Whole tree transportation system for timber processing depots

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Abstract

The growing demand for alternative energy has led those who are interested in producing sustainable energy from renewable timber to devise new concepts to satisfy those demands. The concept of timber processing depots, where whole stem trees will be delivered for future processing into wood products and high quality energy fuel, has led to the re-evaluation of our current timber transportation method and whether it can viably transport unprocessed trees in an efficient, legal and safe manner. Modifications for log trailers will be developed to accommodate tree length, unprocessed southern yellow pine. Consideration of criteria such as modification weight, load force analysis, ease of attachment and detachment, and overall feasibility will determine which of the two trailer modification designs will be chosen for payload capacity utilization testing. The first design is a swinging guide design and the second is an extendable bolster design. These designs ensure that tree crowns are contained within the trailer to prevent contact with and damage to other vehicles while in transport. Furthermore, three different loading arrangements will be tested on the modified trailer to determine which configuration maximizes the payload while remaining legal to transport timber according to the laws and regulations of 11 states in the southeastern United States. These payload capacity utilization rates will be compared to the rate of an unmodified log trailer loaded with tree length, unprocessed southern yellow pine. We hypothesize that the modified trailer with a standard loading configuration will optimize and increase the payload over the unmodified trailer.

Keywords: Biomass Transportation, Harvesting

Introduction

There has been controversy in recent decades in the United States about our country's energy production from the consumption of fossil fuels and whether we should pursue alternative forms of energy production via renewable resources. Whether the citizens of the United States will choose to fully adopt a new energy production method built on the foundation of renewable resources has yet to be determined, but nonetheless, scientists and engineers are exploring the capabilities of producing energy from renewable resources so that the country and the world will have alternatives if they decide to move in this direction.

Currently, one alternative form of energy production is available through the use of biomass materials, specifically wood (McKendry, 2002; Scott and Tiarks, 2008). The United States has an abundance of forested land that is well stocked with timber capable of producing biomass for energy as well as a surplus of land available for conversion into timber stands for energy production (Haberl et al., 2010; Beringer et al., 2011), giving this alternative great potential. This idea has caught the attention of those in the energy sector because of timber's

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ability to renew itself within a relatively short period of time due to intensive silvicultural practices such as genetic breeding for improved planting stock, irrigation, competition control and fertilization (Tuskan 1998; Dickmann, 2006). Unlike fossil fuels, which take a great amount of time to form and are essentially considered non-renewable and irreplaceable (Daniels and Duffie, 1955), timber can be grown into a usable biomass fuel material for energy production in as little as 15 years depending on the species (Drew et al., 1987). Another advantage that is seen in timber as a potential renewable energy source is the already-established systems of cultivation and harvesting to grow timber and deliver it to market.

One system that is currently being designed to optimize the amount of biomass fuel material yielded from timber is a timber processing depot. This facility will essentially move the processing of limbs and crowns of trees from the logging site in the woods to the location of the facility. By processing all of the timber at one central location, researchers believe they can optimize the amount of biomass fuel material yielded from each tree by reducing the amount of usable biomass fuel material that is left behind on the harvesting site and by reducing the ash content of the biomass fuel material to produce a higher quality energy fuel product. For this facility to operate, it relies on having timber delivered in an unprocessed form with all limbs still attached to the bole of a full-length tree.

This delivery method raises concerns for those within the forest operations and harvesting industry because the current system of delivery entails complete processing and size reduction of each tree before it is transported to market (Tuskan, 1998). Those behind the design of the timber processing depot envision its greatest utilization will be achieved when processing southern yellow pine that is yielded from second thinnings. Attempting to haul southern yellow pine of that size on a traditional trailer will leave much, if not all, of the crowns uncontained and unsupported by the trailer. This could potentially lead to the crowns coming in contact with other vehicles while in transport and could cause damage to other vehicles as well as the road. To mitigate this risk, those who haul unprocessed timber on traditional log trailers trim the crowns with pole saws once the trailer is loaded to remove any limbs that could cause damage while being transported. Unfortunately, this reduces the payload and leaves behind valuable material that can be processed into biomass fuel material. We plan to address this transportation issue by designing modifications that can be attached to log trailers to accommodate the transportation of unprocessed trees in a legal manner without the excessive trimming that results in loss of payload and decreased payload capacity utilization.

