WHY?

Geardriven Drawworks

Innovation for Drilling Efficiency!

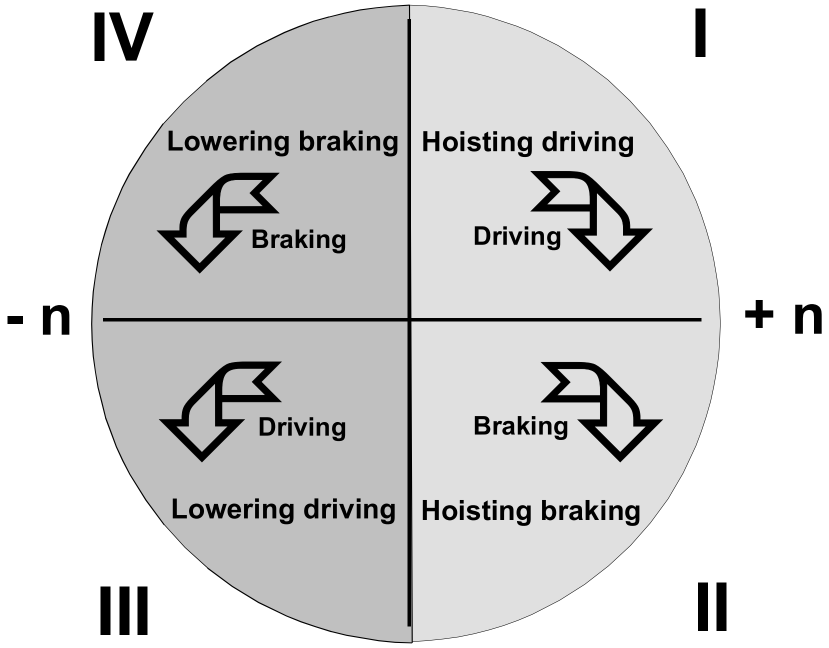
WIRTH

Innovation for Drilling Efficiency

Geardriven Drawworks and its features

Geardriven drawworks are gaining more and more acceptance in the oil industry. Beside some landrigs and offshore operations, the new technology has been utilised in the North Sea almost exclusively in recent years. The major reasons are improved safety, optimal performance and control, significant weight reduction, and considerably increased reliability. Combining the different performance characteristics of a dynamic brake, a regenerative brake via the drive motors, with an intelligent automated Drawworks Control Package (DCP) provides a new standard. Performance, comfort and safety of this standard are hardly to achieve in the traditional way. The key to this success is the development of a drawworks with positive-locking drive configuration and the utilisation of the unique features of gear drives, which are beyond the capacity of standard chain driven drawworks, both technically and with regard to safety. Utilising the 4-quadrant (4Q) mode for the drive, a major obstacle for a chain drive configuration generates additional regenerative braking power via elements, motors already in place.

4Q-Drive



+ n ⟶ hoisting rpm
- n ⟶ lowering rpm

4Q-Drive means that all 4 variations of rotating drive energy of a motor are utilised.

The first quadrant is represented by running out of the hole where the required energy is used for accelerating and lifting the load. This is the drive quadrant used in hoisting operations.

The 2nd quadrant is used to stop the lifting cycle. Braking is effected via the drive motor acting as a generator to decelerate and stop the rising load. A mechanic brake, as on a traditional drawworks, is not utilised.

In the 3rd quadrant power is applied to the motors while lowering, accelerating the load as long as the drill line is subject to tensile stress. In contrast to the traditional design where the mass moment of inertia of the drum and associated components had to be overcome by the weight of the empty block, it applies in a controlled driven manner.

In the 4th quadrant braking is applied while lowering the string acting the motor as a generator. The ideal complement of dynamic braking and regenerative braking with drive motors, both frictionless is always applied in the optimum range demanded. Here too, the need of a mechanic brake is not required.

Advantages

Running the 3rd quadrant, a considerable timesaving is achieved.

