

Vehicle Systems

Dampers II

- Introduction
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 - Continuous velocity
- Damper checks

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Damper Dyno

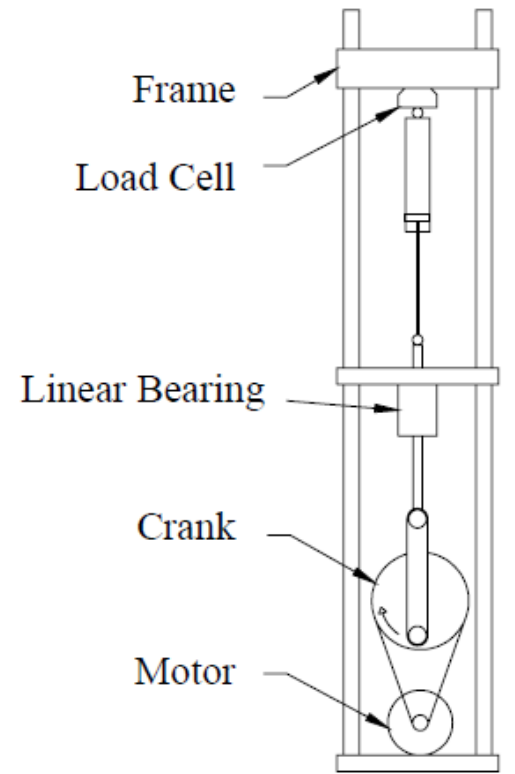
- Dampers produce a force proportional to the speed of shaft movement.
 - If you compress a damper slowly, it generates less resistant force than if you move it faster.
- The shock dyno is a tool used to test dampers and learn about their behaviour.



Damper Dyno

- This is a machine that compresses and extends a damper at known speeds and measure the forces produced by the damper.
- A frame holding an electric motor with a drive belt and pulleys that spins a crank attached to the damper shaft through a linear bearing.
- As the motor spins the crank, the damper piston moves up and down just like the piston in a cylinder of an engine.
- Different pulley diameters or a variable speed motor give different crank rotation speeds.
- The load cell measures the damper force.

Damper Dyno



BDC
0 Degrees
Velocity = 0

Mid Stroke
Compression
90 Degrees
Velocity = Max

TDC
180 Degrees
Velocity = 0

Mid Stroke
Rebound
270 Degrees
Velocity = Max

Damper Dyno

- Speed of a piston connected to a crank varies continuously as the crank rotates.
- This motion is called sinusoidal because it varies with the sine of the crank angle.
- Piston comes to a stop at bottom dead centre (BDC), accelerates to a maximum speed halfway up the cylinder, and slows down to a stop again at the top (TDC).
- If you have a damper attached to a crank, its piston does the same, and the force generated also varies continuously.
- Maximum speed of the piston happens only once per stroke, when the piston is halfway between top and bottom;
 - that's also when the damper generates maximum force.

Damper Dyno Operation

- You put a damper in the dyno, choose a stroke and RPM, and turn on the motor.
 - Careful with the stroke you choose. You should know what the stroke of the damper you are about to test is. If in doubt choose a very short stroke and increase slightly or you will damage the damper!
- The crank turns and the damper shaft moves up and down until you turn off the motor.
- If you know the crank RPM, and the stroke, you can calculate the maximum damper shaft speed.
 - $100 \text{ rpm} = 1.67 \text{ rev/sec}$
 - $\text{Stroke } 200\text{mm} = 0.2\text{m}$
 - $1.67 \times 3.14 \times 0.2 = 1.05\text{m/s}$
- It happens twice each revolution of the crank, once with the piston going up in compression and once again with the piston going down in rebound.

Damper Dyno Operation

- Assume we now put some scales on the dyno bolt.
- What we'll see is the pointer cycling from 0 to some maximum bump force as the shock compresses, returns to 0, and then peaks out again at the max. rebound force as the piston comes back down.
- The needle on our scale goes from plus some number to minus some number as the damper cycles from compression to rebound and back.
- A commercially available shock dyno uses a computer to read the load cell and store the data.

