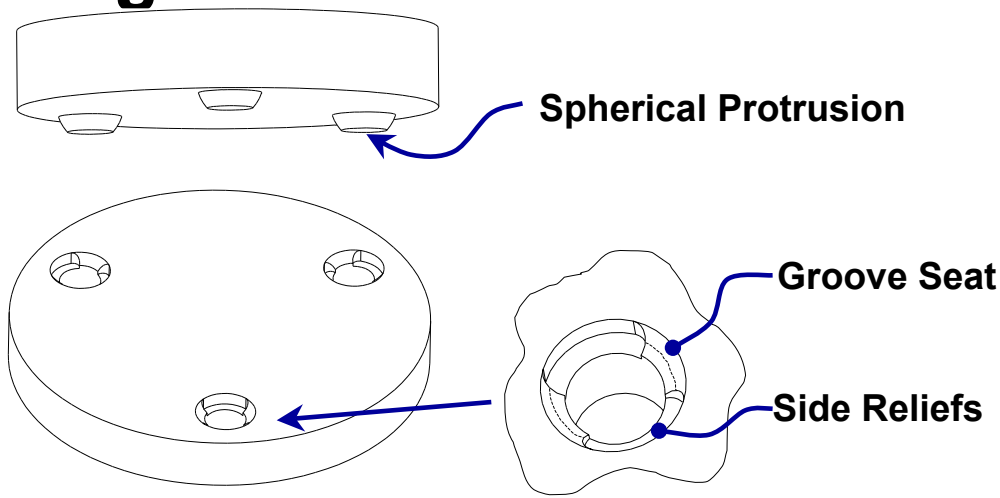
NEAR KINEMATIC CONSTRAINT

Quasi-Kinematic (QKC) alignment

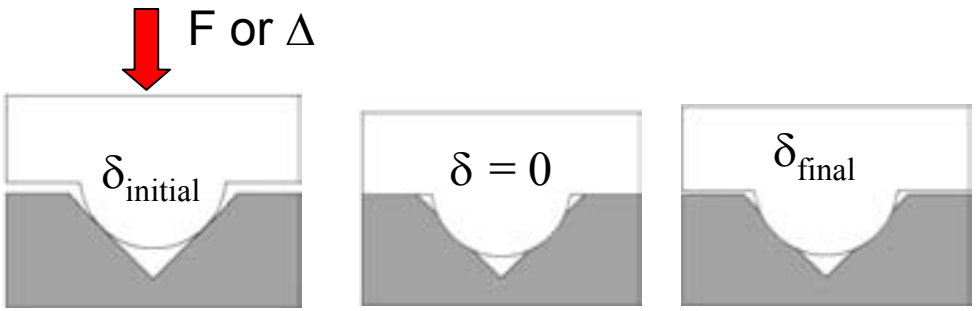
QKC characteristics:

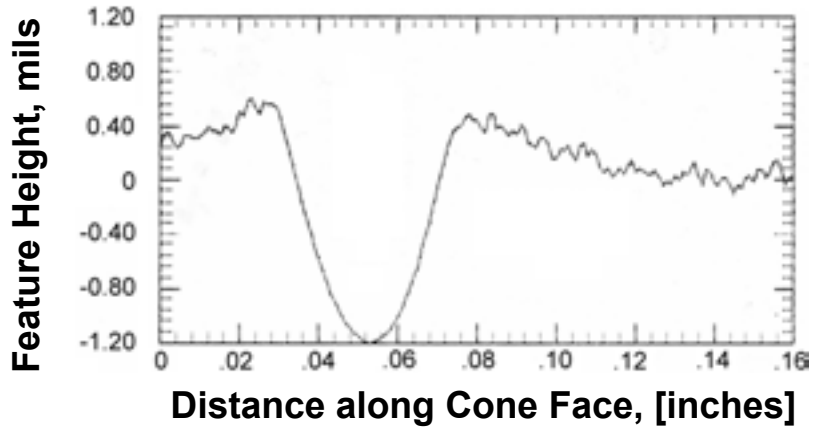
- Arc contact
- Submicron repeatability
- Stiff, sealing contact
- Less expensive than KCs
- Easier to make than KCs



QKC Function:

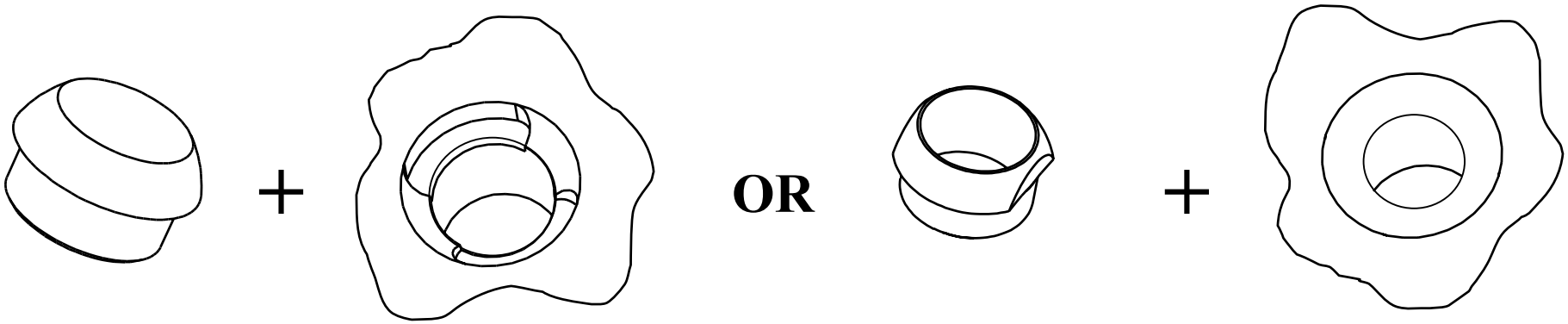
- Ball & groove comply
- Burnish surface irregularities
- Elastic recovery restores gap





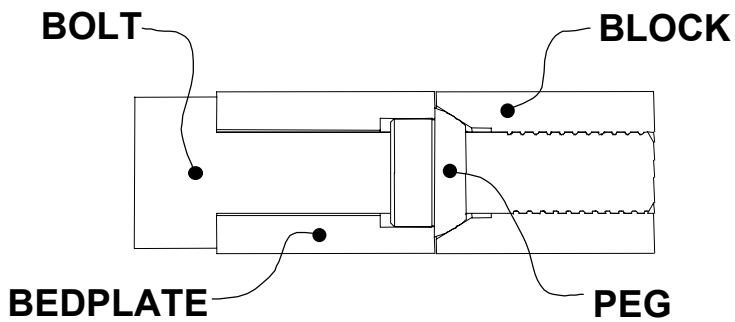
Details of QKC element geometry

PAIRS OF QKC ELEMENTS



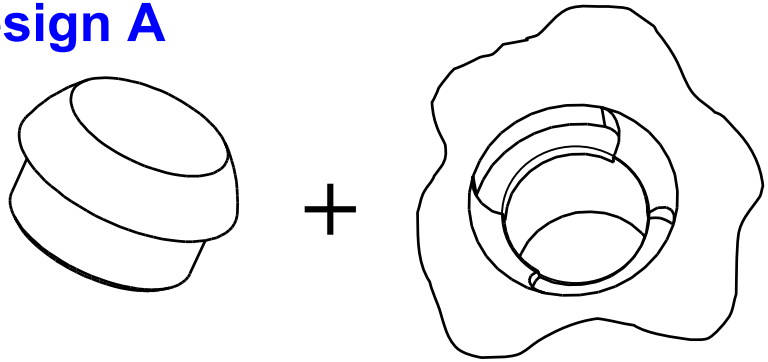
TYPE 2 GROOVE MFG.

