Small Ceramic Structural Components for Automotive Exhaust Sensors

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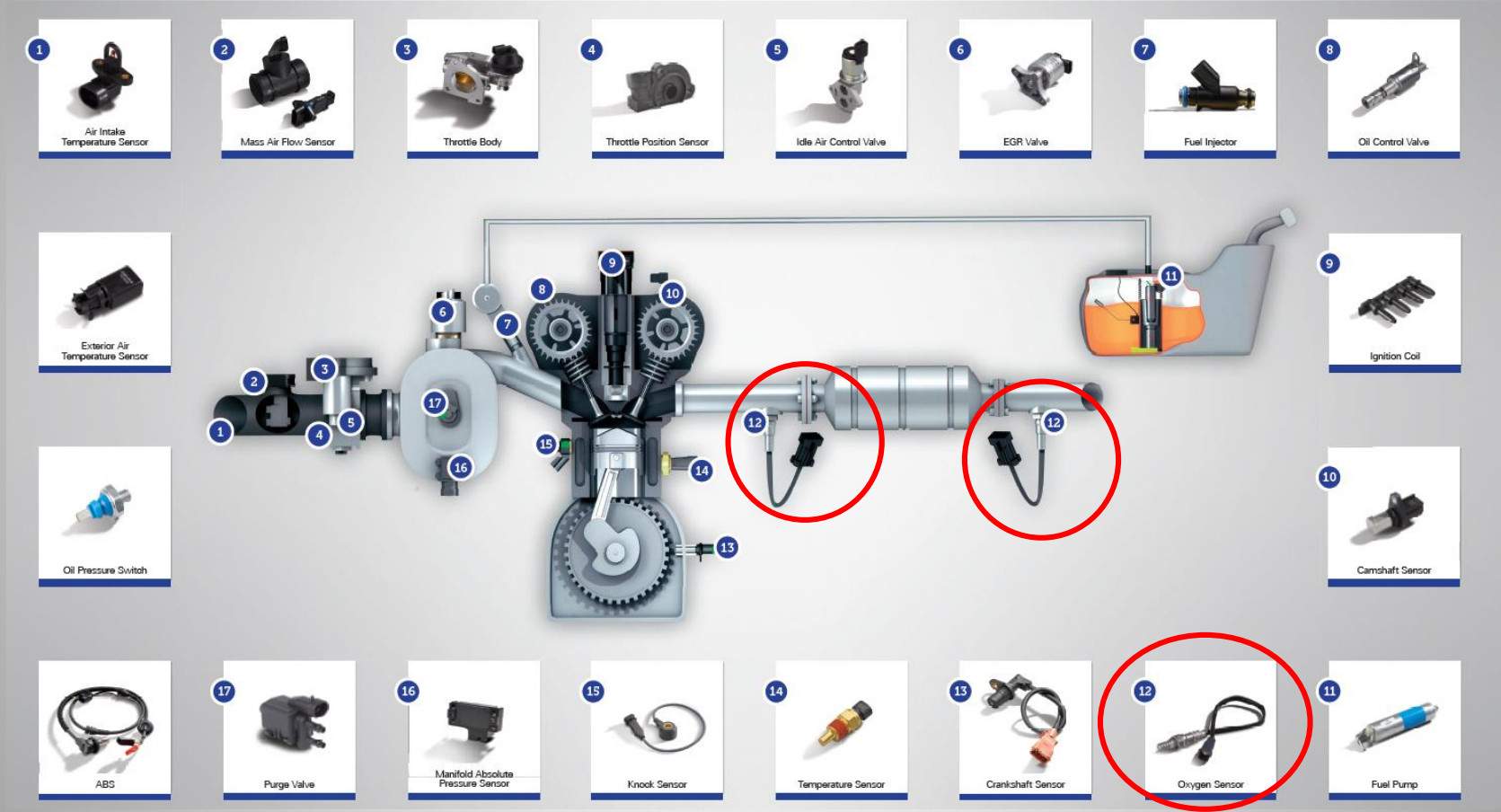
Automotive engine sensors and actuators



Automotive exhaust sensors

- Exhaust Oxygen Sensors are key to improving fuel economy and reducing pollution

- Global volume of exhaust sensors
  - Current: ~200 million sensors/year
  - Future: (2021) ~280 million sensors/year

- Exhaust Sensors are exposed to severe environments
  - -60°C to +1000°C (1832°F) exhaust gas
  - Soot, acids, high amounts of water (liquid and vapor) and toxic fumes
  - High vibrations levels
  - Stone impacts

Sensor size is decreasing

- Exhaust sensors are being mounted in tight spaces
  - Motorcycles/mopeds
  - Lawnmowers
  - Tight locations on cars
- New technology sensors are 50% smaller in size
  - Higher Performance
  - Increased requirements
  - Lower cost

Traditional Sensor

New Technology Sensor

Traditional Element

New Technology Element

OEM customer requirements drives cost

- Unnecessary/outdated performance requirements can result in increased product prices

Example: Wire size/terminal pull

Requirement: 20 gage wire

100 N Individual wire pull (based on wire size – not requirement)

Increased terminal dimensions required to meet target

terminal creates thin walls in ceramic connector

Thin walls require injection molding ceramic

Component price increase

Sensor price increase

Trend in automotive exhaust sensor ceramics
Where can your company contribute?