Two side by side drilling operations showed that a 2000 hp gear-driven drawworks is negligibly faster through a 16,000-ft. roundtrip than a 3000 hp chain-driven drawworks. This proved that the power advantage of 1000 hp more lifting capacity was not only eliminated by the 4-Q drive configuration of the gear-driven drawworks, but had even been surpassed. Both drawworks had comparable pulling capacities.
With its 3-speed design, the gear-driven drawworks was perfectly designed for casing operation and drill pipe tripping as well as for operations with low loads, e.g. an empty block.

Running the 4th quadrant, improvement on HSE and maintenance is achieved.

Brake noise of up to 130 dBA as on chain drawworks is completely eliminated, which represents a significant improvement in health and safety contributing to the adherence to maximum drill-floor area noise standards and the environment. The mechanic brake is only used as parking or emergency brake. Downtime due to maintenance of the brake is almost eliminated.

The power transition from quadrant 1 to 2 and/or from 3 to 4 demands highly on the components of the drive train. In this respect it is advantageous to use gears instead of chains. Considering the well-known chain slack in the lower layer while driving that promptly changes into a slack in the upper layer upon braking represents beside extreme wear a safety relevant problem.

Steadily increasing demands of higher drilling loads make the limits of chain as a drive element evident. The chain can only be designed for a limited service life (e.g. for the 1st gear with maximum load only a few hundred hours will be reached), whereas the gear type design is easily be engineered for extended durability and fatigue resistance resulting in an enormous improvement of safety and maintenance.

The 4Q-Drive system can be applied with either DC or AC motors. AC motors with a slightly higher braking capacity than DCs deliver the advantage of full load control at 0 speed, whereas, with a DC drive the parking brake will take the load after a brief period to protect the commutators. DC-4-Q drives have been utilised on numerous drawworks applications and became state of the art for gear-driven drawworks.

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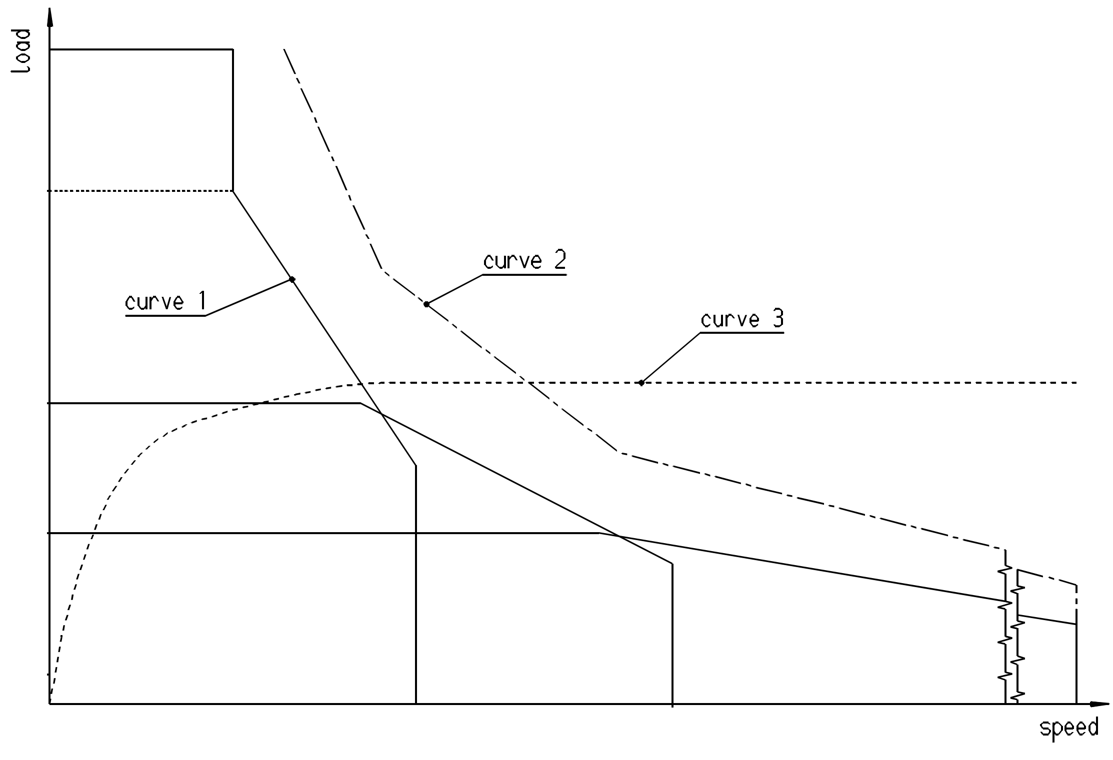
Optimised Braking System