ASSEMBLED JOINT



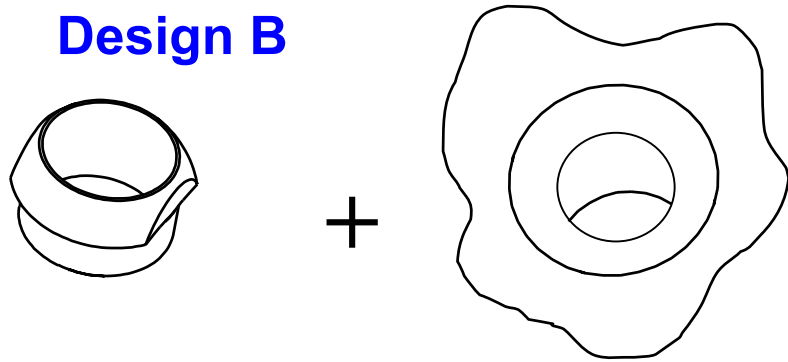
Which variation of QKC to use

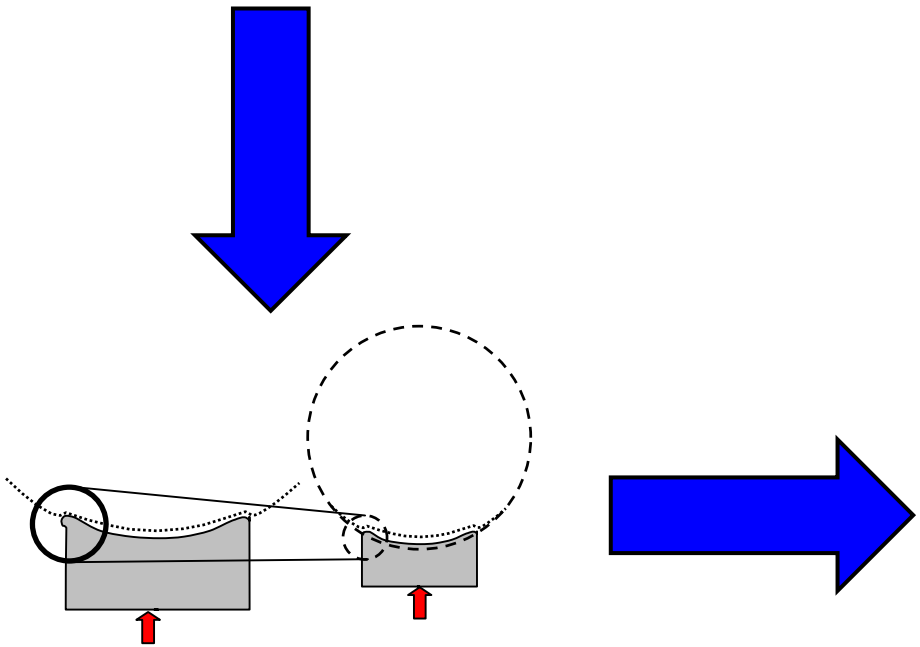
Design A



OR

