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Dock Leveller Lip Control for Trailer Suspension Settling Compensation

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Abstract

This disclosure describes a dock leveller lip control system designed to maintain continuous contact between the leveller lip and a trailer bed during loading or unloading operations. The system addresses the problem of trailer suspension settling, which causes the trailer bed height to decrease as its load increases, potentially leading to a loss of bearing for the leveller lip. It incorporates mechanisms for detecting lip contact loss and features an interlock with a vehicle restraint system to ensure operational safety and efficiency. The control system permits a designated settling range while actively managing lip position to ensure proper load transfer.

1. Technical Field

[0001] The present technical disclosure relates to dock levelling equipment used for loading and unloading cargo from vehicles, specifically addressing mechanisms for controlling the lip section of a dock leveller to maintain continuous contact with a vehicle's cargo bed despite changes in the vehicle's suspension height during loading or unloading operations.

2. Technical Context

[0002] Loading and unloading operations at a loading dock typically involve a dock leveller forming a bridge between the dock floor and a vehicle's cargo bed. The leveller's main deck raises or lowers to match the vehicle bed height, and a hinged lip extends to overlap the bed, creating a continuous surface for material handling equipment. A common challenge arises from the dynamic nature of vehicle suspensions. As cargo is loaded onto a trailer, its suspension compresses, causing the trailer bed to settle or lower. Conversely, as cargo is unloaded, the suspension extends, and the bed rises. If the leveller lip (34) does not adapt to these changes, it can lose contact with the trailer bed (36), creating a gap or an unsafe angle that impedes material flow, damages equipment, or poses a hazard. This issue is particularly pronounced with trailers equipped with air ride or soft suspensions, where settling can be significant. The system described herein provides a control methodology and associated components to actively manage the lip's position, ensuring continuous, safe bearing on the trailer bed throughout the loading or unloading cycle.

3. System Overview

[0003] The dock leveller lip control system comprises a central control unit (10), a hydraulic power unit (12), hydraulic cylinders for both the main deck (14) and the lip (16), and various sensors, including a lip position sensor (18) and a settling detection sensor (22). An operator panel (24) provides user interface capabilities. The system is designed to integrate with a

vehicle restraint system (20) to ensure the vehicle is securely positioned before and during operations. The core functionality involves continuously monitoring the interaction between the leveller lip (34) and the trailer bed (36). When the system detects that the lip is losing contact or is about to lose contact due to trailer settling, it automatically adjusts the lip's position to re-establish and maintain firm bearing. This proactive adjustment allows for a specified settling range, accommodating the typical vertical movement of a trailer bed during cargo transfer. FIG. 1 illustrates the functional blocks and their interconnections within this system.

4. Components

[0004] The primary components of the system include:

[0005]

- **Control Unit (10)**: This electronic unit contains a microprocessor and associated circuitry. It receives inputs from various sensors, processes control algorithms, and generates output signals to actuate hydraulic valves. The control unit (10) manages the overall operation, including sequencing, interlocks, and adjustment responses.
- **Hydraulic Power Unit (12)**: A self-contained unit comprising an electric motor, a hydraulic pump, a fluid reservoir, and control valves. It supplies pressurized hydraulic fluid to the main deck cylinder (14) and the lip cylinder (16) under the direction of the control unit (10).
- **Main Deck Cylinder (14)**: A hydraulic cylinder responsible for raising and lowering the main deck (30) of the dock leveller to align with the initial height of the trailer bed (36).
- **Lip Cylinder (16)**: A smaller hydraulic cylinder, typically mounted beneath the main deck (30), which extends or retracts to pivot the lip section (34) up or down around its hinge (32).
- **Lip Position Sensor (18)**: A sensor, such as a rotary encoder or a linear potentiometer, attached to the lip hinge (32) or lip cylinder (16), providing continuous feedback to the control unit (10) regarding the precise angle or extension of the lip section (34).
- **Settling Detection Sensor (22)**: This sensor is crucial for identifying loss of contact between the lip (34) and the trailer bed (36). It may be a pressure sensor integrated into the lip support structure, a proximity sensor mounted near the lip's end, or a load cell system.
- **Vehicle Restraint System (20)**: An electromechanical or hydraulic device that secures the trailer to the loading dock. It communicates its status (engaged/disengaged) to the control unit (10).
- **Operator Panel (24)**: A panel with buttons, indicator lights, and potentially a display, allowing an operator to initiate leveller operations, select modes, and receive status feedback.