Traditionally, a chain-driven drawworks DC motor is not used to regenerate energy of the drawworks. The drawworks DC motors are disengaged from the drum and are slowed down to cathead speed by utilizing either regenerative or dynamic braking (energy dissipates as heat). The new generation of gear-driven drawworks is equipped with two or three main DC or AC motors and enables the operator to retard and stop a descending or ascending load smoothly in a controlled manner without exceeding equipment limits. Both the DC and AC motors in the 4-Q mode provide regenerative braking by feeding the braking energy back into the respective 600/690 V bus, or AC chopper resistor bank system.

It is often stated that for an AC 4-Q drive, a dynamic brake (electro-magnetic or hydraulic) is not required. In principle, this statement appears correct. The reduction of Capex for a dynamic brake has to be paid with tripping time and confinement of safety.

The optimisation of a braking system has to be seen in the ideal complementation of the different performance characteristics of the involved brakes, their friction free operation and the mobilisation of equipment already installed (drive motors). See next graphs.

Picture I



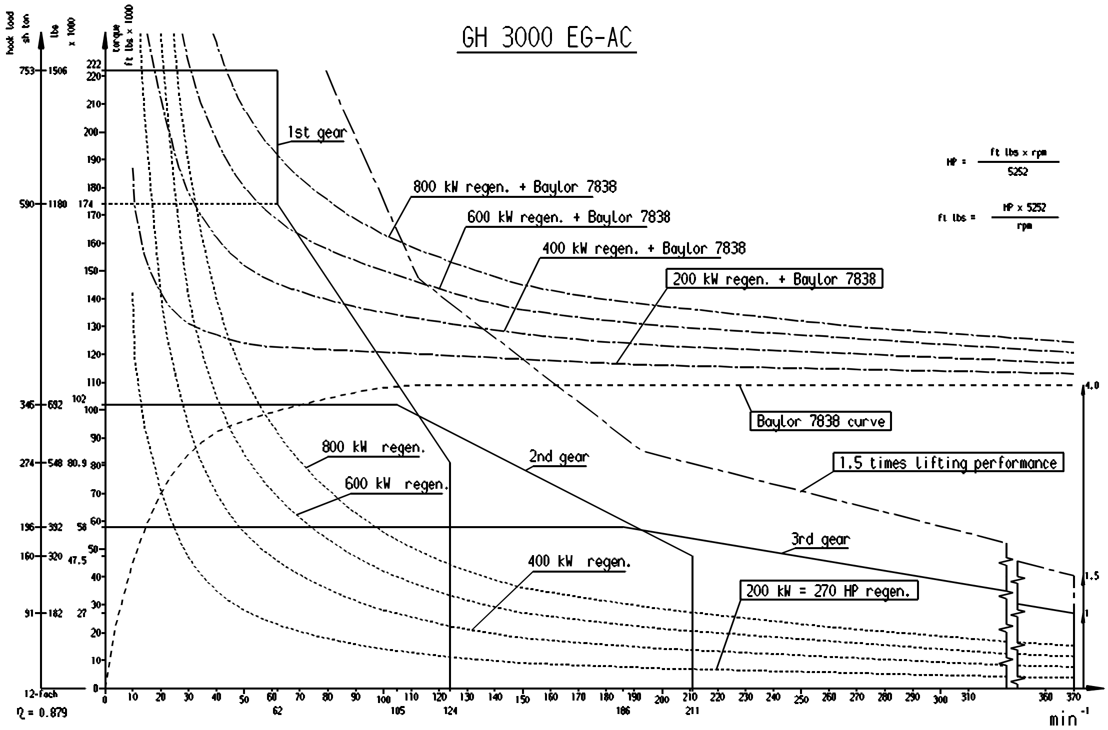
Curve 1 shows the performance of a three-speed drawworks.

