

Evaluating In-Woods Truck Scales

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Abstract

Transportation can account for half the cost to deliver wood to a mill. Contractors seek to maximize truck payload to increase productivity and minimize cost. One method to ensure a maximum payload is to utilize in-woods truck scales. In-woods scales allow the contractor to maximize payload while not exceeding legal limits. Additionally, measuring axle weights allows a contractor to determine whether alternative loading techniques would yield a larger load or avoid over/under axle loads. This paper reports on in-woods truck scales and a field evaluation of an onboard truck scale system.

Introduction

Wackerman et al (1966) and McCraw (1963) state that harvesting forest products is primarily a transportation problem. First, transporting the material from the stump to the landing and secondly from the landing to the mill. The second phase of transporting forest products is generally considered the largest single item in the delivered cost. Conway (1982) reported industry estimates of transportation costs ranging from 50 to 60 percent of total operating costs. Thus, transportation efficiency is critical for harvesting contractors to remain profitable. One aspect of transportation efficiency is maximizing payload. Delivered forest products take many shapes and forms, from round wood to chips and forest residues. Specifically, round wood characteristics not only vary by species, age, diameter and height, but also by geographic location, location within the stand itself and time of year. These factors make it difficult for contractors to maximize payload without either under loading or exceeding legal limits. In-woods weighing overcomes these issues.

In-woods weighing is not a new concept. Weighing systems and scales have been available since at least the 1960's (Winans, 1972), but have not been adopted by a majority of harvesting contractors. There are many reasons for the lack of adoption of in-woods weighing; purchase cost, complicated installation/use, lack of portability between equipment and loss of productivity during loading operations.

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There are three main alternatives for in-woods weighing (Shaffer and McNeel, 1986); loader scales, platform scales, and on-board truck scales. Loader scales are more common in material handling industries such as aggregate and agricultural bucket loaders and warehouse forklifts. The systems usually involve a pressure transducer to measure the hydraulic pressure on the lift cylinders or a load cell installed within the boom or lift mechanism. Pressure sensing systems require the operator to place and hold the grapple at a specific height and orientation to get an accurate reading (Shaffer and McNeel, 1986; Michaelsen, 1993), although modern systems have overcome this limitation somewhat. Load cell systems (Michaelsen and Williams, 1990) can more accurately weigh automatically as the load is being transported but require an experienced operator and proper technique. A search of current forestry harvesting equipment manufacturer's literature shows no currently available loader scales for Knuckleboom loaders. There are aftermarket scale systems for knuckleboom loaders, but Jenkins (2010) notes their limitations for tree length material and loaders that utilize a heel boom. To achieve an accurate weight the load must be free hanging and not bouncing or flexing as this induces high variance on the scale reading. Additionally, loader scales cannot calculate axle weights, only the accumulated weight of the wood loaded.

Platform scales or portable weighing pads (Shaffer and McNeel, 1986) are another viable option for weighing in the woods. The typical system utilizes load cells placed in a steel frame and deck. Scale size varies from units small enough to measure a single wheel or tandem wheels to large pads capable of measuring an axle or a set of tandem axles. Most harvesting contractors use large platform scales that weigh a set of tandem axles at once. These large scales can weigh as much as 7500 lbs. (Murray, 1998) with dimensions of approximately 16 ft. by 10 ft. and therefore must be placed with a loader or dragged into place with a skidder. The scale is typically placed next to the loader and the tandem drive axles or the tandem trailer axles are placed on the scale as the trailer is loaded. The readout for the scale is located in the loader cab and communicates wirelessly with the scale. Once that set of axles is loaded fully (volume or weight maximum) the other axle groups are then weighed and any adjustments necessary are made (adding or removing wood as needed). Once a truck's steer axle has been weighed once, it may not be weighed each time since it is relatively constant. The need to move the truck to weigh all axle groups and then adjust weight is a drawback to the system. The ability to weigh contract trucks (Shell, 1999) is an advantage of platform scale systems. Shafer and McNeel (1986) suggested that platform scales are better suited to large tracts where frequent moving will not be required.

