Developing a new yarder-controlled mechanical slackpulling carriage for double-drum winches

Morten A Nitteberg* and Bruce Talbot
Norwegian Forest and Landscape Institute
Section for Forest Technology and Economics
Høgskoleveien 8. 1432 Ås. Norway
nim@skogoglandskap.no

Abstract:
This paper briefly describes the conceptualization, design, and construction of a 1:3 scale yarder controlled, mechanical slackpulling carriage for double drum winches. The construction of such a carriage is motivated by the large number of double drum winches in forestry that are not able to drive a slackpulling drum, resulting in the strenuous work of the choker setter having to perform this manually. The more likely result being that the winches remain inactive, as owners are unable to find staff willing to do this kind of work. A fully functional prototype has been developed and been put through some initial testing. Despite some technical adjustments that are necessary in improving design, the prototype performed better than expected. A fully functional carriage working on the same principles would be expected to have significant market potential in smaller cable-yarding operations.

Keywords: cable yarding, carriage, double-drum, slackpulling

1 Introduction

Cable yarding in steep and difficult terrain is hard work especially when working with small to medium sized cable systems because of the lower degree of automation and often simple winch and carriage system. Smaller, more simple cable systems are useful in settings with low volumes, smaller stands, or small trees as they have a lower capital cost and lower demands on engineering. In theory, the setup times of smaller tower yarders is shorter than for large systems. One disadvantage of simple, lightweight carriages can be the lack of slackpulling capability. Slackpulling refers to the driven lowering or raising of a skid line (also called drop line) from the carriage, and is especially useful in reaching logs in gullies, or at some lateral distance from the corridor centerline. Slackpulling capability greatly reduces the manual work load and increases productivity in the yarding system. There are many carriages with slackpulling capability on the market. These are either powered by small diesel or gasoline engines mounted in the carriage, or controlled from the yarder, requiring at least one additional cable and winch drum. The disadvantage with the self-powered carriages is their heavy weight and the higher cost if damaged, as well as the higher maintenance requirements. The alternatives to slackpulling, manual pulling of the line, or lateral pulling of a slackened skyline, are highly strenuous, and predispose logging crews to accidents (Kirk and Sullman, 2001), and likely contributes to higher job turnover. Heinimann et al. (2001) provide a useful systematization of yarder systems, detailing functions and settings for their use.

At under 100 000 m^3a^{-1} cable logging currently accounts for less than 1% of the annual cut in Norway. However, with over 100 million m^3 in steep terrain approaching harvest maturity in the next 20 to 30 years, activity levels need to be stepped up considerably (Vennesland et al., 2006). One hindrance to this is the lack of willing entrepreneurs, given the marginal economics and the strenuous and isolated nature of the work. The problem is not confined to Norway. There are many double drum winches in operation worldwide with carriages without slackpulling capability. In Japan there are more than 400 excavator based yarders with double drum winches. Almost all these systems use a simple carriage system with 2 interconnected blocks. The cables need to be lowered for each load, and the skid line pulled manually while the operator drives the drum. Manual pulling out of the line will often result in reduced corridor width, which again results in a higher proportion of set up time. A carriage with slack pulling capability that could run with the common double drum configurations would solve a number of these issues, and hopefully contribute to better economic results and higher levels of activity in steep terrain in the future.

2 Carriage design and development

The difficulty in developing a carriage with slackpulling capacity, but with only two lines (and no motor) lies in the need to be able to drive the slackpulling drum in both directions, while keeping the carriage in position. The same two lines are then needed to drive the carriage forth and back to the landing. This requires an innovative way of switching between the travelling and the slackpulling effect of the two cables. In 1986, The Norwegian Forest and Landscape Institute (then NISK) was involved in developing a carriage for two lines with a powered skid line. The prototype was constructed and built by Igland A/S, a Norwegian producer of winch and small cable systems. This construction was based on a system with a hydraulic pump and motors between the running lines and skid line drum (fig. 1, left).

After protracted testing and a number of problems with the hydraulic system the project was stopped. This coincided with falling interest in yarding, and no effort was made to take up developments. Many years later a retired engineer from the original project built a Mecano™ prototype based on a mechanical system (fig.1, right). This was done to circumvent some of the problems that had plagued the hydraulic prototype, and to demonstrate that the mechanism could work in principle.