Curve 2 running in parallel to 1, shows the physically limited braking capacity of the respective AC drive.

Curve 3 shows the braking characteristics of a dynamic brake; the complimentary nature of the dynamic brake with the regenerative brakes is distinctly evident.

The regenerative brake shows its max. capacity with high loads and low speeds, whereas the dynamic brake performs its maximum at high speeds. Here, braking capacity up to 6000 kW is realised.

Picture II

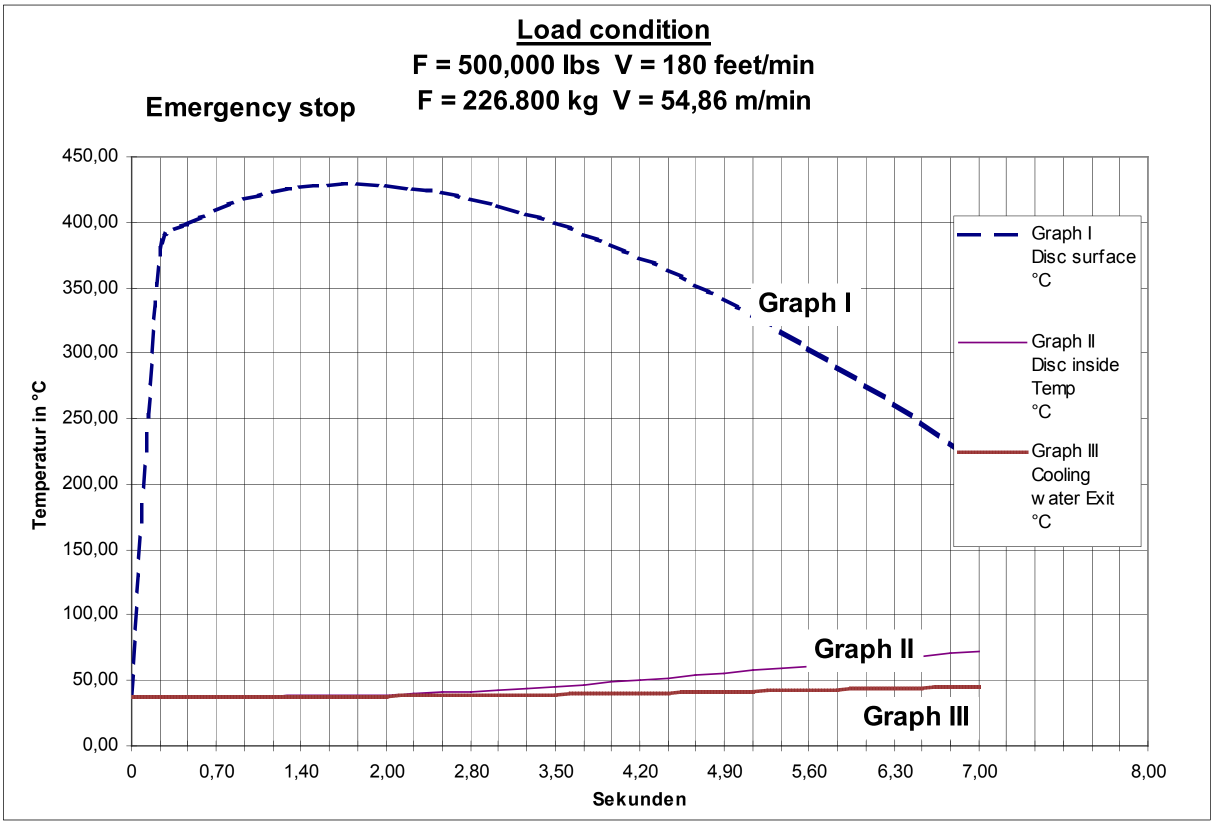


If the dynamic brake is not used, logically, a loss in active safety has to be considered besides the longer braking time. If, for any reasons, the product of load and speed is beyond 150 % of the electric motors driving capacity, an accident is almost unavoidable. In such a high operating range the mechanic brake tends to fade, and its water cooling does not represent an improvement for the safety situation.