Design B

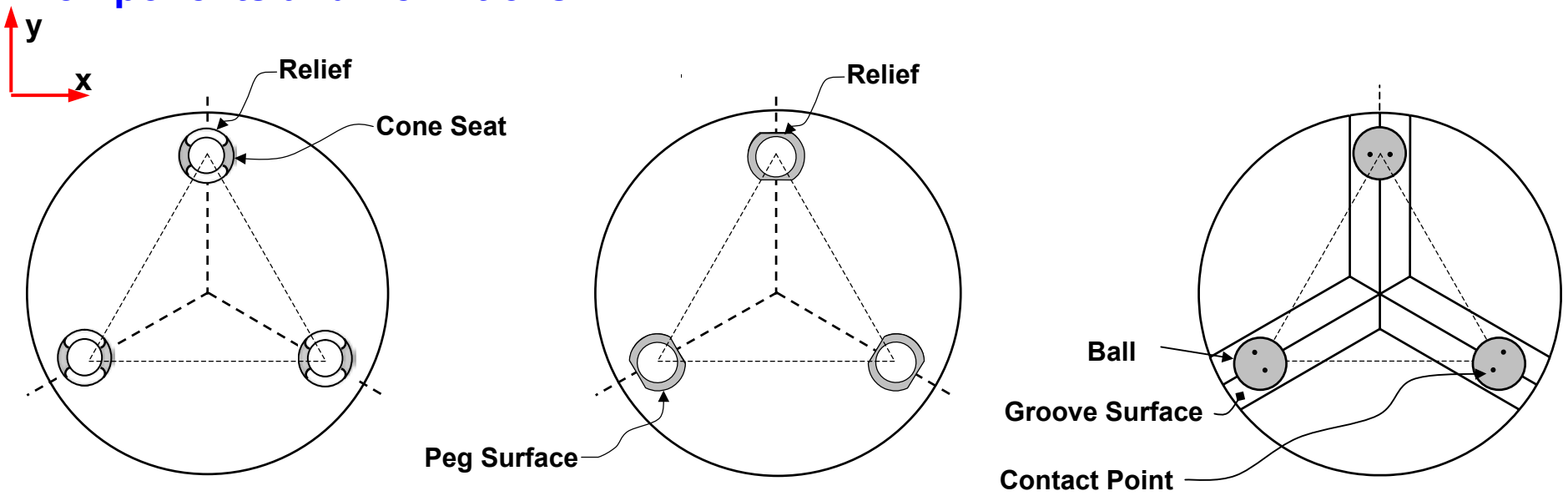




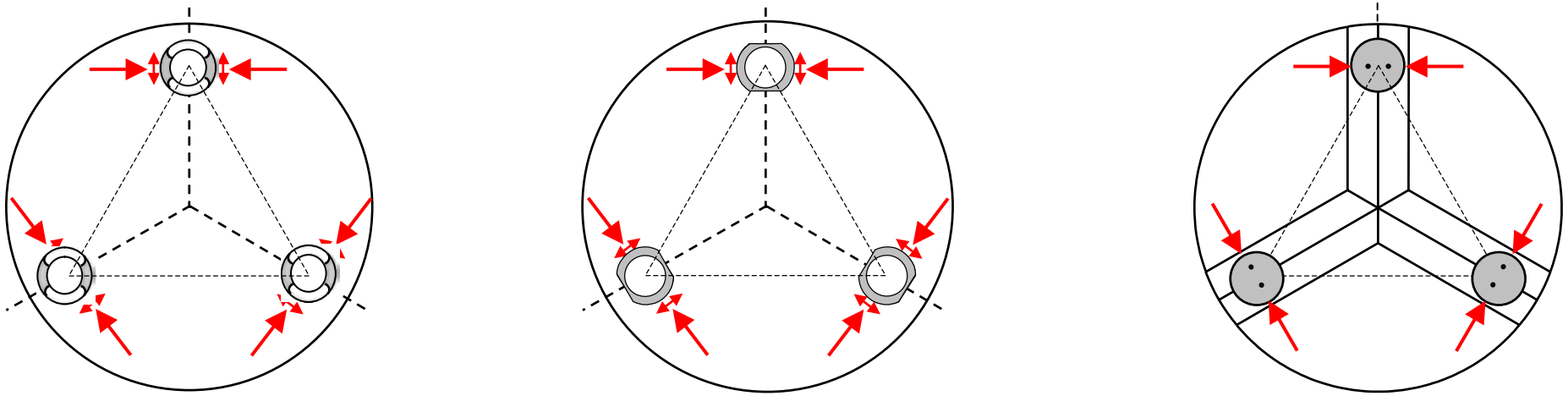
In Design A, Peg deforms on edge -> reduced repeatability

