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Improved Hauler Control Systems for Grapple Yarding

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EXECUTIVE SUMMARY

The specific aim of one FFR Harvesting research project is to increase the uptake of grapple harvesting by the forestry industry. Difficulty in controlling a grapple when using existing hauler-control systems is one of the barriers to increased adoption of grapple harvesting.

The advent of hydraulic grapple carriages such as the Falcon Forestry Claw and the Alpine Grapple has reinforced the need during grapple yarding for fine control of the skyline, as well as rope inhaul and outhaul, in order to direct the grapple onto the target tree stems. The use of brakes and clutches to control the winch drums via pneumatic systems does not provide this fine control.

This project investigated the options for improved hauler control systems. Information was gathered from cab-control system suppliers, and details of systems currently available for upgrading hauler controls are described. Current costs range from $10,000 to around $30,000 depending on whether computer control is required. According to the suppliers, advantages of these conversion systems include easier use of controls by operators, easier maintenance of control systems and reduced training time for operators.

In addition, improvements are proposed for two swing yarder drum, brake and clutch set configurations, and one tower hauler configuration. The most significant change was the installation of a hydraulic drive pump and hydraulic motor. The advantage of using the hydraulic system is that it would provide the fine control required to position grapples and grapple carriages accurately. It was estimated that such a system would cost no more than that used in existing swing yarders and tower haulers.

INTRODUCTION

The goal of the Future Forests Research (FFR) harvesting research programme is to improve productivity and safety, and reduce the cost of steep country harvesting. Grapple yarding is an obvious way to improve safety through eliminating the use of manual breaking out from the operation. Grapple yarding can also be highly productive in good conditions, but can be slow in less favourable conditions. In a survey in 2012 it was found that 30% of hauler operations are swing yarders, with most capable of using grapples[1]. In addition, some twenty tower machines are now using grapple carriages (Barry McIntosh, pers. com), bringing the percentage of grapple yarding capable operations to an estimated 36% of total haulers. The aim of the FFR project in Improved Grapple Control is to increase the uptake of grapple yarding in New Zealand. One of the barriers to wider adoption of grapple yarding has been controlling rope grapples (Figure 1) efficiently with existing hauler control systems.

Figure 1: A typical rope-controlled grapple

The term “control system” describes the system from cab controls to winch drum drives, including brakes. Grapple control has been improved by the recent development and adoption of hydraulically-controlled grapple carriages such as the Falcon Forestry Claw[2] developed by DC Repairs Ltd based in Nelson, and the Alpine Grapple Carriage from South Africa (Figure 2).

These carriages can be used with both tower haulers and swing yarders. One issue with tower haulers is skyline control. Improved control of the skyline, as well as rope inhaul and outhaul is critical for increasing the number of grapple-capable operations.

Figure 2. The Alpine Grapple carriage

Brakes and clutches are applied through existing pneumatic control systems which make it difficult for the operator to have precision control when lowering the skyline, and hence the grapple carriage, onto the target tree stems.

In general, tower yarders constructed more than twenty years ago (the majority of haulers in New Zealand) are characterised by antiquated air control systems for brakes, clutches and throttles. More recently, some tower yarders, such as Madill 172 and Thunderbird 6170, have been built with FX2 type electric lever controls. These controls are similar to outboard motor controls.

In 2007, Brett Henderson of Brett Henderson Ltd (BHL Ltd) and Tony Taylor of Electrical and Machinery Services Ltd in Rotorua developed a system for converting swing yarder cab controls to an electric system, with brakes and clutches controlled by Programmable Logic Controller (PLC). This system was installed in New Zealand on several swing yarders running mechanical grapples[3]. Because of the PLC control, the system could also be programmed for use with other rigging systems. Since then a number of engineering companies and independent engineers have retrofitted old-style control systems with more modern technology and components.

Winch drum sets are driven by mechanical gearing via automatic or manual transmissions from a diesel motor. Another way of improving hauler control would be to convert drivelines to hydraulic systems. As part of this project, Brett Henderson proposed several designs for changing hauler driveline systems from mechanical to hydraulic.

This project investigated options for improved hauler controls to address the identified barriers to uptake of grapples. It examined some possible hauler control system configurations which could improve grapple control. Some of these systems could be applied to tower haulers as well as swing yarders.