[0006] FIG. 2 provides an elevation view depicting the spatial relationship between the main deck (30), lip section (34), lip cylinder (16), and the trailer bed (36), along with the placement of the settling detection sensor (22).

5. Operation

[0007] The operation of the dock leveller lip control system proceeds through several phases:

[0008] **Start-up and Initial Positioning:**

[0009]

- An operator initiates the leveller sequence via the operator panel (24).
- The control unit (10) verifies that the vehicle restraint system (20) is engaged and the trailer is secure. If not, operation is inhibited, and an alert is displayed.
- The main deck (30) is raised by the main deck cylinder (14) to its full upright position.
- The lip cylinder (16) extends, causing the lip section (34) to pivot outward and extend beyond the edge of the dock.
- The main deck (30) is then lowered until the lip section (34) makes contact with the trailer bed (36). The lip position sensor (18) confirms the lip's angle, and the settling detection sensor (22) registers initial contact pressure or proximity.
- Once the lip (34) is bearing correctly on the trailer bed (36), the system enters steady-state running mode.

[0010] **Steady Running (Load/Unload Cycle):**

[0011]

- During loading or unloading, the trailer bed (36) may settle or rise.
- The settling detection sensor (22) continuously monitors the contact condition between the lip (34) and the trailer bed (36).
- If the trailer bed (36) settles, the contact pressure or proximity measured by the settling detection sensor (22) may decrease, indicating potential loss of bearing.
- The control unit (10) processes this input. If the detected condition falls below a predefined threshold or indicates a gap, the control unit (10) activates the lip cylinder (16) to slightly lower the lip section (34) or the main deck (30) to follow the trailer bed (36).
- Conversely, if the trailer bed (36) rises, the contact pressure may increase, or the lip angle may become too steep. The control unit (10) would then command the lip cylinder (16) or main deck cylinder (14) to raise the lip section (34) or main deck (30) to maintain optimal contact.
- This active adjustment occurs dynamically and continuously, within a pre-programmed settling range (e.g., 100 mm to 200 mm of vertical movement), ensuring the lip (34) remains securely on the trailer bed (36). The lip position sensor (18) provides feedback for precise control.

[0012] **Fault or Interruption:**

[0013]

- If the settling detection sensor (22) indicates a complete loss of contact for a duration exceeding a set time (e.g., 2 seconds), or if the lip position sensor (18) indicates the lip (34) is outside its operational angle range, the control unit (10) registers a fault.
- In a fault condition, the system may automatically halt operations, raise the main deck (30) and retract the lip (34) to a safe position, and activate an alarm on the operator panel (24).
- If the vehicle restraint system (20) disengages during operation, the control unit (10) immediately initiates an emergency stop sequence, retracting the lip (34) and raising the main deck (30), while signaling a warning.
- Manual override or reset functions are available via the operator panel (24) for safe recovery from faults.

6. Example Embodiments

[0014] **Embodiment 1: Hydraulic Float Lip System** In this configuration, the lip cylinder (16) is connected to the hydraulic power unit (12) through a valve that allows for a "float" condition. During steady running, after initial lip placement, the valve is set to permit limited hydraulic fluid flow to or from the lip cylinder (16). This allows the lip (34) to float vertically with the trailer bed (36) under gravity, while maintaining pressure from the main deck (30) via the main deck cylinder (14). The settling detection sensor (22) acts as a monitor, and if the float range is exceeded or contact is lost, the control unit (10) takes active command to reposition the main deck (30) or the lip (34). This embodiment is suitable for applications where the expected settling range is moderate and dynamic response needs are less stringent. The float mechanism reduces the frequency of active hydraulic adjustments, potentially extending component life.

[0015] **Embodiment 2: Actively Driven Lip System** This embodiment utilizes the lip cylinder (16) in a fully active, closed-loop control mode. The control unit (10) continuously receives data from the lip position sensor (18) and the settling detection sensor (22). Based on these inputs, the control unit (10) constantly modulates the hydraulic flow to the lip cylinder (16) via proportional or servo valves. This enables precise and rapid adjustments of the lip angle to match trailer bed (36) movements. The system actively pushes the lip (34) into contact with the trailer bed (36) at a predetermined force or maintains a specific contact pressure, even as the trailer settles or rises. This configuration offers higher responsiveness and precision, accommodating a broader and more dynamic settling range, typically from 150 mm to 300 mm.

