TLC – a unique advantage of BT Reflex R-series/E-series and BT Vector R-series

The conventional problem

The critical issue in most material handling operations – alongside the pre-requisite for safety – is efficiency, which for many means speed of operation. And in higher-level storage systems, typical for reach trucks, speed is as much about vertical movement as it is about travel speed.

Travel speed is usually expressed in km/h, and will typically be up to 14 km/h for mainstream reach trucks. That equates to 3.9 m/s. Lift speed on the same scale is substantially lower – typically 0.6 m/s–0.7 m/s. It is therefore self-evident how improvements in lift speed can make a substantial difference to productivity, particularly with lift heights now approaching 12 m in some applications.

Truck manufacturers have responded to this by developing lift motors that offer increased performance, but the degree of realisability of high lift speeds has been the subject of debate, given the need for secure operation.

This is due to the conventional design of hydraulic lift systems and multi-stage masts employed on reach trucks. In order to achieve high lift heights but with a closed (lowered) overall mast height that is low enough to allow the vehicle to accommodate height restrictions when travelling around the site, trucks are often fitted with three-stage (triplex) masts.

Conventional lift systems rely upon hydraulic oil pressure to determine the sequence of movement during the lifting process. In the normal first-stage of lift (‘free-lift’), the forks are elevated within the first section of the mast without the need for the mast itself to extend. This is achieved by selecting a wider diameter lift cylinder for the free-lift stage. The larger diameter cylinder results in lower oil pressure within this section, and therefore less resistance. Consequently the oil flow will initially cause movement in this section of the system.

Once the free-lift movement is fully achieved the oil pressure will switch to the next lowest point of resistance, as determined by the lift cylinder diameter of the next section of the system. This elevates the next mast section.

The consequence of this fully hydraulically controlled system is that there is – in most raw systems, no normal ‘cushioning’ between the stages. There is a physical impact when the fork carriage reaches the top of the first mast stage, beyond which the next section is elevated. Likewise an impact will occur when the second stage reaches maximum extension, and beyond. These impacts between mast stages cause a shock-effect on the entire vehicle and in particular on the load, which is located close to the point of impact.

As a result, there is a risk of load slippage and consequent damage, unless the operator consciously reduces lift speed at the point of transition between mast sections. Speed reduction lessens the impact and the consequent shock, but also reduces work pace and relies on operator judgement.

Recent innovations in truck design aim to address this by introducing technology that automatically adjusts lift speed within the process. Lift height is measured by a cable-based altimeter, which sends electronic pulses to the lift motor controller. As a result, lift speed is adapted according to height, with corresponding reduction in shocks. However the downside to this is, again, a reduction in overall speed of operation.

Toyota Material Handling Europe has developed a unique solution to this problem – incorporated as standard on all BT Reflex R-series and E-series reach trucks and BT Vector R-series VNA trucks. The solution is marketed as TLC – Transitional Lift Control.

TMHE's solution

TLC is a complete re-think of the way that the hydraulic system is controlled. Rather than depending on the differential pressure in the stages of the lifting systems, the process is controlled by electronic valves.

This means that when the operator activates the lift pump the full oil-flow is firstly directed to the free-lift stage of the process, elevating the fork carriage. The degree of elevation is measured by an altimeter and, as the fork carriage reaches the top of the first lift stage, the valve closes, slowing down and stopping the flow while simultaneously opening the flow to the second stage of the process, elevating the next mast section.

Completely smooth lifting

This 'Transitional Lift Control' means that the shock effect normally associated with the fork carriage reaching the top of the first mast stage is eliminated completely. Also the 'take-up' of second stage mast lift coincides with the slow-down of free-lift and, therefore, there is virtually no perceptible reduction in speed as the transition occurs.

This transitional valve control is repeated at the next stage of the lift in three-stage mast systems, thereby providing smooth, shock-less high-speed lifting all the way up to the maximum lift height.

However, the smooth control of the lift process is just one benefit from the system. A further advantage is that the conventional need to vary the cylinder widths within the hydraulic system could be re-assessed. Rather than having to rely upon a wider-diameter first stage lift cylinder, to reduce oil pressure and therefore prioritise oil flow, the first stage lift cylinder can have a much narrower diameter.

Faster lowering

The result is two-fold. Firstly, the narrower cylinder means that the lift speed is increased, giving further productivity benefits. It also means that less oil is required in the overall hydraulic system, with environmental and maintenance advantages.

There are also benefits when lowering the forks. This has always relied on gravity, but with lowering speed affected by the resistance of the hydraulic system. Once again the impact of varied oil pressures within the different mast stages has been noticeable in conventional truck design. The upper sections of the system, with narrower cylinders have facilitated faster lowering, whereas the final stage of lowering has been significantly slower.

TLC on BT Reflex reach trucks, with its narrow cylinders throughout, results in faster lowering, speeding up the overall handling process. Valve control is also employed during lowering, which means that the transitions between mast sections are, again, smoothly controlled, without shocks.

Reduced energy consumption

Another benefit of TLC is energy efficiency. This is derived from the fact that energy consumption in the lift motors is optimised when they are run at constant speed. The TLC system allows the operator to run the lift motor at full speed, without risk to the load, due to the smoothness of the movement. This increases energy efficiency by up to 25%.

Another change that has been implemented in TLC is upgraded Parker hoses, to accommodate the increased oil pressure within the system, at around 250 bar.

In summary:

- The flow of oil in the hydraulic system is controlled by valves, which in turn are activated by a cable-based altimeter that measures lift height
- Valve control allows:
  - Smooth transition between stages, and therefore shock-less lifting and lowering
  - Narrower lift cylinders, increasing lift and lower speeds
  - Fully realisable high lift and lower speeds due to elimination of shocks
- Less oil is required in the system
- Up to 25% less energy is required as the lift motor is running at a constant high speed

The benefits are clear – higher productivity and safer load handling – a clear and unique commercial advantage.

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