METHODS

This project was conducted in two parts. Firstly, a survey was undertaken of the types of cab-control improvement systems currently available in New Zealand. This was undertaken by telephone discussions with technical representatives or principals from five selected engineering companies in late 2013. Details of the five companies that participated in this study are provided in Table 1.

Table 1. Details of companies that participated in the current study

Company Name	Name of person interviewed	Company activities	Website/Address	Contact detailsl
Brightwater Engineering Ltd[4]	Josh Wilson	Swing-yarder and tower-yarder controls	www.brightwater.co.nz	josh.wilson@ brightwater.co.nz Phone 03 5435300
Yarding Solutions Limited	Beau Candy	Single or double lever control conversion for both tower and swing yarders	230B Lodore Road RD1 Okaihau 0475	yarding.solutions@ xtra.co.nz Phone 021 585633
Active Equipment[5]	Tony Henderson	Pneumatic lever controls for both tower and swing yarders	www.activeequipment.co.nz	tony@activeequipment.co.nz Phone 027 3336824
Brett Henderson Limited	Brett Henderson	Swing-yarder and tower conversions	9 Ascot Vale RD4 Rotorua 3074	bhl.maria@xtra.co.nz Phone 027 4203128
DC Repairs Ltd [6]	Dale Ewers	Tower conversion	www.dcrepairs.co.nz	dale@logger.co.nz Phone 027 4385955

In the second part of the project, Brett Henderson of Brett Henderson Limited (BHL Ltd), an expert with extensive experience in hauler maintenance and repair as well as the design of hauler control systems, was invited to participate in this project. As a result of discussions with FFR as part of this project, Brett Henderson proposed several new design improvements to existing hauler control systems, comprising:

- Two proposed swing yarder drum, brake and clutch set configurations
- One proposed tower hauler drum, brake and clutch set configuration.

The operating methods of these alternatives and their advantages and disadvantages were discussed and are presented here.

RESULTS

A. Types of Cab-control Systems

Existing Systems

Many New Zealand haulers are second-hand machines dating from the 1970s that are fitted with their original control systems. Old control systems comprise foot pedals, throttles, and lever clutch and brake controls. Considerable time is required to learn to use them efficiently. Training time in many operations is expensive, and is often unavailable because of production requirements. Also, operators can find it difficult to transfer skills from one machine type to another because controls can differ between models and makes of equipment.

Grappling with towers involves the fine control of the skyline drum and brake to firstly lower the grapple carriage onto the target log, and secondly to return the skyline to the desired tension. The band brakes fitted to older skyline drums do not allow the fine control required. If rope tension monitors are used, the skyline can be returned quickly to the appropriate tension settings. Not all contractors make use of skyline-mounted tension monitors.

Old cab controls are characterised by:

- Having multiple control levers
- Having obsolete valving
- Being difficult to learn
- Being stressful to operate when used in combination with grapple carriages and cameras
- Having different controls for different machines.

An example is shown in Figure 3.

Figure 3. Old tower-hauler controls and new joystick-type controls fitted toa Madill 171 machine converted by Brightwater Engineering (Source: Bill Winmill).

Updating Existing Systems

Improvements and changes to some hauler controls have coincided with the additional adoption of grapple carriages, cameras and outhaul-measurement technology. This means that fine grapple control cannot always be attributed to hauler-control developments alone.

Five companies supplied information for this study on the types and cost of cab-control improvements that they offer. Details are provided below.

1. Brightwater Engineering of Nelson supplies pneumatic lever controls with PLC for a swing yarder. A PLC-based system design is currently priced at $30,000, which includes an air system and hydraulics for pull clutches. This company is currently re-designing the controls of their range of tower haulers. Features will include the use of a seven-inch touch-screen and integrated engine management. Controls will be simplified and will be operator-friendly.

2. DC Repairs Limited of Nelson supplies electric, single- or double-lever controls for tower hauler conversions. Double-lever control has been preferred by customers because additional functions can be added for grapple-carriage control (e.g., a trigger for grapple open/close). Four haulers have been converted. Cost is estimated at less than $10,000.

3. Yarding Solutions Limited of Kerikeri undertakes conversion of tower and swing yarders to single- or double-lever control systems. Pneumatic-over-hydraulic or over-air systems are used but not PLC. The cost of an upgrade is $12,000 to $15,000 ($15,000 includes a cab dashboard).