[0016] **Embodiment 3: Hybrid Lip Control with Load Sensing** This embodiment combines aspects of both float and actively driven systems, while adding a load sensing capability. Load cells or strain gauges are integrated into the lip hinge (32) or main deck support structure to directly measure the downward force exerted by the lip (34) on the trailer bed (36). The settling detection sensor (22) could be augmented by these load cells. The system operates in a float mode for minor trailer movements, but if the load cell readings indicate a reduction in bearing force below a threshold, or an increase above a maximum safe limit, the control unit (10) switches to an actively driven mode to precisely adjust the lip (34) or main deck (30) position. This provides a balance between energy efficiency (float mode) and precise control (driven mode), while ensuring load integrity.

7. Alternative Configurations

[0017]

- **Electric Actuation**: Instead of hydraulic cylinders, the main deck (30) and lip section (34) could be actuated by electric motors coupled with gearboxes or linear actuators. This would replace the hydraulic power unit (12) with motor controllers and power supplies.
- **Pneumatic Actuation**: For lighter duty applications or where hydraulic fluid contamination is a concern, pneumatic cylinders and a compressed air system could be used for deck and lip movement. This would require appropriate sizing for the desired force and speed.
- **Wireless Sensor Integration**: Sensors (18, 22) could transmit data wirelessly to the control unit (10), simplifying wiring and installation, particularly for retrofit applications.

- **Inductive Loop Vehicle Detection**: In place of or in addition to the vehicle restraint system (20) for initial presence detection, an inductive loop embedded in the approach lane could signal the arrival and position of a trailer.
- **Camera-based Lip Position Sensing**: A vision system comprising a camera and image processing software could be employed to non-invasively monitor the lip angle and its contact with the trailer bed (36), potentially replacing or augmenting the lip position sensor (18) and settling detection sensor (22).

8. Parameter Variations

Parameter	Range	Effect of increasing value	Effect of decreasing value
Trailer Settling Range	100 mm to 300 mm	Requires greater travel for lip/deck, more frequent or larger adjustments, increased actuator sizing.	Reduces required travel, fewer adjustments, simpler actuator requirements.
Lip Contact Force Threshold	50 N to 200 N	Ensures firmer contact, potentially reducing chatter, but may induce more stress on lip/trailer.	Risk of intermittent contact or loss of bearing, smoother operation, less stress.
Lip Adjustment Speed	10 mm/s to 50 mm/s	Faster response to settling, maintains tighter contact during rapid load changes.	Slower response, may lead to temporary gaps or excessive force, less smooth operation.
Settling Detection Delay	0.5 s to 5 s	Reduces nuisance adjustments from momentary disturbances, but increases risk of prolonged contact loss.	More immediate response, but may react to minor, transient fluctuations.
Lip Overlap Distance	200 mm to 400 mm	Provides more bearing surface, greater tolerance for trailer misalignment, requires longer lip.	Reduced bearing surface, less tolerant of misalignment, shorter lip.
System Cycle Time (Scan Rate)	10 Hz to 100 Hz	More frequent monitoring and faster control loop updates, increased processing demand.	Less frequent monitoring, slower detection of settling, potential for larger deviations.

9. Additional Implementations

[0019] The control principles described can be extended to various other material handling scenarios. For instance, the system could be adapted for levelling platforms that interact with rail cars, which also exhibit suspension settling characteristics. The same methodology for detecting contact loss and dynamically adjusting a bridging element can be applied. Furthermore, the system could incorporate predictive algorithms that learn typical settling patterns for different trailer types or cargo densities, allowing for proactive adjustments rather than purely reactive ones. This would involve a data logging and analysis module within the control unit (10) that correlates load changes with observed settling rates. The interlock with vehicle restraint systems (20) can be augmented with additional safety layers, such as optical sensors that confirm the absence of personnel between the dock and trailer before any lip movement. The operator panel (24) could feature advanced diagnostics, displaying real-time graphs of lip contact force and position, assisting maintenance personnel in system tuning and troubleshooting.