Damper Dyno Operation

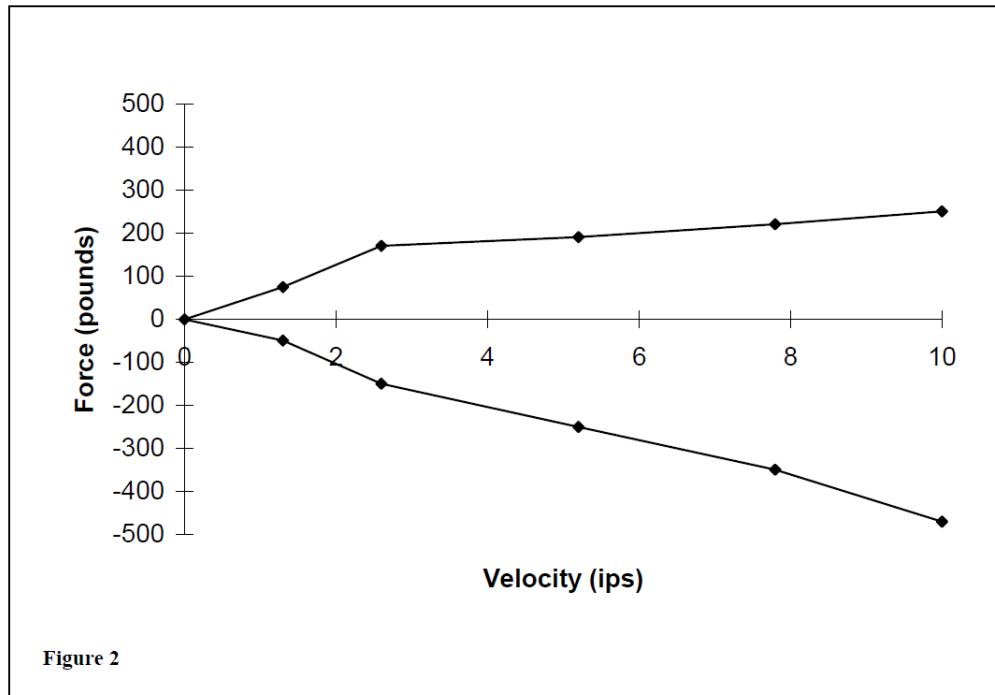
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- The needle on our scale goes from plus some number to minus some number as the damper cycles from compression to rebound and back.
- A commercially available shock dyno uses a computer to read the load cell and store the data.
- Some dampers are set up to give more force in rebound than compression
 - Our simple machine we might see the scale peak at 190 pounds in compression and 250 pounds in rebound for example.
 - At a shaft speed of 1.05m/s the damper produces 190 N in compression (or bump) and 250 N in rebound.

Damper Dyno Operation

- If we reduce the crank speed to 50 RPM, and 25 RPM, and also speed it up to 150, and 200 RPM, this gives us five data points.

CRANK RPM	MAX SPEED IN/SEC	BUMP FORCE LBS	REBOUND FORCE LBS
25	1.3	75	50
50	2.6	170	150
100	5.2	190	250
150	7.8	220	350
200	10.4	250	470