Methods

Design Process

There are three primary goals to guide the design process of this project. First, the design should be a modification to a log trailer rather than designing a trailer built specifically for hauling unprocessed timber. This will allow loggers to remain adaptable and versatile in the products they are able to haul to market, whereas a specialty trailer adds additional costs to an operation and runs the risk of being underutilized if loggers are hauling mainly processed products on a particular harvesting site. Second, the modification should add only the minimal amount of weight necessary to the log trailer to serve its purpose of aiding in the transportation of unprocessed timber. Third, the modification should be easily attachable and removable so loggers can quickly and easily detach the modification when they are not hauling unprocessed timber and therefore do not have to sacrifice valuable payload capacity.

Two designs were conceived for the modification of the log trailers. Criteria such as total weight, load force analysis, ease of attachment and detachment, modification cost and overall feasibility will be considered in the decision to choose one modification over the other for payload capacity utilization testing. The two modifications considered are a swinging guide design and an extendable bolster design.

The swinging guide design incorporates the use of a crosshatched metal guide (Figure 1) mounted between the standards on the rear bunk of the log trailer. Rather than mounting the guide to both sets of standards, the modification calls for the guide to be mounted only to the rear standards. The two rear standards are modified to allow a 180-degree pivot, therefore swinging the guide from the closed position (Figure 1) to a new open position (Figure 2). When the guide is swung open to the rear (Figure 2), this design will contain the limbs from the tree crowns that extend beyond the end of the trailer that would normally be trimmed if hauled on an unmodified trailer. When the modification needs to be detached from the trailer, the two standards with the swinging guides are lifted straight up and off of the pivoting pins and are replaced with two regular standards pre-equipped to be placed on the same pins.

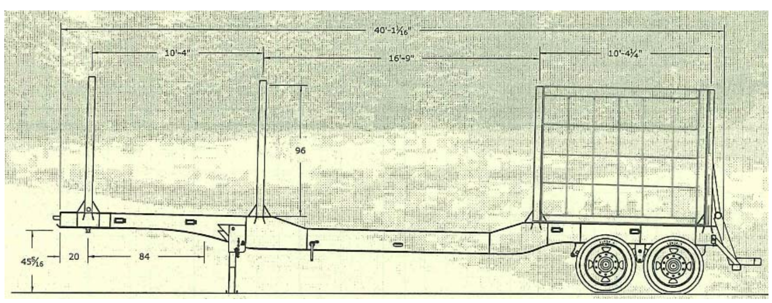

Figure 1. Swinging guide design - closed.

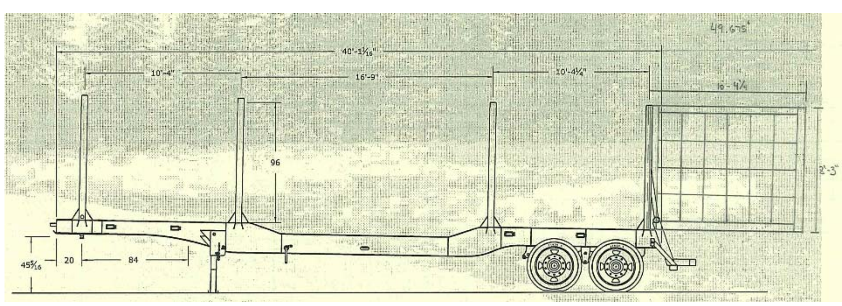

Figure 2. Swinging guide design - open.

