SPECIALIST IN HIGH PERFORMANCE SHOCKS

Introduction

- Vehicle dynamics and damping
- Converting kinetic energy into Thermal energy
- Controllong extension stroke of the suspension

Integrated suspension/damping system

- Damping important part of suspension working
  In harmony with other important components
- Tire,Damper,Spring,unsprung mass
- Sprung mass
- Anti roll bar
- Sprung mass varies under dynamic conditions

Over riding factors

- Exceptional high spring rate
- To strong anti roll bar settings
- High rebound damping forces at low velocity
- Friction

Damping a mysterious component ?

- Damping force generated by combination of
- Orifices,valves,fluid,displacement and velocity
- Larger displacement is better against fade

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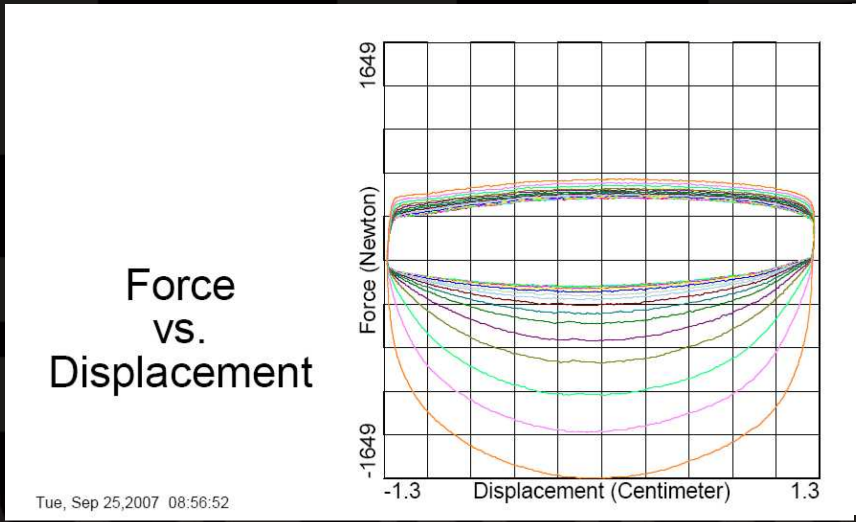
Adjustments

- Bad handling,understeer,oversteer
- Traction, Grip not cured by stronger rebound force
- Importance of compression damping not always understood

Dynamometer readings

- Dyno usefull piece of equipment
- Dyno forces damper through velocity range
- Recorded in force velocity graph or force displacement graph
- Damper in suspension does not follow exact line
- Responds to input from suspension resisting movement

Dyno curves


Force
vs.
Displacement
1649
-1649
Force (Newton)
-1.3
Displacement (Centimeter)
1.3
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Force
vs.
Displacement
1410
-1410
Force (Newton)
-1.3
Displacement (Centimeter)
1.3
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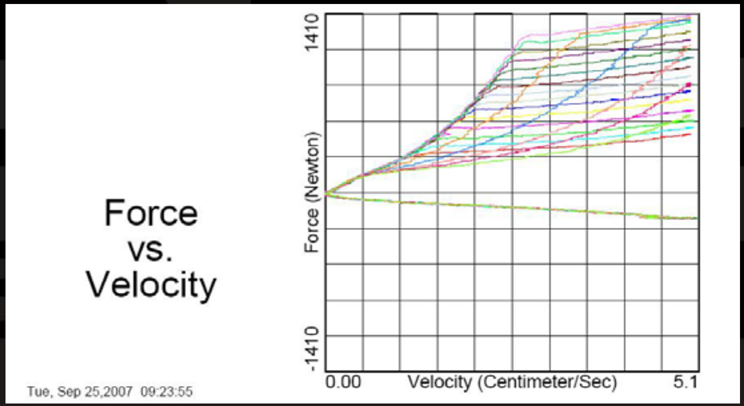
Damping characteristic

- Damping characteristic not cast in stone
- More ways to realize the correct damping curve
- Drivers have different opinions
- One goal ,a perfect handling car



Effect of damping

- Damping characteristic design, not a black art.
- Dampers respond to laws of physics.
- Damping force in range from 0 to 5 cm /second piston velocity more effective.
- High speed damping less important.

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Twin tube design damper

- worked well but had restrictions.
- Had to be mounted vertical.
- Not suited for horizontal installation without modification.