4. Active Equipment Limited of Rotorua. This company offers pneumatic lever controls for both tower and swing yarders. Systems can be configured with or without PLC depending on requirements. Tower and swing yarders are fitted with air controls using the same control lever configuration, which enables operators to move easily from one hauler type to another. No costs were quoted as there is a range of costs depending on the make and model of machine as well as options for associated upgrading of dash displays or transmission controls.

5. Brett Henderson Limited of Rotorua. Previous conversions undertaken by BHL Ltd featured a Danfoss computer and operated drums, brakes and clutches using the same methods and sequences described in the Madill operating manual. This company offers PLC-based pneumatic lever control systems for swing yarders. Computers and software are sourced from Electrical and Machinery Services Ltd in Rotorua (EMS). Six swing yarders have been converted. The cost of a single conversion is approximately $30,000. BHL Ltd can retrofit PLC-based controls into tower haulers. BHL Ltd also offers pneumatic single-lever control systems for tower yarders. These systems do not have PLC so they cannot be pre-programmed for different rigging systems or diagnostics. The company prepares parts and documentation for installation by a third party. The cost of a single conversion is approximately $10,000 to $15,000 depending on machine type.

Advantages and disadvantages of the systems are outlined below. These tend to be similar regardless of the supplier of the technology.

Advantages

Advantages depend on whether or not a PLC system is chosen.

- PLC systems have the advantage over non-PLC systems of diagnostic capability.
- PLC systems have the option of programming clutch and brake combinations for different rigging systems, which reduces the mental and physical workload on an operator.
- The use of a display may also enable other functions, such as line tension and distance out, to be displayed.

- Converted haulers are often easier to maintain because they have just one type of valve that is used for all applications.
- Sophisticated hauler controls make haulers easier to operate.
- Costly training time required for new operators is reduced because of simplified operating controls.
- Operator comfort is improved.
- Operators can make the transition from one converted machine type to another easily, as there is usually some similarity of lever and button layout.
- In terms of choice of pneumatic or electric systems, pneumatic systems are sometimes quoted as being simpler, and they also offer a degree of feedback pressure to the operator

Disadvantages

- Cost of converting exisiting hauler systems.
- Programmable logic computer systems are more expensive than non-PLC systems
- Time out of production.
- Training in operating new control system.