QKC methods vs kinematic method

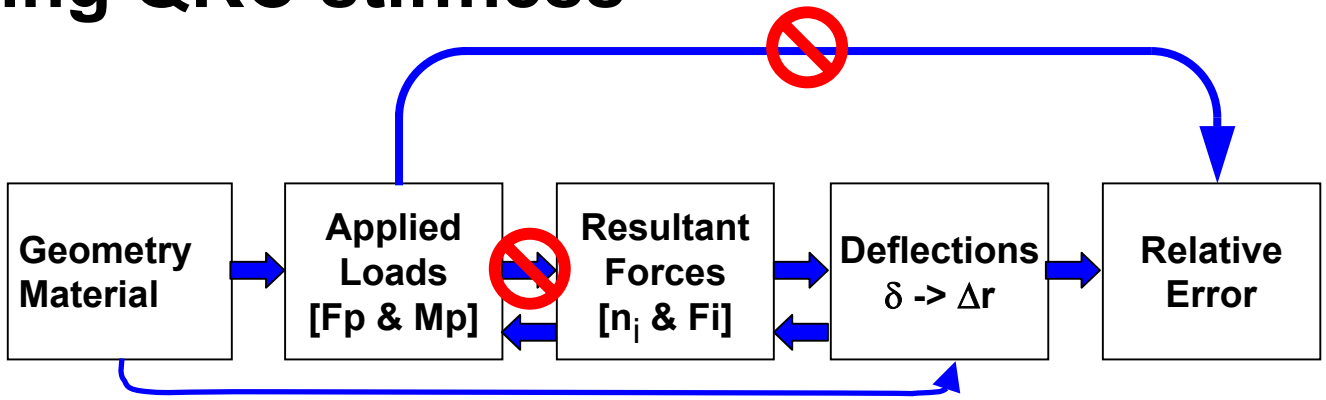
Components and Definitions

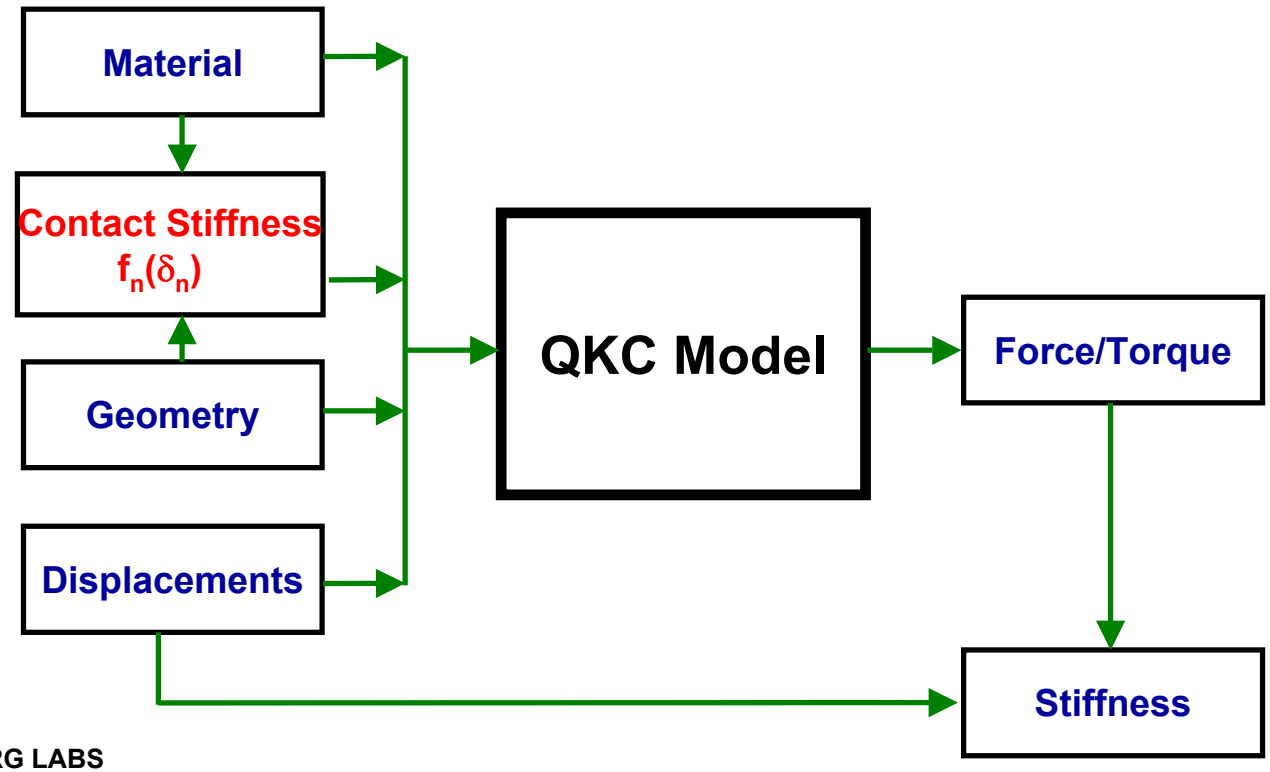


Force Diagrams



Modeling QKC stiffness

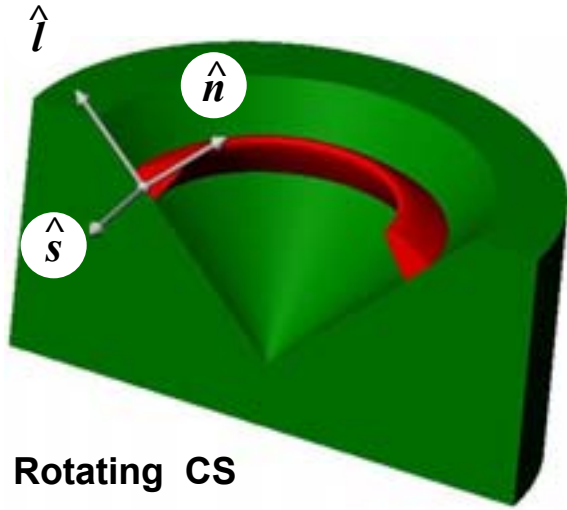




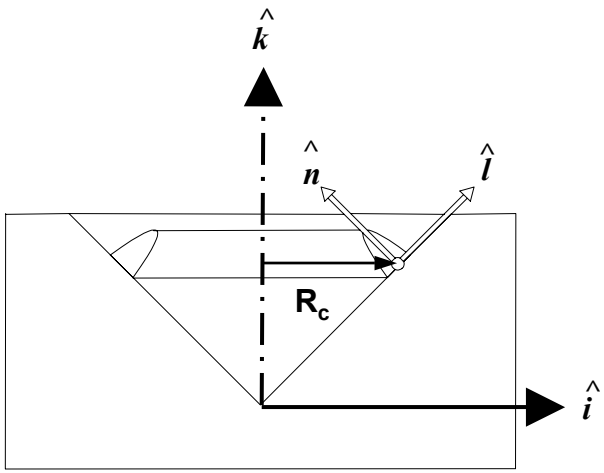