Casing operation, or similar high load work, in the low drive ration is always executed at reduced speed. In the middle and lower load range, in which the tripping is carried out, there is the danger of a dynamic overload and of exceeding the stopping capacity without a dynamic brake. Mechanical brakes have a tendency to fade under such high loads, causing a steadily increasing loss in braking capacity. In an emergency stop without dynamic brake, tests have proved that temperatures up to 430° C can temporarily occur on the disc surface when lowering a normal string weight of about 250 tons (Picture III). The temperature gradient through the thickness of a brake disc is clear evidence of the short-term ineffectiveness of the cooling water in controlling the disc surface temperature.

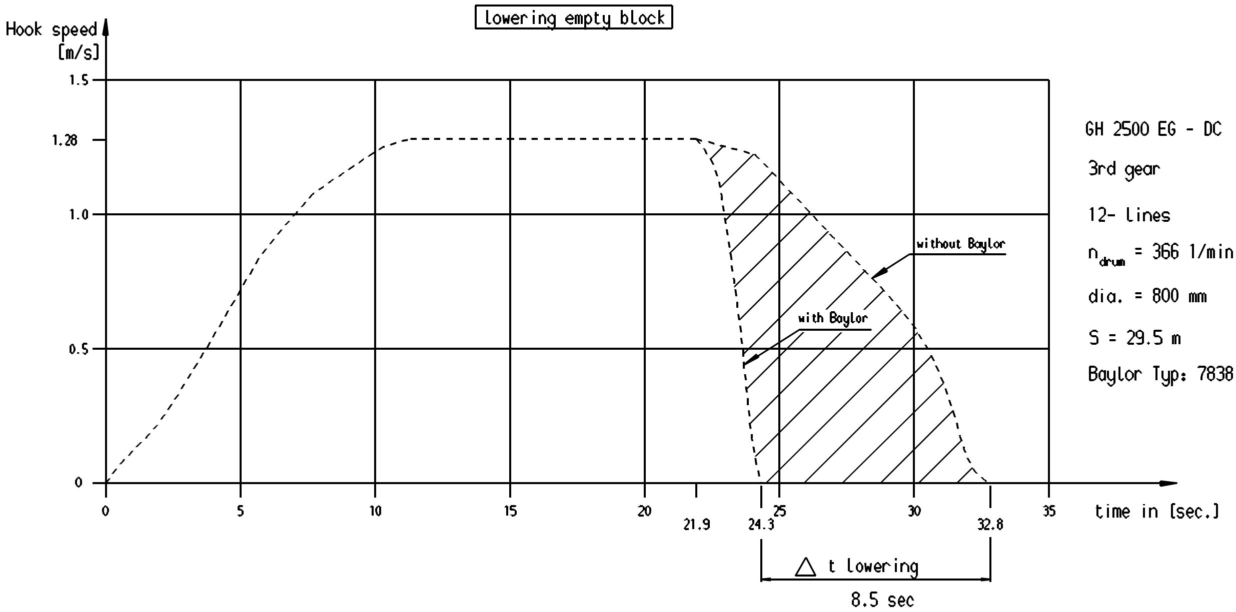
Graph II represents the surface temperature inside the disc. The temperature inside increases only by about 8 % above the temperature of the outer disc surface. This shows that water cooling does not have any influence in this extreme situation. It only contributes during long term, routine operations, such as tripping. The multi-disc, water cooled brakes, frequently used for drawworks brakes, can only be safely operated at loads inversely proportional to the speed, time consuming. At increasing speed the maximum braking moment must be reduced to prevent thermal damage to the brake. Only a dynamic brake is able to absorb greater energy at higher speeds without the potential for thermal damage or additional speed related modulation.

