Adaptive Brakes, A Revolution in Safety

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INTORQ Locations

- Market Leader Forklift Industry
- Worldwide Manufacturing
- German Engineering
- Development Partner
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The Idea!

A Device for Every Truck Application …

Braking Situations and Performance
The Concept: Think different!

- Control the Deceleration Rate
- Torque Transfer – Brake And Drive
- Load-Dependent Braking
- Braking without Blocking Drive Wheels
The Benefits!

- Intelligent Braking System
- Additional Performance Value
- Monitoring of all the Brake Safety Functions e.g. Wear Monitoring
- Unique Technical Solution
Spring Applied Brake: Working Principle

\[
F_N = F_F - F_M \\
M = 2 \mu r_m F_N \\
F_M = f(I,s) \sim I / s
\]

Normal force \( F_N \),
Mean friction radius \( r_m \),
Magnetic force \( F_M \),
Friction coefficient \( \mu \),
Spring force \( F_F \),
Current \( I \), Air gap \( s \)

1 = Armature plate
2 = Springs
3 = Rotor
4 = Hub
5 = Shaft
6 = Flange
7 = Stator
The Perfect Solution!

Variation of the Brake Torque from 20% to 100% of the Rated Torque

Spring- Applied Brake  +  Control
How to Simulate the Braking Behavior?

GUI Configuration Tool

- **Sensors**
- **Brake**
- **CAN Adapter**
- **Control**
- **24V**
Braking Test With and Without Controller
Emergency Stops Without Smart Control

Stopping Behavior Depended of Load and Speed

\[ a_{\text{Loaded}} < a_{\text{Unloaded}} \]
Emergency Stops With INTORQ Control

Constant Deceleration Rate Independent of Load and Speed

Braking Process without Pedal

\[ a_{\text{Loaded}} = a_{\text{Unloaded}} \]

\[ a_1 = a_2 \]
Ramp Controlled Braking Concept

Time-Controlled Selection of Braking Torque

Torque to Threshold at 100%

Threshold to 100%

Dosing Start

Time [s]
Pedal Controlled Braking Concept

Example: 100% of Pedal Travel, Braking Torque will be 80%

- Torque to Threshold at 100%
- Threshold to 100%

Dosing Start

Analog Input

Position of Pedal
Torque Transfer Between Brake and Drive
Torque Transfer Between Brake and Drive

**Acceleration**

Motor Designed for Deceleration

**Deceleration**

Synchronization between ITC and Motor
Torque Transfer Between Brake and Drive

- Maximum Motor Torque
- Minimum Brake Control Torque
- Motor Torque
- Brake Torque

Pedal

Motor Torque vs. Brake Torque

Torque Transfer Between Brake and Drive

- Maximum Motor Torque
- Minimum Brake Control Torque
- Motor Torque
- Brake Torque

Pedal

Motor Torque vs. Brake Torque
Control - Application

Load Dependent Braking

No Blocking of the Drive Wheel!
Future Application: AGV

Braking in a Defined Distance
Does our Safety Brake Fulfill Performance Level C?
Safety Brake, Performance Level C

\[ B_{10d} = 6 \times 10^6 \]
\[ MTTF_d = 94.6 \text{ Years} \]
\[ PFH_d = 1.205 \times 10^{-6} \]

Safety Integrity Level (SIL) 1
Performance Level C, Controller & Brake

Communication
Motor Controller

Control

CAN

External signal

Safety Brake
Professional Forklift Maintenance

- Monitoring of Safety Functions
- Self-Diagnose in Case of Failure
- Parameterization of Brake System
- Function Monitoring of the CAN-Bus
Monitoring Functions

Configuration

- Labelling
- Control mode
- Alarm
- CAN output

Alarm mask:
- Air gap too small
- Air gap too big
- Min. current drop
- Max. current drop
- Undervoltage (supply)
- Overvoltage (supply)
- Cell resistance too low
- Cell resistance too high
- Overtemperature
- Potentiometer resistance too low
- Potentiometer resistance too high
- Input voltage too low
- Input voltage too high
- Out of frequency limits
- Not enabled
- Time out alarm flag (see below)
- Brake cycle

Alarm flag:
- Brake action

Shutdown
- Relay
- CAN alarm
- Save status
Brake Coordination between Load and Main Brake
Load Wheel Brake Concept

Control Mode 2
Load Wheel Brake

Control Mode 1
Drive Wheel Brake

CAN-Bus
What Are The Advantages of Controller Use?
Benefits:

- Defined Braking Performance
- Motor Size Standardization
- Braking without Blocking Wheels
- Brake Torque Coordination
- Extensive Security Features
Questions?
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