On-board truck scales are the most commonly used in-woods weighing system. Winans (1972) and Arola (1972) documented on-board truck scales in the early 1970's and the Forest Engineering Research Institute of Canada (FERIC, now FP Innovations) evaluated on-board truck scales in the 1980's and 1990's (Phillips, 1989, and Michaelsen, 1998). FERIC classified on-board truck scales into three categories; temporary load-bearing scales, non-load-bearing scales, and load-bearing scales. Phillips (1989) defines temporary load-bearing scales as lift pads

that are mounted between the trailer frame and the bolster frame. The pads are inflated to lift the load and the weight is calculated by the pressure required to inflate the pad. The pads are deflated while the truck is traveling. Non-load-bearing scales measure the bending of a structural member of the truck and trailer frame / suspension to measure load. Strain gauges, which are electrical circuits that measure the change in electrical resistance as it bends, are utilized to measure the bending of the frame / suspension and calculate the load. The strain gauges are typically incorporated into a steel block and the block is welded to the frame / suspension. Load-bearing scales, consist of a load cell that is incorporated into a load bearing component of the truck or trailer frame / suspension. Load cells are typically incorporated into suspension brackets and fifth wheel mounting brackets. Michaelsen (1998) reported on load-bearing scales that measure the load based on the air pressure in the air bag suspension of the truck. Most manufacturer's offer combination systems for trucks with air bag suspensions and mechanical suspension trailers.

Evaluation of an On-Board Truck Scale System

Researchers with the Forest Operations Research Unit, Southern Research Station, United States Forest Service, in Auburn, Alabama purchased an on-board truck scale system to test and evaluate, and as a data gathering tool for timber harvesting operations and transportation research. The Truck Weight Smart Scale⁴ system by Smart Scale Technologies, Inc. (<http://www.truckweight.com>) was chosen based on its low purchase price and advertised ease of installation. Installing the system does not require welding or replacing structural components of the suspension system to be replaced.

The Truck Weight system is designed to work with mechanical, air or combination suspension systems. The system consists of sensors that measure axle weights and communicate wirelessly to a handheld display. The sensors can be hardwired to the truck / trailer electrical system or can be purchased as battery powered units. The air sensor is plumbed into the air suspension between the air bags. The mechanical sensor reads the output from strain gauges that are installed on a weight bearing component of the truck / trailer suspension. The strain gauges must be individually adhered to the structural members. A typical installation requires four strain gauges, two on each side (front and rear) of the tandem axle group. Each sensor has a unique identification number that must be entered into the handheld display and the handheld unit can store up to 30 truck and trailer combinations. The handheld unit displays each axle group weight and the total weight for the truck / trailer. The steer axle of the truck can be instrumented with a mechanical sensor or a static weight can be set in the handheld display. Set-out trailers equipped with sensors can therefore be substituted into a truck / trailer combination.

⁴ The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U. S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

Installation

A combination, air and mechanical, system was purchased based on the truck and trailer combinations of the collaborating harvesting contractor for the project. Hardwired sensors were also purchased based on the relatively easy access to DC power from the truck / trailer light wiring. It was also decided to not instrument the steer axle and to use a representative static weight. The manufacturer's installation literature, online videos and technical assistance allow for self-installation by the end user or a local shop. The air sensor installation was the most straight forward. The air supply lines for the truck air bag suspension for the tandem drive axles were located and the sensor was plumbed into the system via a manufacturer supplied tee fitting (Figure 1). The sensor was powered via the truck's tail lights.



Figure 1: Air sensor installed in truck air bag suspension.

The mechanical sensor and strain gauges required more preparation and planning to install. A suitable location on a component of the trailer's mechanical suspension had to be determined. The top leaf of the leaf springs, in front of and behind the pivot point on each side of the tandem axles, was chosen. The area where each strain gauge was to be adhered to the leaf spring was ground smooth with an abrasive disk and sanded. Once the area was prepared, it was cleaned with rubbing alcohol to remove all dust and contaminants. The strain gauge was then adhered to the leaf spring using a permanent adhesive (Figure 2). After the strain gauge was bonded to the



Figure 2: Strain gauge adhered to leaf spring.

leaf spring, the manufacturer suggested testing the strain gauge for proper operation. Testing consisted of applying a 12 volt DC voltage to the strain gauge while watching for fluctuations in the handheld display pressure readings. If the pressure readings varied too much (\pm a few psi), the manufacturer suggested removing the strain gauge and installing a new one. The scale kit, as purchased, included extra strain gauges. Once checked for proper installation, the strain gauge was then coated in caulking to protect the strain gauge from moisture and contaminants (Figure 3). The wires for each of the 4 strain gauges were then wired into a junction box attached to the sensor. The sensor was powered through the trailer lights.