- But to best visualise what is happening we draw up a graph of force v velocity



Damper Dyno Operation

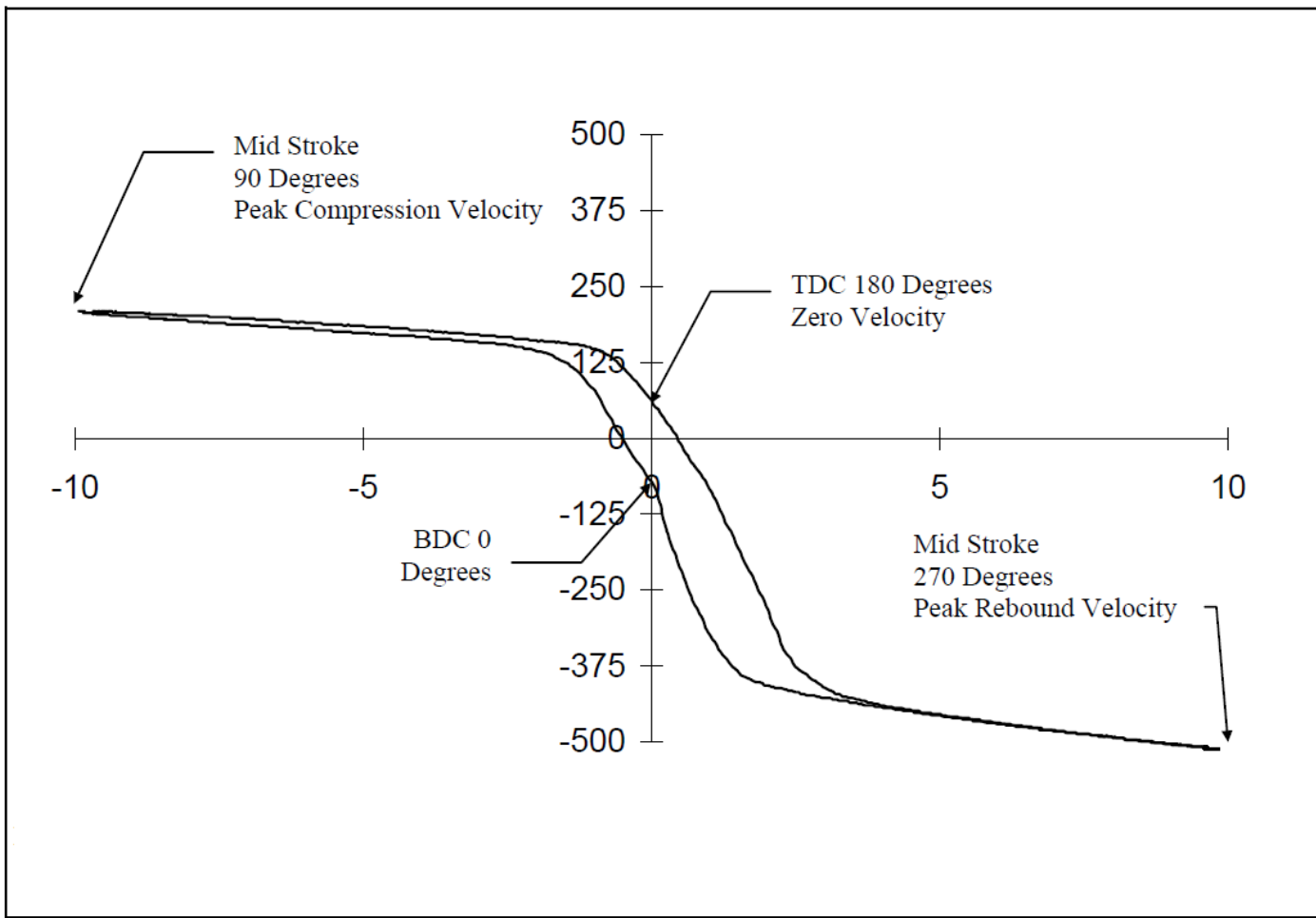
- Test all four dampers off your race car and find out that they all give different readings even though they are supposed to have the same valving, and you've, hopefully, set them all to the same external adjustments before you started the test?
- Maybe you'll find contaminated oil, bad seals, or worn parts. Dampers wear out like any other mechanism and need to be rebuilt periodically.
- A damper dyno also allows you to see the effects of external adjustments.
- Varying them in increments from full-hard to full-soft will give you curves that show the effect of those changes.
- Used to pair two dampers on the same axle.

