Horsepower requirements are relatively low, increasing the potential for adapting the roll crusher/splitter concept to a mobile biomass harvester for reducing field moisture levels of biomass fuels.

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