10. Figures

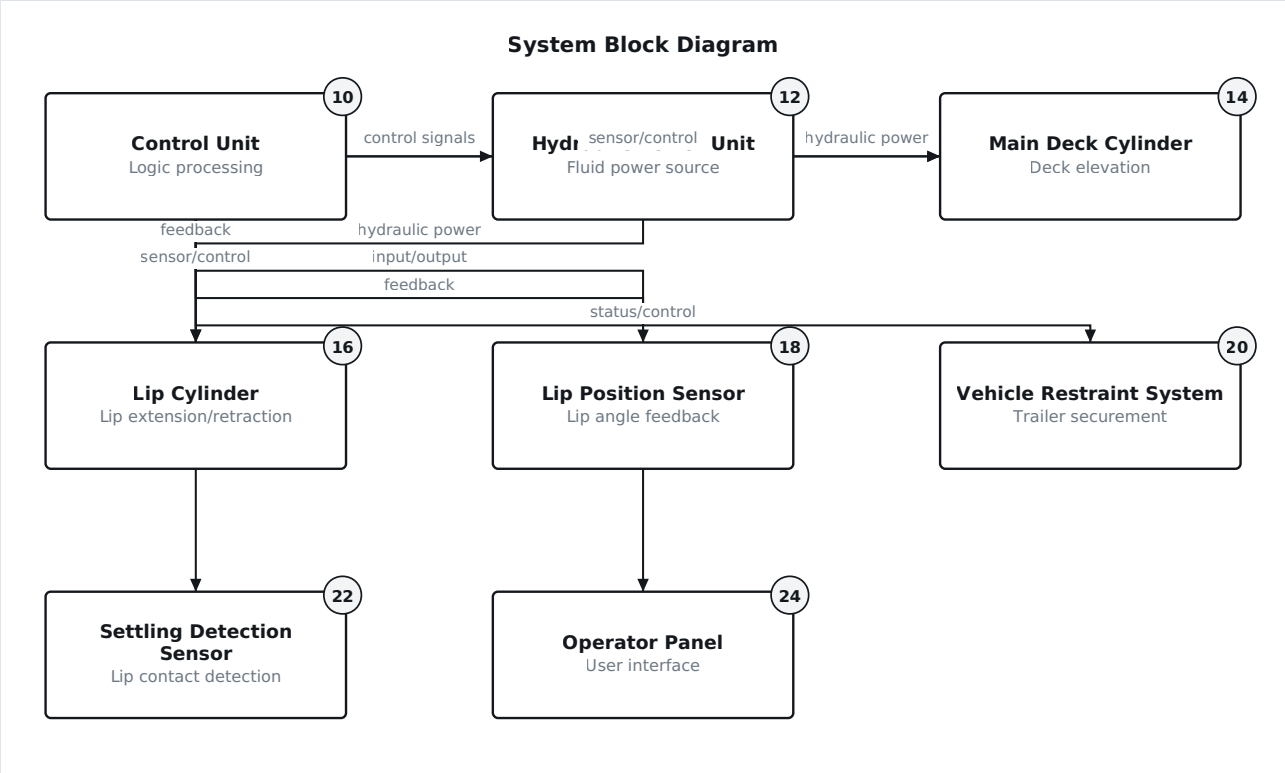

FIG. 1 A block diagram illustrating the primary components and their functional relationships within the dock leveller lip control system. PNG

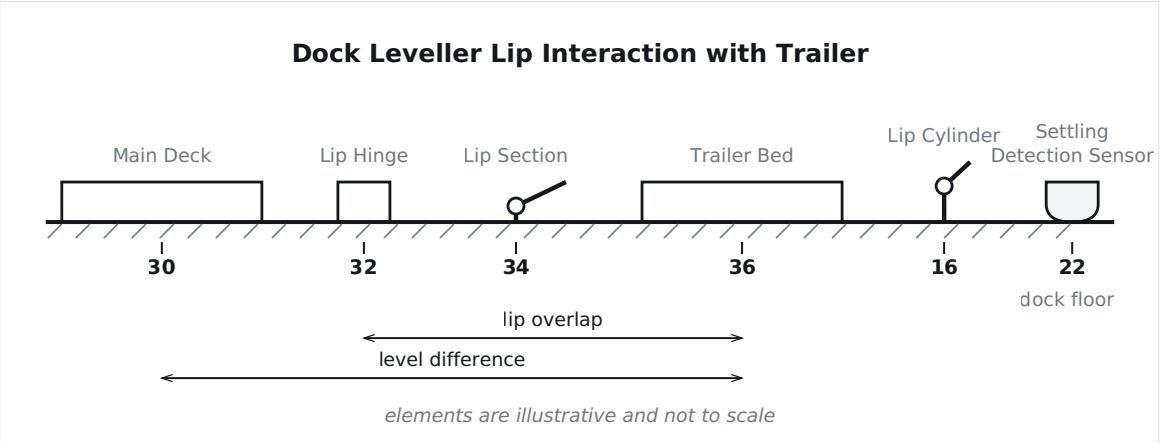

FIG. 2 An elevation view showing the dock leveller lip in contact with a trailer bed and key associated components. PNG

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