Low pressure twin tube gas damper

- Design improvement over twin tube
- Gas pressure replacing the baric pressure
- Better ride qualities for road cars
- Still not very usefull for race aplications

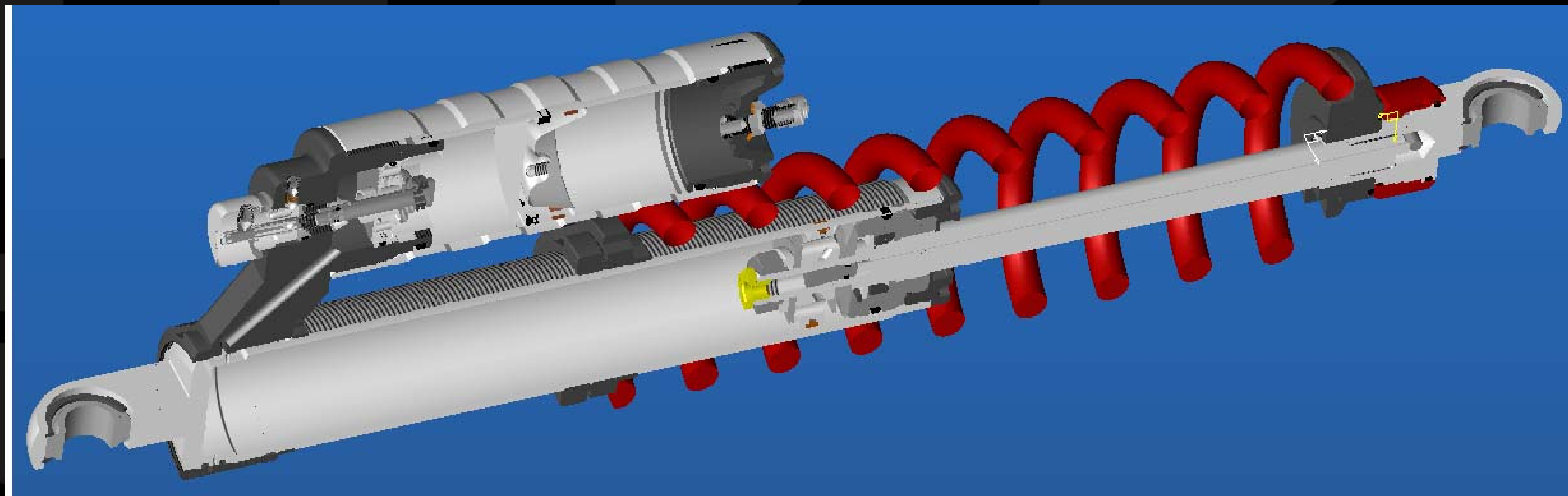
External adjustable twintube damper

- Big step ahead
- Could be adjusted on the car
- With external reservoir transformed performance

Single tube gas damper

- Single tube gas damper better performance.
- Packaging restrictions because of axial gas reservoir.
- Piston rod restricted in diameter of 12 mm.
- 20 bar of gas pressure needed.
- Larger piston rod would displace to much fluid.
- Mc pherson strut needs large piston rod.

Cutaway single tube damper



New approach to damping

- Fresh look at damper design and operation
- Critical look at existing ways
- Design combination adjustable damper / gas spring
- Scaled down damper do not work well
- more fluid displacement needed
- Damper most effective at 0 to 5 cm piston velocity

External reservoir,compression valving

External reservoir

- Compression damping valving in reservoir.
- Low and high speed adjustment independent.
- Single tube damper functions in compression as twin tube damper.
- Shim stack on top of piston not necessary for compression damping.
- Gas pressure not needed for damper operation in compression.
- Gas pressure variation used as suspension support.

Gas pressure supporting the suspension

- Suspension moved less by 50% with gas support.
- Car could run lower ,better use of aero dynamics.
- Spring rate can be build in by varying gas volume according to boyles law PXV =C.