Smaller

- Products are getting smaller
- Tolerances need to decrease accordingly
- Tooling decreases in size
- Tooling increasing in complexity
- Wall thicknesses decrease

Stronger

- Thinner walls require stronger materials
- Smaller tooling increases wear rate
- Smaller components have higher stress
- Less defects can be tolerated
- More extensive FEA is required
- Higher strength raw material is required

Less Variation

- Enables meeting tight tolerance requirements
- Allows for increased wall thickness
- Better particle size control minimizes voids

Lower Cost

- Market pressure is driving final product price lower and localization
- Ceramic components are becoming a larger percentage of total component cost

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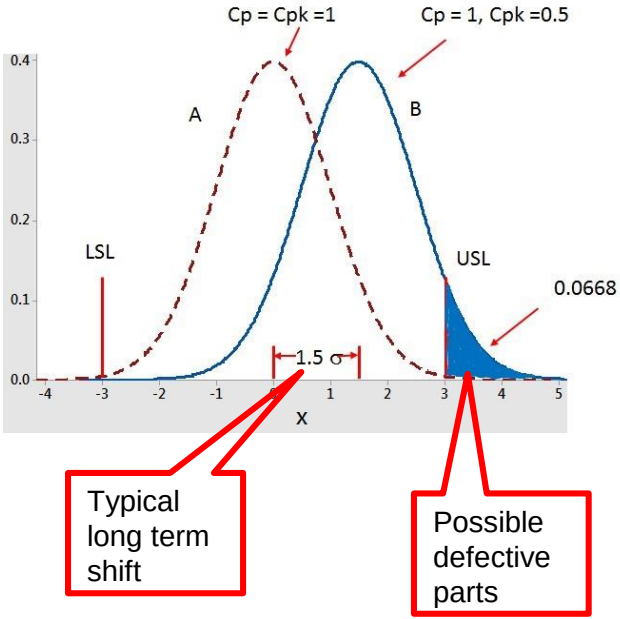
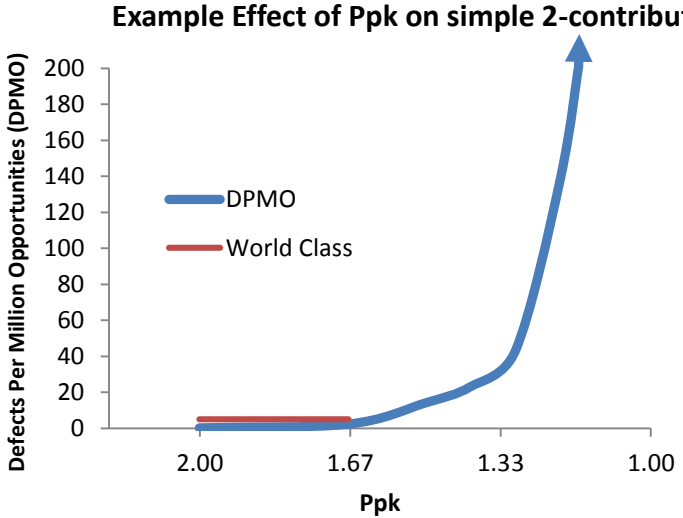
Prototypes

- Complex parts often require iteration in order to perfect
- Prototypes are required for testing sensors on various tests
  - Typically need 1,000 to 2,000 parts during a development cycle
  - Require parts to be representative of final product
- Creative methods must sometimes be used to keep prototype cost down
  - Potentially using fast wear tooling
  - Alternative fabrication methods for less complex components
  - Alternative low cost suppliers/partnerships that specialize in low volume “production”
  - As customers, we do not want vendors to lose money on prototypes
    - While working with the customer in the development stage builds a critical engineering relationship, it does not guarantee future production business without a competitive price

Effect of not meeting process capability metrics

- World class suppliers
  - Strive to meet all dimensions with a Ppk of 2.0
  - Inform the customer which ones cannot meet 2.0 so negotiations can be made





Cpk: Process Capability
Ppk: Process Performance Capability

Supplier input is critical!

- Suppliers are the experts, we as your customers need your comments and feedback!
- If there are difficult areas of a design that will cause more variation or cost, please offer your suggestions
- Together we will win!

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