Figure 1: (left) the hydraulic prototype,(right) retired engineer Mr. Torstein Lisland demonstrates an improved, mechanical system constructed in Mecano™

Given the potential marked for a slackpulling carriage running on a double drum winch, and the benefits that this might bring to the Norwegian forestry sector which is struggling to increase the level of yarder extraction, a decision was made to proceed with the construction of the new mechanical prototype in 2010. In order to reduce development costs, and because of access to a unique scale 1:3 Owren 400 tower yarder, it was decided to design the new carriage in scale 1:3 as well. This would allow for interactive development and testing to be carried out at the institute. The first step in the process was to make a list of specifications and requirements. This included:

- The material and construction of prototype carriage must tolerate falling 5 m without functional failure.
- Material must be decided on in cooperation with the constructor. Especially the advantages of lightweight alloys over steel, but the ease of repairing steel in remote workshops.
- There must be horizontal distance between mainline and haul-back line to avoid twist.
- Carriage must be operated by wireless remote control.
- Shifting operation from slackpulling to travelling by hydraulic or electric actuator
- Speed of skid line ca. 1m/sec
- It should be easy to mount lines on carriage.

- Colours - should be orange with black on capstan for good visibility

The final design and construction was outsourced to the same consulting engineer that constructed the Owren 400 mini-yarder. One of the most important requirements was that all the components should be off-the-shelf and not specifically machined for the carriage. There were many challenges, meetings and discussions during the construction phase. Laser cutting and welding of the chassis was also outsourced, leaving only mounting and painting to be completed by the institute workshop. The final design is represented in figure 2.

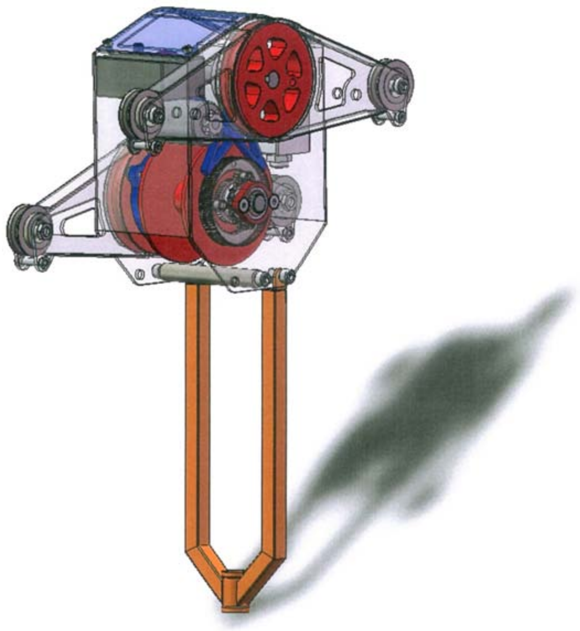

Figure 2: Construction diagram for the new mechanical slackpulling two line carriage

The construction is based on an innovative mechanical system using a planetary gear inside the carriage, and an electric actuator that engages either the skidding line gear cog or the travelling gear, moving the carriage along the lines. The switch operation is remote controlled. The carriage has two capstans; one for the mainline, and one for haul-back line. The switching operation on this scale model is done by two solenoids. There is no accumulator on the scale model because the current consumption is very low.

3 Results of initial testing

As is often the case with machine development, construction of the prototype took a longer time than expected, leaving insufficient time for the comprehensive testing intended for this paper. However, in May 2011 the carriage was mounted in anticipation of testing. It was immediately evident that the balance in carriage was incorrect, and two metal bars had to be attached to the swing-arm as ballast. Also, some adjustments were necessary on the shifting arms which did not fully engage the drive gears as intended. In beginning of June numerous tests were done, and showed that some modifications were necessary to the planetary gear. The axial thrusting had to be improved. By the middle of June the carriage was working according to expectation (fig.3). In a run of 15 cycles requiring 30 shifts between the travelling and slackpulling gear, only 2 malfunctioned. Testing to date has however, only been carried out on a 10% slope on a permanent rig at the institute. Further tests, and the necessary adaptations, will initially be done on 20 and 30% inclinations before continuing onto steeper slopes. The most significant problem that has been detected is slippage on the driving gear when the switching arm does not engage in a synchronized way.

Figure 3 The completed 1:3 scale mechanical slackpulling carriage undergoing testing

4 Discussion

A mechanical slackpulling carriage for two lines was conceptualized, constructed and tested. The constitution of the project group, including researchers, engineers and practitioners, and the outsourcing of key functions, have contributed to the success of the process. Initial testing has shown generally positive results although some technical adaptations have been necessary underway. The design of the gear cog or the engaging mechanism needs to be improved upon. Also, further testing on steeper inclines and under heavier load still needs to be carried out in verifying the true capability of the carriage.

More development is necessary on solutions for locking planetary gear. Some possibilities include a break disc or a lock plunger – each having their own advantages and disadvantages. It is safe to conclude that the development of such a piece of equipment requires a longer, interactive process. The Owren 400 mini-yarder has given birth to the first of hopefully many spin-off projects, both technical and methodological. Given the promising initial results, we are convinced that we will succeed in developing a new yarder-controlled mechanical slackpulling carriage for double-drum winches.

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