B. Future Driveline Design

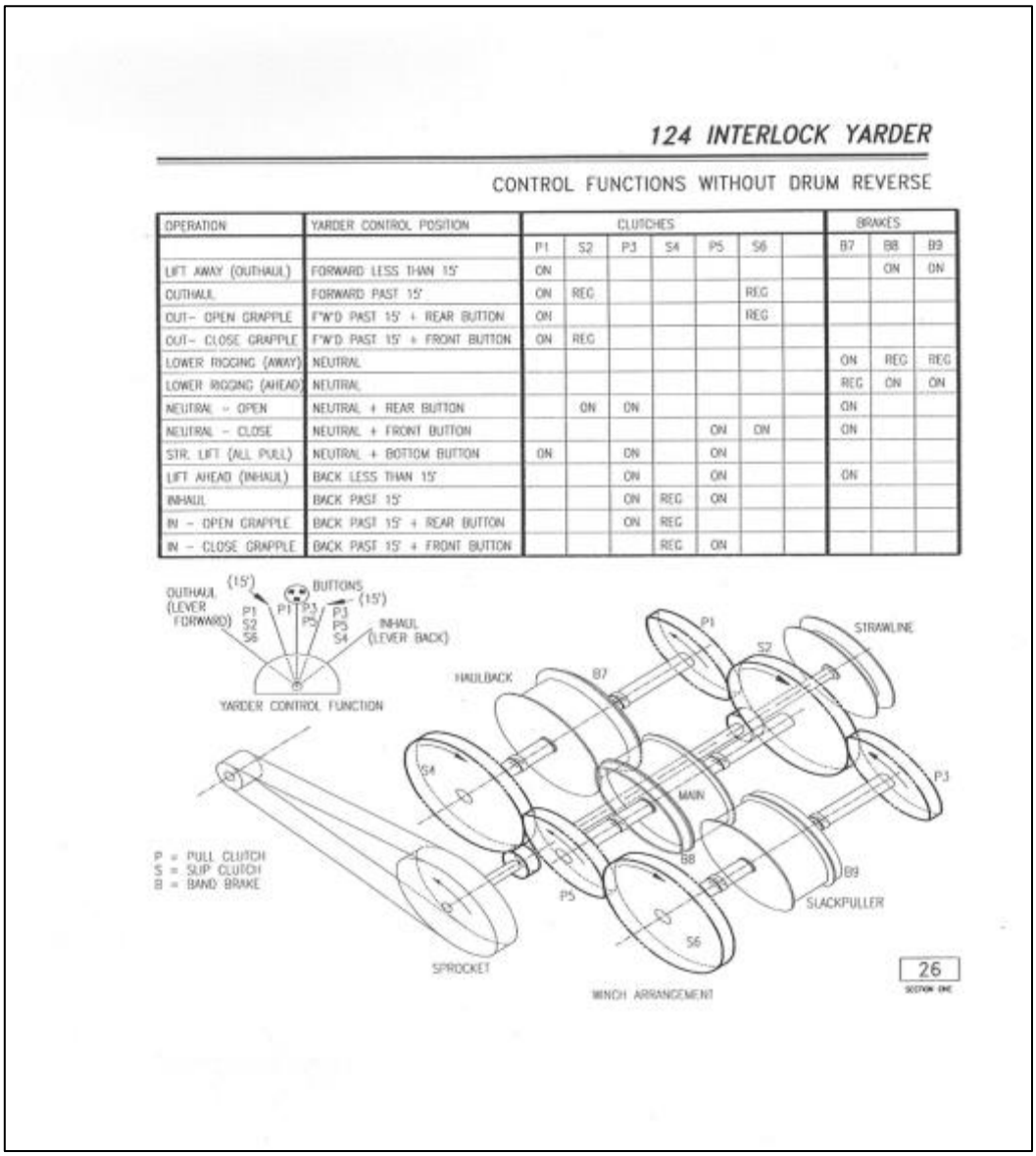
The design of an existing swing yarder drum and brake configuration is described, followed by three proposed control systems for improving control of grapple harvesting:

1. Proposed New Swing Yarder Design Version 1
2. Proposed Dual Tower/Swing Yarder Configuration – Tower
3. Proposed Dual Tower/Swing Yarder Configuration – Swing Yarder

Existing Design

The design of a current swing yarder drum and brake configuration (Madill 124 Swing Yarder) is described in Figure 4. The operation of the control lever is shown, as well as the sequence of operation of brakes and clutches for grapple operation.

Control handles currently fitted in Madill 124 machines are FX2-type lever air controls with both forward and back movement. For example, forward <15 degrees corresponds to outhaul with lift, and forward >15 degrees corresponds to outhaul. Speed is controlled with the throttle. Earlier machines were fitted with similar outboard motor-type electric controls (up to Madill 124 #50). Air-based controls have the advantage of providing “feel” or feedback resistance to the operator and are also cheaper and easier to maintain.



124 INTERLOCK YARDER

CONTROL FUNCTIONS WITHOUT DRUM REVERSE

OPERATION	YARDER CONTROL POSITION	CLUTCHES							BRAKES		
		P1	S2	P3	S4	P5	S6		B7	B8	B9
LIFT AWAY (OUTHAUL)	FORWARD LESS THAN 15°	ON								ON	ON
OUTHAUL	FORWARD PAST 15°	ON	REG				REG				
OUT– OPEN GRAPPLE	F'W'D PAST 15° + REAR BUTTON	ON					REG				
OUT– CLOSE GRAPPLE	F'W'D PAST 15° + FRONT BUTTON	ON	REG								
LOWER RIGGING (AWAY)	NEUTRAL								ON	REG	REG
LOWER RIGGING (AHEAD)	NEUTRAL								REG	ON	ON
NEUTRAL – OPEN	NEUTRAL + REAR BUTTON		ON	ON					ON		
NEUTRAL – CLOSE	NEUTRAL + FRONT BUTTON					ON	ON		ON		
STR. LIFT (ALL PULL)	NEUTRAL + BOTTOM BUTTON	ON		ON		ON					
LIFT AHEAD (INHAUL)	BACK LESS THAN 15°			ON		ON			ON		
INHAUL	BACK PAST 15°			ON	REG	ON					
IN – OPEN GRAPPLE	BACK PAST 15° + REAR BUTTON			ON	REG						
IN – CLOSE GRAPPLE	BACK PAST 15° + FRONT BUTTON				REG	ON					