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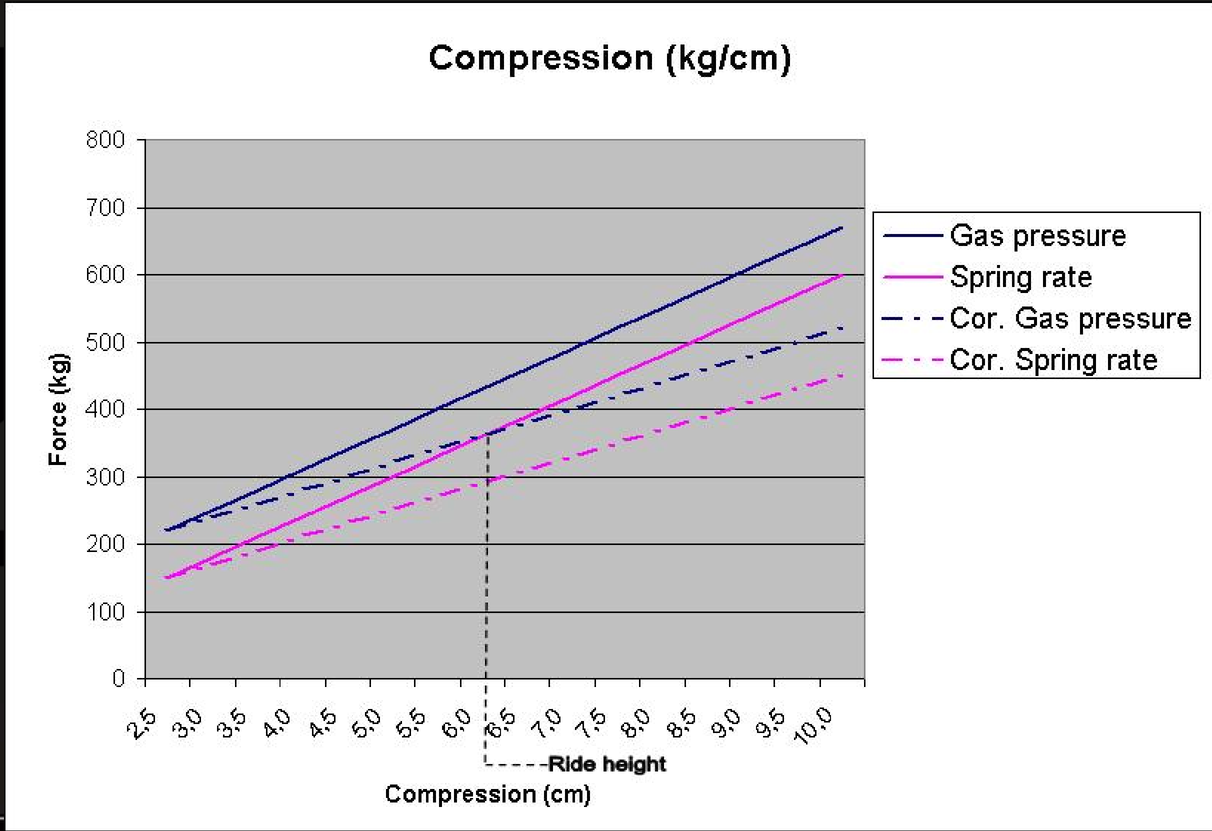
Gas force positive effect compression stroke

- 20 bar pressure provides 75.8 kg support or lift.
- Damping function does not depend on gas pressure.
- Gas pressure is variable from 6 bar to 25 bar.
- Gas support runs paralel on spring rate .
- Spring rate can be lowered .
- Lower natural frequency good for traction.

Spring rate graph ,gas force



Damping the unsprung mass

- Damping unsprung mass big gain .
- Unsprung mass moves with higher frequency.
- Most underestimated cause for bad handling.
- Tire road contact is much better with gas lift.
- Lap times do not deteriorate during race.
- Increase in grip levels.
- Gas pressure as tuning tool,very effective.

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Wide range of support

- Gas pressure force at 5 bar is 18,95 kg .
- Gas pressure force at 25 bar is 94,72 kg.
- Pressure can be varied without adverse effects.
- Gas pressure supports outside wheel in corner.
- Left and right operate independently .
- Less suspension travel in compression.

Most significant improvement in handling

- Daytona 24 hour test days 2008.
- No results with conventional way.
- Heavy understeer,low grip levels.
- Increased gas pressure, compression damping.
- Fastest lap of the day and P1 of GT.

Mechanical grip

- Improvement in handling due to mechanical grip
- Basis for good handling
- Handling less dependent on aero dynamics
- Report race engineer