Damper Dyno Operation

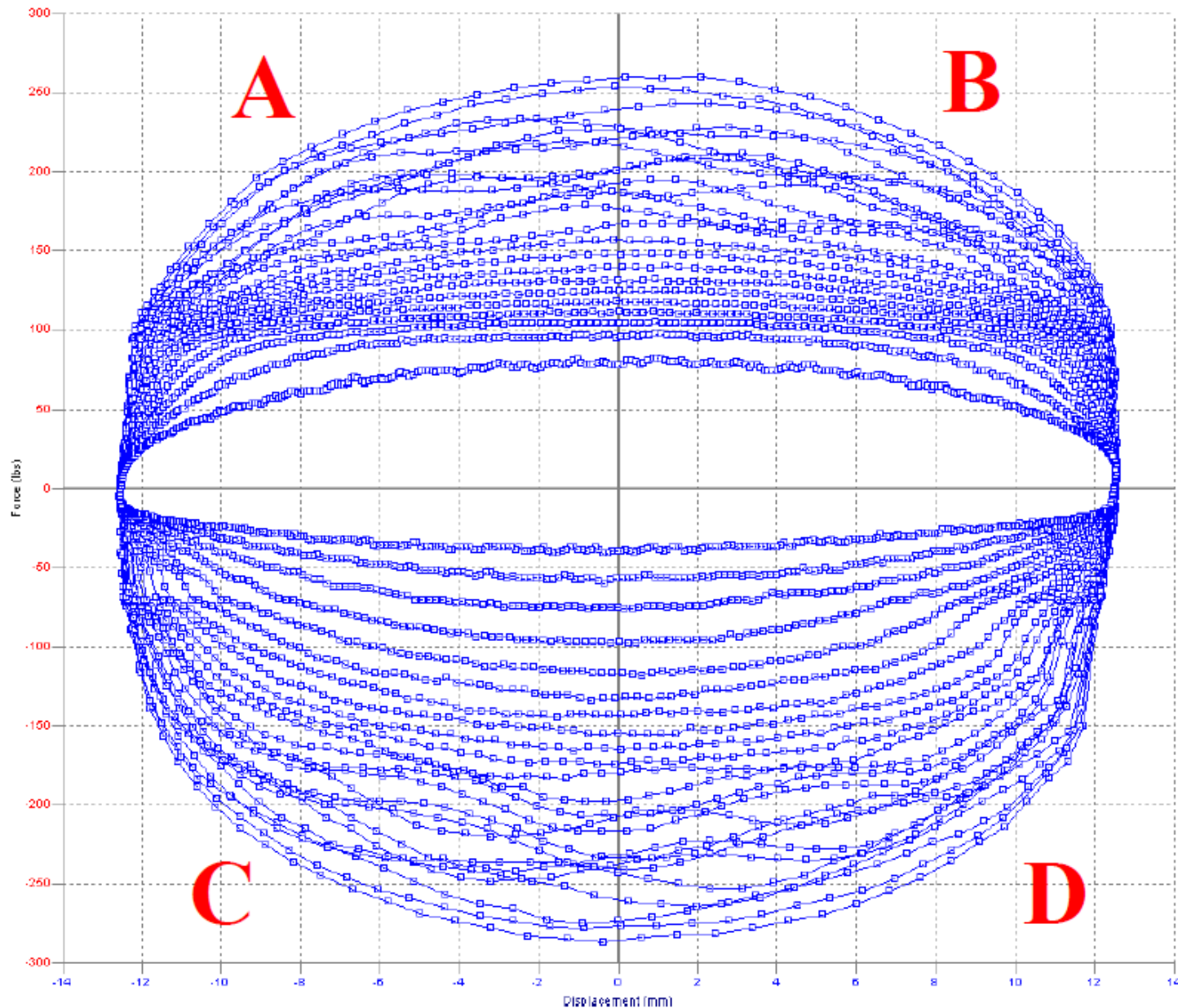
- You can get more data from a damper by taking data over a complete cycle of compression and rebound and graphing that
- This is called a Continuous Velocity Plot
- When the crank pin is at BDC the damper is fully extended.
- As the crank rotates clockwise it's compressing the shock in the bump direction so that the damper piston accelerates from a stop to maximum speed at 90 degrees and then slows to a stop again at TDC.
- Rotation continues and the piston accelerates in rebound direction to maximum speed at 270 degrees and slows to a stop again at BDC.

Damper Dyno Operation

- Shaft speed in the down direction is positive and compression force is positive.
- The bottom part of the curve shows shaft speed and negative force increasing as the crank goes from TDC (180 deg.) to 270 degrees
- Then decreasing as the curve goes back toward zero speed and force at BDC (0 deg.).
- As rotation continues, speed goes negative (compression) and force increases to a maximum at 90 degrees and back to 0 at TDC (180 deg.).