Figure 4. Madill 124 Swing-Yarder drum and brake configuration (Source: Madill Equipment)

Disadvantages of existing configurations:

There are several disadvantages to the existing design, which is used on Madill 122,123, 124 and TSY355 machines:

- The drums are driven off the transmission, so there is no mechanism to stop the drums "running on" (minimal transmission braking at low rpm). Consequently, any braking is carried out using brake bands to bring drums to a stop. The brakes work against the inertia of the turning drums. The transmission has no braking, or minimal braking effect, particularly at low rpm.
- A combination of idling and use of foot brakes is used for fine control.
- Non-PLC controlled systems offer only one "style" of logging (there are no "variable-reversing"/no reversing options).

Note: A hydraulically operated system would provide precise control over drum movement. Braking would occur within the hydraulic motor (dynamic braking). Conventional brakes would have minimal use and would be used only as parking brakes and for safety.

Proposed Designs

1. Proposed New Swing Yarder Design Version 1.

In this proposal, the swing yarder has an additional hydraulic transmission and hydraulic motor fitted (Figure 5).

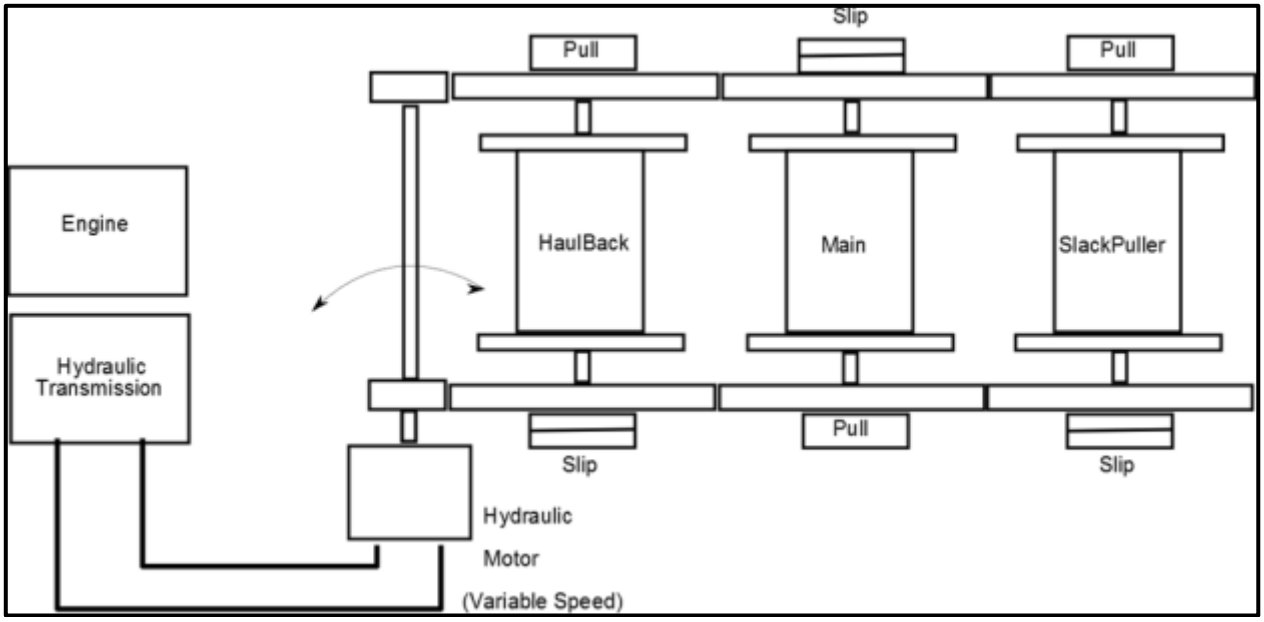


Figure 5. Proposed Swing Yarder design with additional hydraulic motor and transmission

Advantages

- Cost of the hauler is about the same as a conventional transmission hauler.
- There is less risk of stalling on landing (landing/slewing and dumping), as revolutions are automatically reduced at the same time as the swing hydraulic motor is activated.
- There is less risk of stalling as ropes are in-hauled. Ropes can act on the transmission as a consequence of the ropes tending to run off the drums driving the transmission in reverse – i.e., the hydraulic motor acts as a brake.
- This system provides greater control of speed during acceleration and de-acceleration because there is no throttle. Conventional transmissions systems lose slew power when throttling off.
- The grapple can be raised and lowered with the control lever.