QKC contact mechanics

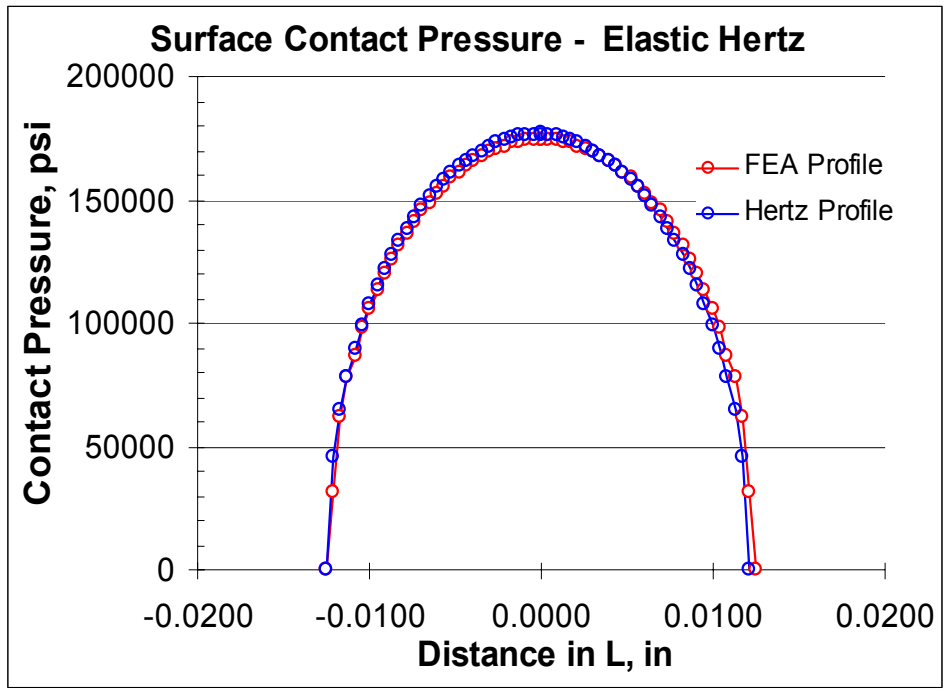
MECHANICS:

- Use Rotating Coordinate System
- Assume Sinusoidal Normal Distance of Approach
- Obtain Contact Stress Profile as Function of Above
- Integrate Stress Profile in Rotating CS thru contact