The extendable bolster design incorporates the use of an additional bolster equipped with two standards that can be extended from its collapsed position (Figure 3), adjacent to the rear bolster and standards, to its extended position, where it can support and contain tree crowns that extend beyond the end of the trailer. Figure 4 shows the modification in its extended position to accommodate the crowns of trees that extend beyond the rear of the trailer. Two square pieces of steel tubing are slid through pre-cut slots in the existing bolsters of the trailer serving in a similar manner to a sliding rail guide. A stopper is placed on the tube ends closest to the front of the trailer to limit the distance that the modification is allowed to extend. Two crosshatched chain nets, one for the left and right side of the trailer, will be attached between the rear standards of the trailer and the standards of the extendable bolster. Therefore, when the bolster is extended, the chain nets are also extended and serve to contain the crown of the tree (Figure 4). When the bolster is collapsed into its stored position, the chain nets will also collapse making the

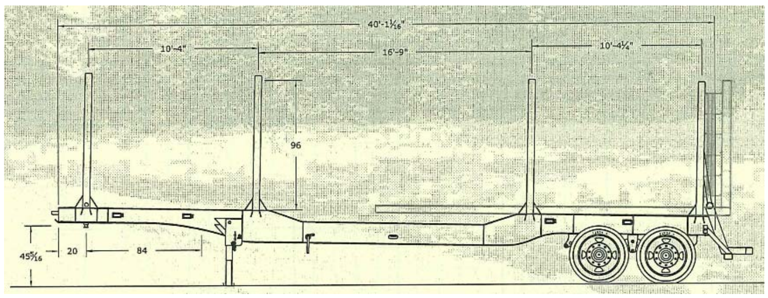

Figure 3. Extendable bolster design – collapsed.

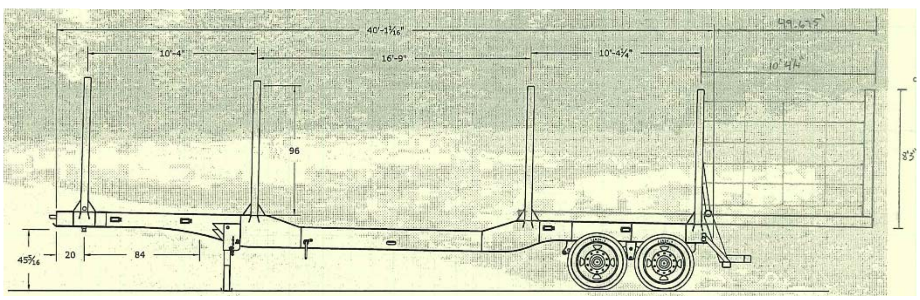

Figure 4. Extendable bolster design – extended.

modification easier to maneuver and less bulky. Additionally, the chains weigh less than a solid metal crosshatched device, which will result in the modification having a smaller total weight. When the modification needs to be detached from the trailer, the stoppers can be removed to allow the tubing to slide all the way through the pre-cut slots in the bolsters.

The design process is still ongoing and the criteria for choosing a design are still being calculated and considered. We estimate that the design criteria calculations should be completed by mid-July 2016 and a decision regarding the selection of a design shortly after for immediate fabrication and payload capacity utilization testing.

Payload Capacity Utilization Testing

Payload capacity utilization testing will begin with loading an unmodified (standard) log trailer with unprocessed whole *Pinus taeda* trees from a second thinning operation to establish an average weight for our alternative hypotheses (modified trailer) to be tested against. This will allow us to determine if there is any significance in the weight difference between the standard trailer and the modified trailer. Since we plan to test the modified trailer with three different loading configurations, an analysis of variance (ANOVA) test will be conducted on the load weight means.

The unmodified trailer will be loaded multiple times with a standard arrangement of second thinning unprocessed *P. taeda* in order to determine an average load weight. Weights will be measured with portable truck scales. The trailer will be loaded until either the maximum gross allowable load weight of 88,000 pounds is reached or until the available volume of the trailer is completely utilized. Since the low bulk density of unprocessed raw materials such as timber limit the size of a load by volume capacity rather than by mass capacity (Ranta and Rinne, 2006), it is likely that the load testing on the unmodified trailer will also by limited by volume capacity. The unprocessed timber on the trailer will also be trimmed to meet legal highway transportation standards, further reducing the weight of the load. Therefore, it is hypothesized that the unmodified trailer load will not reach near the maximum gross allowable weight of 88,000 pounds due to the low bulk density, large trailer volume capacity and crown trimming.