Picture III



As a result of these conditions, only the combined use of a dynamic brake and a regenerative brake remains practical for safety reasons. The same conclusion can be reached for economical reasons. With almost equal equipment costs and weight of a dynamic brake compared to resistor banks, the loss in operating speed and rig time using only regenerative braking, justifies the inclusion of the dynamic brake.

Picture IV



To demonstrate the benefit of using a dynamic brake in combination with 200 kW regenerating braking power compared to a drawworks with regenerative braking only, a site test was arranged with a 2500 HP gear-driven drawworks. It was executed with an eddy current brake combined with 250 kW regenerating power via the drive motors into the net. The second test was executed with 2500 hp regenerating power only.
The results are represented in picture IV and show a loss of 8.5 seconds per stand just in lowering mode of the empty block. The test was carried out with 12 lines strung to the block, in the 3rd gear, and a block speed of about 330 fpm (1.7 m/s). On this rig, a loss of 8.5 seconds for every stand would result in a loss of 3.8 stands per hour tripping speed. Considerably higher time losses would result for drawworks without gear-shifting where the AC motors operate at 3000 rpm. Here, the possible braking capacities of the AC motors of 1.5 times driving capacity at 1600 rpm drop to only 1.09 times at 3000 rpm. This means tripping speed equals almost tripping out speed and inevitably causes further serious losses of time.

The eddy current brake performs only in dynamic condition and can neither stop nor hold a static load. It is directly attached to the drawworks shaft and acts together with the motor brake in a complementary way suitable for all dynamic conditions. Regenerative motor braking with AC power in the 4-Q configuration is able to brake the load down to zero speed, completely without any wear, silent and frictionless.

The drawworks standard disc brake is equipped with service callipers that are applied to the disc mounted on the drawworks drum shaft. Three sets of disc pads are installed. These callipers are used for parking and in case of emergency. The emergency system is realised by spring loaded callipers and applies with hydraulic pressure release, thereby providing a failsafe system. Any loss of power or hydraulic failure will apply all the callipers for an emergency stop. The regular drawworks control (DCP) will only apply the callipers for parking and under service conditions holding the load in a static condition, thus preventing unintentional lowering or raising of the load. Therefore no cooling system is necessary.

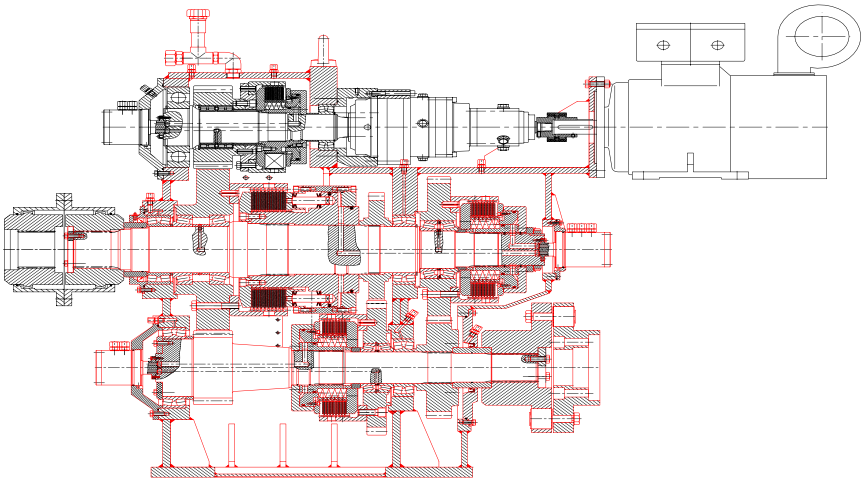
Reduction of the Mass Moments of Inertia

The impact on the mass moments of inertia is of importance. Due to the required locked-in engagement of the drive train of the 4Q-drive, all drive components also have to be considered in the calculation, besides the drawworks drum and the chain drive for a conventional drawworks. A disengagement of the drum and the drive of a geardriven drawworks is for safety reasons not allowed.