Disadvantages

- One disadvantage is that the engine will be running at high idling speed to provide power to the hydraulic pump. This would result in an increase in fuel consumption.
- This is a full-interlocked machine, but operates at high rpm (revolutions per minute).

2. Proposed Dual Tower/Swing Yarder Configuration – Tower

This is a proposed design for either a tower or swing yarder, modified by adding a hydraulic transmission and hydraulic motor. In this design the motor and drive is located between the Skyline/Main and Main/Slackpuller drums (Figure 6). Note: a water-cooled brake is included for North Bend configuration, but is excluded from the swing yarder option below. The gear set is the same as for the swing yarder.

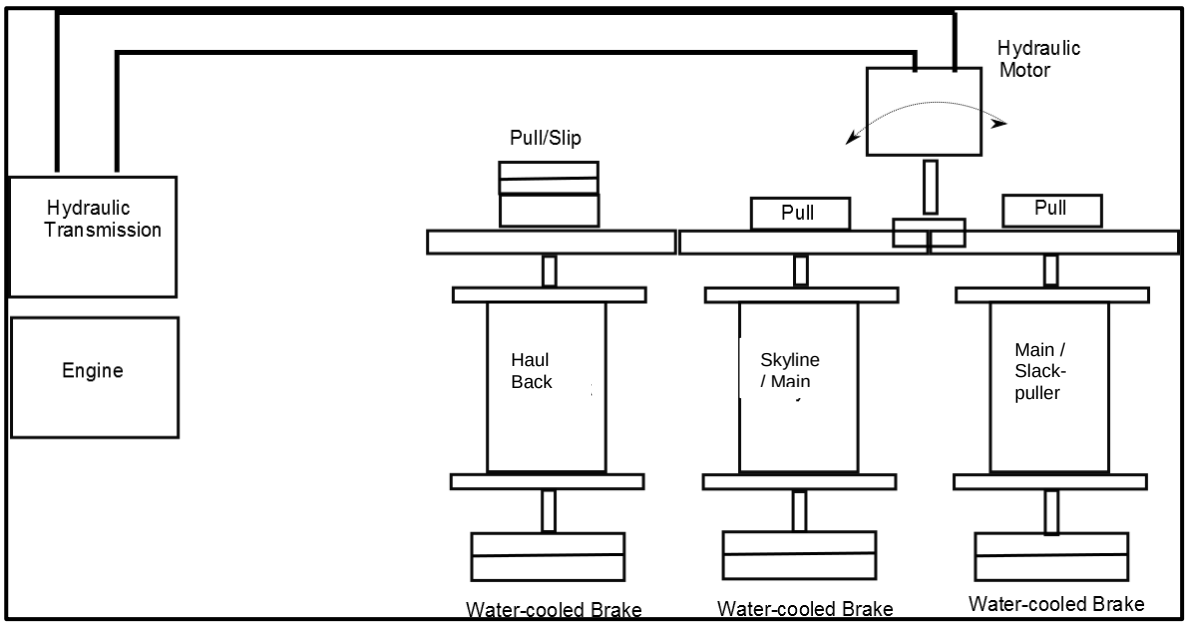


Figure 6. Proposed dual tower/swing yarder configuration – tower

Advantages

- A tower yarder can be constructed using the same basic design.
- For construction, one manufacturer can build the drum set and gears, hence it would be cheaper to build.
- This configuration would be simpler and be able to use multiple rigging systems. The design is based on a modified TSY255 drum-set.
- The hauler could be used as a half-interlocked machine, and run either a grapple or a Mechanical Slack-pulling (MSP) carriage.

Disadvantage

- A service brake (fitted pins or dogs) is required. A truck three-calliper disk brake could be used.

3. Proposed Dual Tower/Swing Yarder Configuration – Swing Yarder

In this proposal, either a tower or swing yarder is modified by adding a hydraulic transmission and motor, but locating the motor and drive by the Haul Back drum
An example of this proposed design is shown in Figure 7.