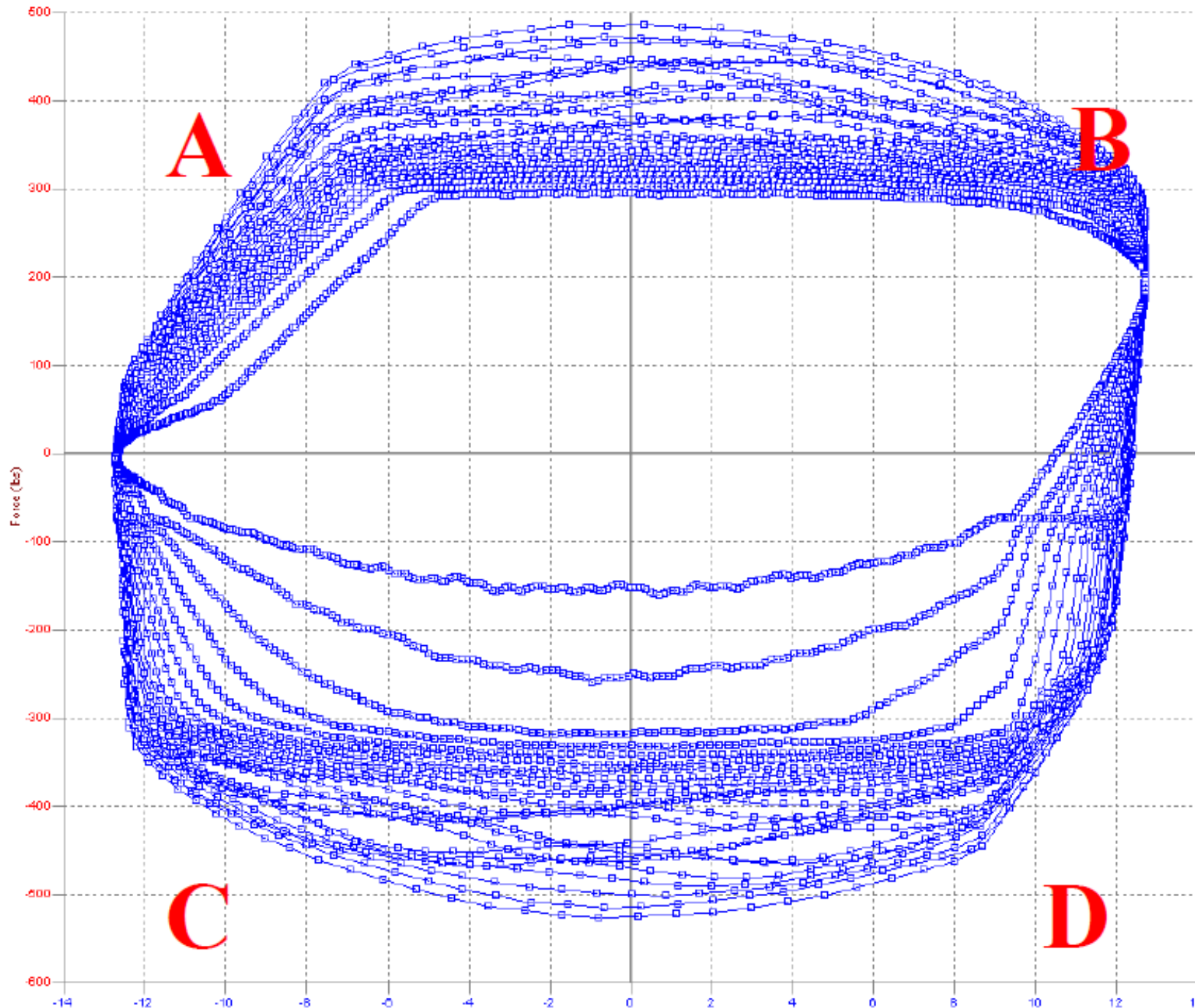
- The important point is the force increases with piston speed.
- Lower section of the curve the piston is accelerating where the curve is headed down and slowing down as the curve swings back up.
- On the top part the piston speed and damping force increase to a maximum and then slow again.



