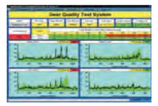
Data-Driven Decisions Through In-Process Test

Axle Manufacturing



Gear Quality Verification

Test Description: Verify machining quality through vibration analysis on gear test machine prior to assembly.

Signatures: Vibration vs. time or encoder. FFT and order tracking.

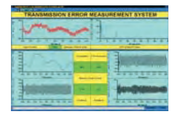
Defects: Gear geometry, machining problems, nicks, burrs, alignment, surface finish, sub-micron machining errors, etc.

Gear Transmission Error

Test Description: Measure gear error (commonly known as transmission error) as gear set is rotated.

Signatures: Input vs. output position, filtered and FFT analysis of difference.

Defects: Gear geometry, gear machining problems, nicks, burrs, alignment, etc.



MACHINING LINE

M10 — M20

Ring Gear Run Down

Test Description: Monitor torque vs. angle during run down.

Signatures: Torque vs. Angle.

Defects: Cross threads, damaged bolts.

Traceability: Store entire torque waveform in a database.

Press Monitoring

Test Description: Monitor press load and displacement as parts are pressed together.

Signatures: Force vs. time, distance vs. time, and force vs. distance.

Defects: Loose part, oversized parts, not fully bottomed out part, damaged or bent parts, cracked bore, debris, incorrect bearing, out of round.

ASSEMBLY LINE

10 — 20 — 30 — 40 — 50 — 60 — 80 — 90 — 100 — 110 — 120

Tone/Exciter Ring Gaging

Test Description: Using an encoder and laser or inductive sensor, verify ring profile, number of notches, and symmetry and depth of each.

Signatures: Depth vs. angle.

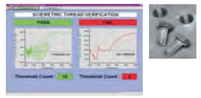
Defects: Improper spacing, bad machining, missing or damaged teeth, wrong number of teeth, eccentricity.

Thread Verification

Test Description: Verify the presence and integrity of major fastening points on axle assembly before it goes to the vehicle assembly plant.

Signatures: Eddy current or laser sensor vs. thread depth.

Defects: Missing threads, wrong pitch, shallow holes, undrilled holes, damaged threads.



Pinion Nut Torque

Test Description: Measure drag torque as the pinion nut is tightened to set bearing pre-load. Collapsible or solid spacer derivatives.

Signatures: Torque vs. angle.

Defects: Incorrect pre-load, spacer integrity, dirty bearings, thread quality.

Balance Station

Test Description: Spin the input shaft to determine weight amount and position to balance assembly.

Signatures: Vibration vs. angle (X-Y, 1 plane). An out of balance assembly yields a sinusoidal acceleration signature where the amplitude is proportional to the amount of weight, and the phase of the peak is used to calculate the correction weight position.

Q10

REPAIR BAY MANAGER

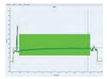
Using QualityWorX, collects information about the parts at repair station. Associates test and operation step failures to defects and repairs. Provides statistical data to enable defect avoidance.

Liquid Gasket Verification

Test Description: Monitor and capture machine vision images during the dispensing process while beads, swirls or drops of liquid gasket or sealant is applied.

Signatures: Pressure vs. time, flow vs. time.

Defects: Air bubbles, blocked nozzles, incorrect nozzle, too little or too much sealant, etc.

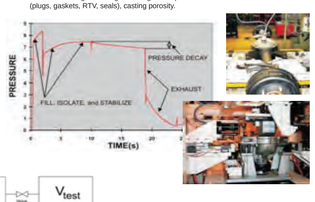


Leak Test

Test Description: Verify casting and seal integrity using a pressurized air test.

Signatures: Pressure decay vs. time or mass flow.

Defects: Missing or leaking or damaged components (plugs, gaskets, RTV, seals), casting porosity.



Hand Brake Force Test

Test Description: Pull hand brake cable to verify resistant force.

Signatures: Force vs. cable displacement.

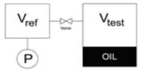
Defects: Binding cables, missing drum springs, damaged rivets, missing brake components.

Oil Fluid Level Test

Test Description: Estimate oil level using pressure change and reference volume.

Signatures: Pressure change vs. time. PV=nRT ideal gas law, Vtest = (P1/P2-1) * Vref

Defects: Too much or too little oil.



KEY IPT APPLICATIONS

130 — 130a — 130b — 130c — 130d

End of Line Tests

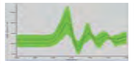
Test Description: Axle is turned by a drive motor at different speeds with and without output load, all functions verified.

Mechanical

Test Description: Measure input shaft torque against angle as motor drives axle with and without output shaft load.

Signatures: Breakaway and running torque vs. angle, input/output shaft position, gear ratio, backlash.

Defects: Damaged/incorrect gears, tight assembly, rubs, debris.



Brake Test

Test Description: Measure input shaft torque against angle as motor drives axle with and without hydraulic and cable brakes operated. (Hydraulic system verified using compressed air). Leak test of hydraulic circuit. Force/Distance measurement of cable pull.

Signatures: Drive torque vs. angle, cable pull force vs. distance, hydraulic circuit pressure vs. time (leak).

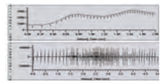
Defects: Missing brake components, snagged/stiff cables, leaky seals/joints.

ABS Sensor/Circuitry

Test Description: Measure ABS sensor output as axle is driven by motor. Also verifies the presence of the tone ring and identifies correct tone rings.

Signatures: ABS pulse value vs. shaft angle, pulse spacing.

Defects: Damaged/faulty ABS sensors, damaged wiring/connections.

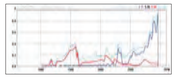


Sound/Vibration

Test Description: Measure sound and/or vibration as the axle is driven at various speeds.

Signatures: Sound/vibration vs. time, sound/vibration vs. shaft speed (order tracking), psycho-acoustic parameters (e.g. loudness).

Defects: Damaged/poor quality gears, bearings, splines, resonances, loose items, axles which will be noisy in-vehicle.



Q20

REPAIR BAY MANAGER

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130 — 130 — 130 — 130

FINAL ASSEMBLY LINE

KEY IPT APPLICATIONS

70 — 70a — 70b — 70c — 70d — 70e

Axle

Test Description: Axle turned by drive motor at different speeds with and without output load.

Torque

Test Description: Measure input shaft torque against angle as motor drives axle in forward and reverse, with and without output load.

Signatures: Breakaway and running torque vs. angle.

Defects: Damaged gears, tight assembly, dirt and debris, incorrect gear contact pattern (visual).

Ratio and Backlash Check

Test Description: Measure input shaft position and output shaft position as motor rotates input shaft.

Signatures: Input and output shaft position (encoder), forward and backward rotation.

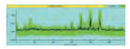
Defects: Incorrect ratio, incorrect gear backlash.

Vibration

Test Description: Measure vibration as motor rotates input shaft. Sensors contact axle casing.

Signatures: Vibration vs. time and vs. angular position (order tracking).

Defects: Gear knock, poor gear finish and geometry, damaged gears, shaft rubs, incorrectly shimmed pinion, damaged bearings.



Other Data

Test Description: Enter various other data, such as; Gear mark (classification of mesh pattern using marking compound), Build dates, Serial number (Bar Code).

Defects: Incorrect gear mark.

Gear Mark

Test Description: Image capture and storage (using vision system).

Traceability: Allows review of mesh patterns for defect containment and recall management.

Tube Press Monitoring

Test Description: Verify force curve and final press depth as tubes are pressed into casing.

Signatures: Force vs. distance.

Defects: Oversize/undersized, out of round, debris, not to final depth.

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LEGEND

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