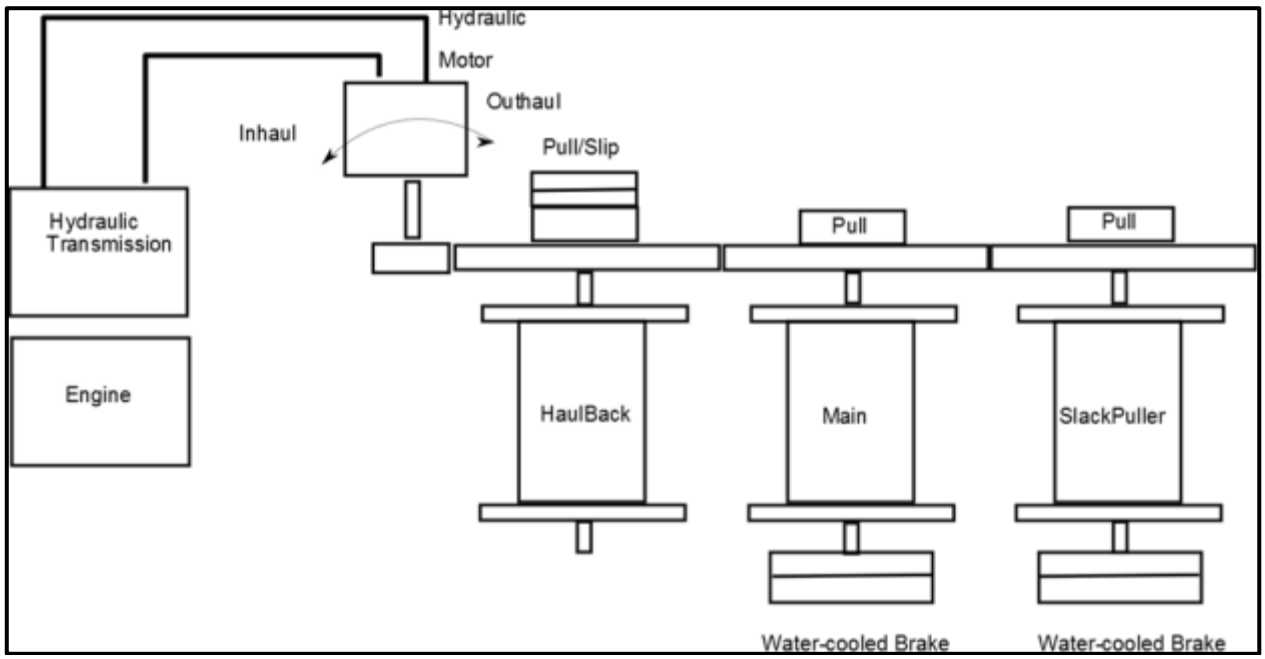


Figure 7. Proposed dual tower/swing yarder configuration – swing yarder

Advantages

- This design is the same basic design as the tower version (Figure 6) above.
- The same advantages apply in terms of construction cost.

Disadvantage

- No disadvantages identified with this system.

CONCLUSION

Improved control of grapples and grapple carriages is required for increased productivity of these systems. Effective control of the grapple carriage and hence the grapple used by towers or swing yarders is possible only through fine and precise control of the winch drum sets. The application of brakes and clutches through air-based systems cannot provide this fine control. Improved control could be achieved through installation of modern cab-control systems, and potentially by drive-line changes.

Information was gathered from cab-control system suppliers, and details of systems currently available for upgrading hauler controls are described. Costs ranged from $10,000 to around $30,000 depending on whether computer control by PLC was required. Advantages quoted include easier use of controls by operators, easier maintenance of control systems and reduced training time for operators.

In addition, improvements are proposed for two swing yarder and one tower hauler winch set configurations. These configurations involved the installation of a hydraulic drive pump and hydraulic motor. The motor would drive either all the drums, or only those drums where fine control was required. In the former case, braking would be applied using the hydraulic system, with an additional mechanical safety or service brake.

It was noted that such drive-line systems would cost about the same as that used in existing tower haulers and swing yarders. These proposed systems would provide the fine control required to position grapples and grapple carriages accurately to help improve grappling productivity.

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