The payload capacity utilization testing will continue with the modified trailer using the design that will be chosen upon completion of the modification design process. The modified trailer will be loaded just as the unmodified trailer will be, with *P. taeda* of the same size and from the same stand of timber in order to reduce the variability in tree size for the experiment. The modified trailers will be loaded using the standard arrangement, indexed arrangement and double bunked arrangement to determine if the loading arrangement has any effect on the payload capacity utilization. The trailer will be loaded until either the maximum gross allowable load weight of 88,000 pounds is reached or until the available volume of the trailer is completely utilized. We hypothesize that the modification will improve containment of the limbs and crowns of the unprocessed timber, thus reducing the amount of material that needs to be trimmed in order to comply with transportation regulations. The weight of the modification is vital to the success of the experiment as keeping the weight of the modification to a minimum will increase the chances that the crown material not trimmed from the modified trailer load will allow the payload capacity utilization to increase. If the modification is too heavy, its weight could offset the weight of the material removed from the crown during trimming resulting in no significant difference in load capacity between the unmodified and modified trailers.

Results

The results of this experiment have not yet been determined. Payload capacity utilization testing is scheduled to commence in early July 2016 with initial unmodified trailer load results yielded shortly after. Results for the modified trailer payload capacity utilization testing are expected by the end of August 2016 due to the fabrication of the chosen design that is required in order to complete the testing.

The results from this experiment are significant to the renewable and sustainable energy initiative. Specifically, those involved with the design of the timber processing depot will find the results of this experiment valuable. These depots will require unprocessed full length timber in order for them to reach their maximum potential as biomass fuel production and log merchandising and optimization facilities. The delivery of timber to these facilities will depend on the feasibility of hauling tree-length unprocessed timber. Since this product has traditionally suffered from low bulk densities, we are determined to increase that density with our modification and loading configuration and thereby increase the feasibility of hauling this type of product. If this project can statistically prove that a simple modification to log trailers can increase the payload capacity utilization and therefore transportation productivity of hauling unprocessed timber, then we will be one step closer to finding a solution to the renewable and sustainable energy problems that we are currently facing.

Conclusion

In summary, we realize that in order to produce the energy needed for consumers while also conserving what finite amount of fossil fuels we have left will require the increased production of energy from renewable and sustainable natural resources such as timber. Timber biomass is currently being utilized for energy production by powering boilers in steam turbine power production facilities, but not at the magnitude needed to conserve our finite fossil fuels. Timber biomass in the form of wood chips could also be utilized by facilities that produce liquid fuel as a source of energy for mechanical engines through processes such as gasification. Researchers understand that in the near future the demand for timber as an energy production fuel could increase drastically and are therefore preemptively working to make sure that there are facilities in place and production capabilities ready to be utilized to supply energy produced from timber biomass to the world.

Currently, facilities called timber processing depots are being designed that will help meet the future demand of timber required for energy production by optimizing the amount of biomass fuel material yielded from each individual tree and by increasing the quality of that material. This facility will require timber to be delivered in a whole tree length and unprocessed form, which is the antithesis of the current method used to deliver timber to market. Therefore, this project is seeking to determine if a simple modification attached to a standard log trailer will increase the payload capacity utilization and therefore the feasibility of hauling timber in this form. By increasing the payload capacity utilization of low bulk density unprocessed full-length timber, transporting this material will become more feasible, potentially persuading more loggers to harvest and haul this material to the proposed timber processing depots.

Two modifications are currently being designed that could increase the gross truck-trailer-load weight closer to the maximum allowable weight of 88,000 pounds when hauling low bulk density whole-length unprocessed trees. The first design will incorporate a guide that swings open to the rear of the trailer and past the rear bumper aiding in the constraint of tree crowns and limbs. The second design will incorporate a sliding extension that will support the additional weight of the crowns that extend beyond the rear of the trailer while also aiding in the constraint of the tree crowns and limbs. Both designs will be easily attachable and detachable to allow the loggers to remain versatile and will keep their capital from being tied down in specialty trailers that could possibly go underutilized within a their operations. Three different loading arrangements will be tested to determine if the way unprocessed timber is loaded will increase the bulk density and have any effect on the payload capacity utilization of the modified log trailer. If a delivery system utilizing the modified trailers proposed in this experiment can be proven more feasible than hauling the same product on standard log trailers, then researchers will be one step closer to providing a solution to the world’s renewable energy problems.

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