An optimal weight configuration is of highest priority for the new drawworks generation. Compact transmission gears with a high reduction ratio provide with the minimum mass moment of inertia possible the best solution for safety and performance in spite of their significant design challenge. Revenues obviously can be gained weight- time- and cost-wise.

Autodriller System

Feed Off Device



The capability to build in an Autodriller is easily given by adding an extra AC drive of 30 or 60 kW, independent from the main drive. With a lifting capacity of up to 350 tons at about 3.5 fpm (65 m/h). This Autodriller drive system is able to control the ROP triggered by different parameters and can also be used as an emergency back-up for the main drive. In case of a major failure of the drawworks AC or DC drive, the drillstring can be secured from the bottom into cased hole at a reduced speed.

During drilling, automatic operation via PC control is possible on any of the following parameters:

constant speed
constant weight on bit
constant mud pressure

The highest sensitivity and accuracy of control will be achieved.
This allows maximum service life of the drilling tools, reduced the work load on the drilling crew, by maximum adherence to the desired drilling parameters.

The same type of autodriller is theoretically possible with AC as primary drive, however, a suitable gearing for this application is not available. The redundancy in case of a failure of the main drive, or the possibility to position components in the mast during rig-up, before connecting the main drive is not given.

ACS-System

The Anti Collision System (ACS) is designed to optimise safety and efficiency of the movement of the travelling assembly during hoisting and lowering activities. The system controls the three individual braking systems of the drawworks, and interlocks them with the controls of the drawworks and other sub-systems as Roughnecks, Pipehandler etc.

The ACS system provides monitoring of the drawworks braking systems. Its two PLCs calculate the position, speed and braking distance required for the hook load independently and compare the kinetic situation permanently with the total braking power actually available. Due to the controlling system algorithm, both PLCs are able to apply the regenerative brake, eddy current brake and disc brake independently taking into account the kinetic energy of the system and the braking capacity of the drawworks braking systems.

Parameters such as hook position, load and required braking distance are continuously checked and compared between both microprocessors and any discrepancy will be regarded as an ACS system fault and will activate the AC/DC motor regenerative braking, eddy current brake and, if necessary, the disc brake, to bring the load to a safely controlled stop.

Both PLCs are checking the following continuously:

- Any discrepancy between the two speed and position sensors
- Load sensor failure
- Encoder failure
- Position fault
- PLC control failure
- Power supply fault
- Drum speed (reference signal)
- Hardware fault (i.e. PLC contacts fault)
- Hook position > 100%
- Hook position < 0%

The ACS interfaces beside a well known kinetic anti collision device to the zone management system. Interlockings with all sub-systems of the rig can be realised. Teachpoints for the hook position allow to reproduce operational sequences for example during trips with high accuracy again and again.

In the Automatic mode the system calculates the optimum braking distance. At a position equal to that of twice the braking distance required, the ACS system initiates the AC/DC motor regenerative braking and indicates to the driller that the system is active. At a position which corresponds to the full braking distance required, the eddy current brake is also activated by the ACS. If the system then determines that the braking efficiency of the AC/DC motors regenerative braking and the eddy current brake is impaired, then the system will engage the emergency disc brake.

In conjunction with the eddy current brake control system, the DC motor regenerative braking will be applied to ensure that the maximum eddy current brake rotor speed (drawworks drum speed) is not exceeded. If this value of speed was allowed to be exceeded, the eddy current brake efficiency will deteriorate and safety will be compromised. However, the ACS system monitors the rotor speed and prevents the drawworks approaching this value by applying the braking system(s).

The amount of regenerative braking of the AC/DC motors is dependant upon the connected available power and the `stiffness` of the system generation. The system takes this into account and calculates the amount of regenerative braking that can be applied.

The system limits will be set to the maximum upper and lower limits on the ACS-HMI located in the drillers control room.

The system provides analysis of the kinetic energy of the hoisting system taking into account the braking capacity of the entire system, hook load, speed and position of the travelling block assembly.

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