Figure 3: Strain gauge coated in protective caulk.

Calibration

Once installed, the system must then be calibrated. Calibration requires weighing all axles groups of the truck / trailer unloaded and loaded. A commercial certified scale operator in the local area was used to weigh the truck. The certified scale guaranteed accurate weights and split the load into axle groups. The collaborating contractor supplies forest products to a number of mills up to 60 miles from the Auburn, AL area. The Forest Harvesting and Operations researchers always endeavor to work with contractors in an effort to not cause a loss of productivity due to research activities. Several months, therefore, passed before the contractor was transporting timber in an area convenient to the certified scales. Before attempting to calibrate the scales the system was inspected to insure that all components were intact and functioning. After inspecting the system and determining that the system was functioning, the truck was weighed loaded and unloaded and the data entered into the handheld display unit. The handheld display unit automatically calculates the weight curve for the truck / trailer combination.

Discussion

The ease of installation was one of the system attributes that led to the decision to purchase the Truck Weight scales. The air sensor portion of the system was indeed very simple to install. The mechanical sensor portion of the system proved to be more complicated than expected. The manufacturer's literature referenced the requirement to properly prepare the location of the strain

gauges and their adhesion to the structural members of the trailer. The trailer chosen for this installation was older and the leaf springs were dirty and pitted. Care was taken to follow the manufacturer's recommendations and each strain gauge was tested for proper installation, but after completing calibration it was immediately evident that there was an error with the system. The trailer sensor was observed to be highly variable, jumping +/- 20,000 lbs. Based on the manufacturer's literature, this indicated a bad strain gauge or the improper installation of a strain gauge. The trouble shooting procedure is the same as during installation, test each strain gauge individually to look for pressure variance. Once the strain gauge or gauges are located that are causing the pressure variance those gauges should be removed and replaced. The system would then have to be recalibrated. At the time this paper was written, due to the contractor's need to keep the trailer in service, the error has not been located and corrected. The initial installation was completed outside in an unpaved area. This could have contributed to dust and contaminants being incorporated into the strain gauge installation. The next step in the testing and evaluation of the system will be to locate the error and replace the strain gauge. Additional steps will be taken to insure a better result, these will include washing down the whole trailer before installation and working in a shop or a paved parking lot.

After the calibration, the air sensor appeared to be working well and the weight indicated for the tandem drive axles matched well with the certified scale weight. The non-instrumented steer axle weighed 1300 more pounds loaded compared to empty. This difference between loaded and unloaded weight was larger than expected. No fuel was added to the truck between the unloaded and loaded weights and the truck travelled approximately 50 miles between being weighed. During calibration it was decided to enter the average of the unloaded and loaded weights for the steer axle. The contractor will have to account for this variance when using the system and should not try to load to the exact legal limit. It may be necessary to increase the static weight of the steer axle in the future if the system consistently weighs less than mill scale tickets.

Conclusion

There are many advantages to weighing trucks in the woods. The literature shows that these potential advantages have been known since the 1960's and that manufacturers have also been producing in-woods scaling systems since at least the late 1960's as well. There are many reasons harvesting contractors have not widely adapted these systems. These include purchase cost, complicated and timely installation, maintenance, and how to accommodate set out trailers and contract trucking. The Truck Weight Smart Scale system appeared to offer a solution to some of these problems with a low purchase cost and a less time consuming installation process. The ongoing evaluation of the system has shown that even advances in technology that have reduced the cost and complexity of scale systems still cannot overcome all of the limitations faced by harvesting contractors wishing to use these systems. Contractors cannot generally afford to take a truck / trailer off the road for extended periods of time to trouble shoot and maintain an on-board scale system. The Truck Weight system shows promise and the Forest Harvesting and Operations Research unit will continue to evaluate and test the system.

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