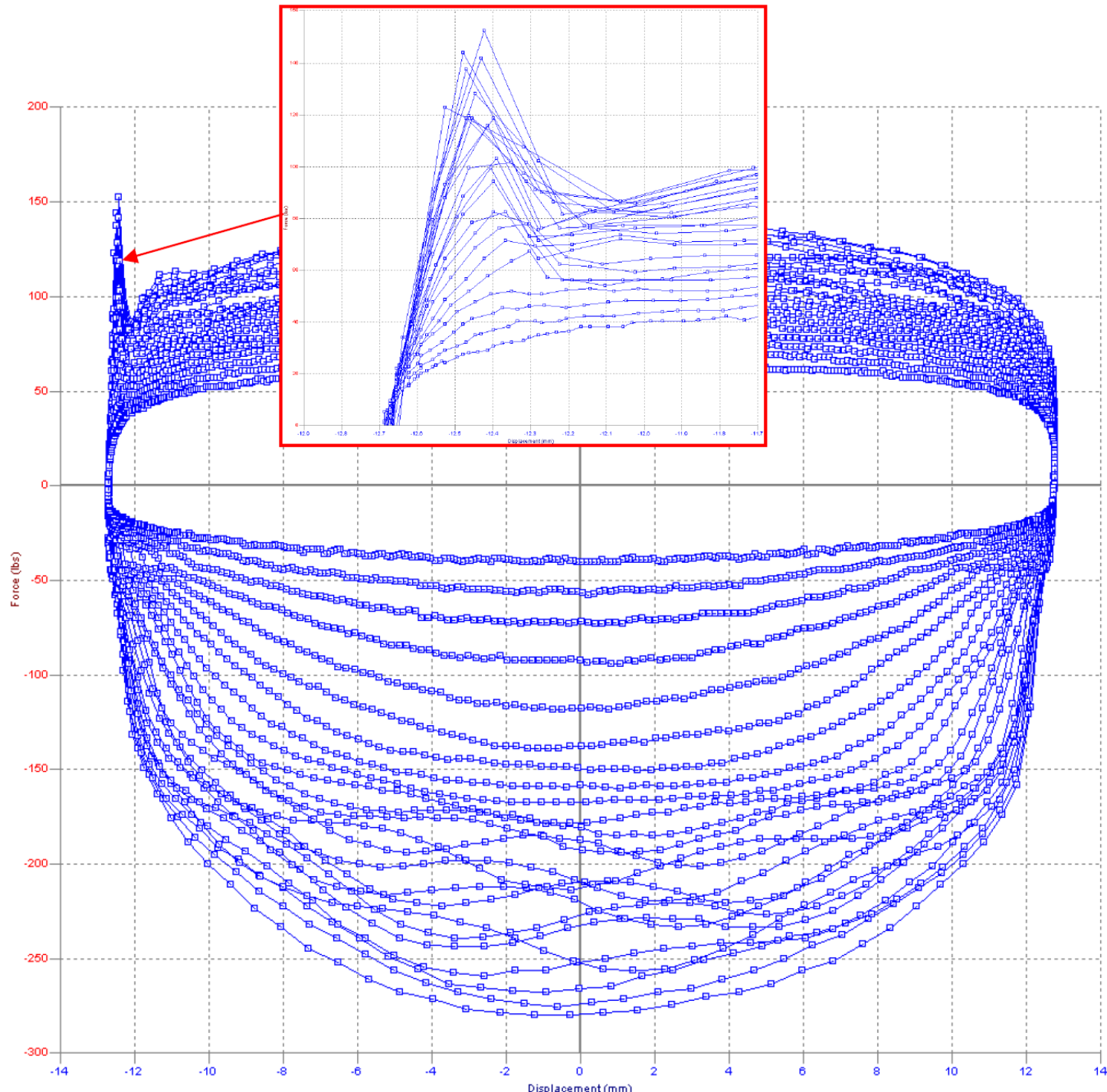
Force v displacement

- Quadrant A displays the shock's force as it is accelerated in bump
- Quadrant B as it is decelerated in bump
- Quadrant C as it is accelerated in rebound and
- D as it is decelerated in rebound.

Force v displacement with hysteresis



- Hysteresis occurs when the damping forces are higher as the damper is decelerating compared to when it is accelerating.
- It will decrease the effectiveness of the damper.
- Damping forces in quadrant B are higher than in quadrant A.
- Hysteresis is the primary reason that a damper should be valved to be used in the middle of its adjustment range.
- hysteresis is significant when you use the stiffest adjustment settings.



Force v displacement
with damper damage