Hydro-pneumatic suspension systems: faster and more cost-effective development

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Overview

- Hydropneumatic Suspensions today
- The MHPS Concept
- Implementation of the Modular System
- First Tests

- Possible Applications
- ARGO-HYTOS suspension competence
- Typical project schedule
ARGO-HYTOS Facts
Turnover: approx. 130 Mio. EUR
Employees: approx. 1,200 worldwide
Sales: own sales organizations & worldwide representatives
We produce fluid power solutions
ARGO-HYTOS supplies its product portfolio into the following markets...

- Agriculture / Farming: 25%
- Construction Equipment: 20%
- Lifting / Material Handling: 15%
- Other Mobile Vehicles: 15%
- Plastic Injection Molding: 5%
- Machine Tool Equipment: 5%
- Other Industrial Applications: 15%
MHPS
Hydropneumatic Suspensions today

- Used mainly in high volume / high spec applications
- Slow expansion to mid and low volume applications
  (even though 2002/44/EC creates an increasing need for suspensions)

  hurdle: **high development costs**

- Additional shortcoming: **long development times**
MHPS
The MHPS concept - Goals

- Provide to the market a **Standard, quickly available hydropneumatic suspension** control system (hydraulics and electronics)

- **Customization** of this system must be **easily possible**

- This can be achieved by a **modular concept**

- Offer full support and **system responsibility**
MHPS
The MHPS concept - Advantages

- **Fast reaction time** to customer requests, prototypes quickly available

- **Standardized modules for small quantity** OEM serial production

- **Customized HICs** (derived from the modular prototype setup) for large quantities and/or special design-space requirements
The MHPS concept - Overview

MHPS

Vehicle

- Hydraulic supply
- Electric supply
- CAN bus
- Sensors and signals

Hydraulic Control Block

Controller

User Interface

Hydraulic Control Block
MHPS
Implementation of the Modular System  Hydraulics

- Basic Module: Level control
- Rod-side Module: Spring rate control
- Piston-side Module: Damping + shut-off control
Examples of module combinations
MHPS
Implementation of the Modular System

Controller

User Interface

Sensors
MHPS
Implementation of the Modular System
Originally intended characteristic curve
Results of simulation
Lab test result

![Graph showing the relationship between Axle spring rate (N/mm) and Vertical nat. frequency [Hz] versus Susp. axle load [N]. The graph includes two lines: one for c [N/mm] and another for fn [Hz].]
Initial Tests
Vehicle Test

Intention of the test
First start-up of the overall MHPS-System on a vehicle
Testing of the calibration procedure and position control

Test vehicle
John Deere 6910 with TLS and LS-Hydraulics, MHPS connected via a selective control valve
Possible Applications

Suspensions for

- axles or wheels
- (operator’s) cabins
- booms and cargo load

e.g. in:

- Agricultural machinery: tractors, self-propelled agricultural machines, telescopic handlers, heavy trailers
- Construction machinery: mobile/truck cranes, dumpers, backhoe loaders, wheel loader, mobile excavator
- Industrial trucks: port and airport transporters, forklifts
- Communal machinery: multi-purpose vehicles (e.g. Holder, Unimog), sweepers and mowers
- Special vehicles: heavy goods trucks, forestry machines
- Responsibility or technical support for the **configuration and optimization of the hydraulic suspension system** (accumulators, cylinders, electronics/algorithms)

- Responsibility for the **development of the hydraulic suspension controls**

- Responsibility or advice and guidance during **vehicle tests** especially for finding the right set of parameters of the hydraulic system and the electronic control
Compeence in HP Suspensions
Development tools

- **Dedicated calculation tools** for the first, basic layout
  (Force vs. displacement, spring rate vs. axle load, accumulator limits, etc.)

- **Simulation of electronically controlled hydraulic systems**, Software: DSHplus
  (simulation of suspension load changes according to real applications, virtual ground excitations according to customer demands or standard ISO-profile)

- **Hardware in the loop testing**
  (DSHplus as virtual environment connected via USB-Profibus adapter and WAGO Profibus system to the tested hardware)
Competence in HP Suspensions
Testing

- **Load simulator**
  (static load variation on real suspension cylinders + accumulators)

- **Suspension tuning testbench**
  (dynamic load variation, finding the optimum set of parameters for spring rate and damping control)

- **Mobile hydraulic measurement and data recording equipment** (max. 20 channels, max. 10kHz) and evaluation with dedicated software (NI Diadem)
Project steps:

1. In **consultation with the customer**, ARGO-HYTOS defines and lays out the suspension system using dedicated calculation and simulation tools.

2. The **prototype system is set up** with the selected modules and preadjusted according to the calculated values.

3. This prototype setup can then be tested and adjusted in the lab with the **ARGO-HYTOS load simulator test** according to customers specifications.

4. In **real test drives** on the vehicle, the system can be optimized.

5. Systems with this setup can then already be used as a **serial solution**.

6. In case of special design space restrictions or for further cost reduction, **customer-specific control blocks** can be derived from the modular setup using exactly the same components as in the prototype.
MHPS demonstrator shown at the ARGO-HYTOS booth (Hall1 / D116)
Thank you for your attention