Rotating CS

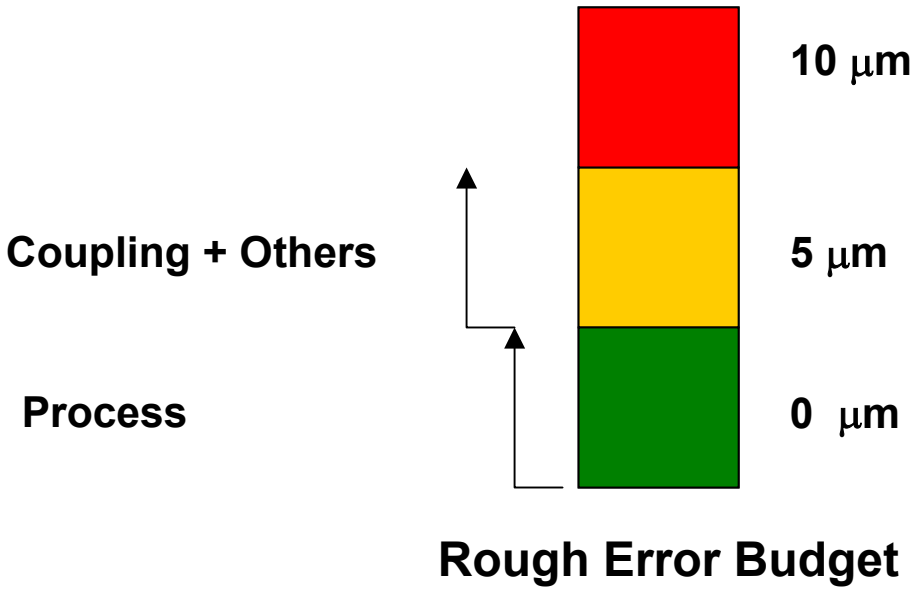




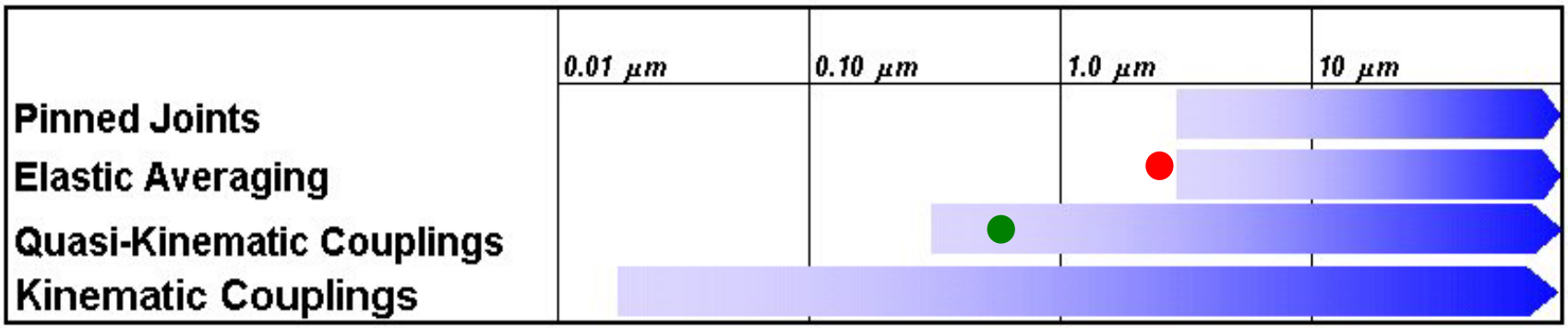
Example: Duratec™ assembly

Characteristics:

- Ford 2.5 & 3.0 L V6
- > 300,000 Units / Year
- Cycle Time: < 30 s



Rough Error Budget



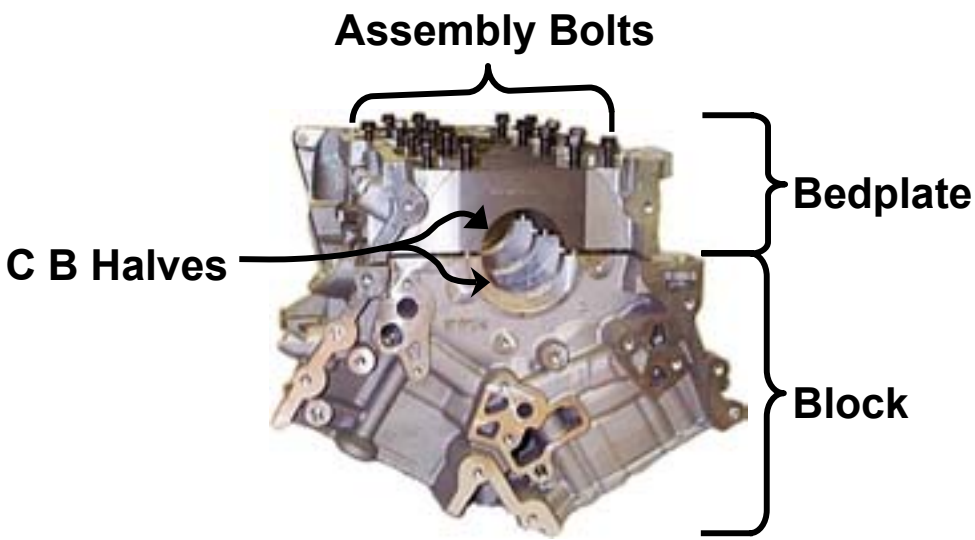
Example: Assembly of Duratec™ block & bedplate

COMPONENTS

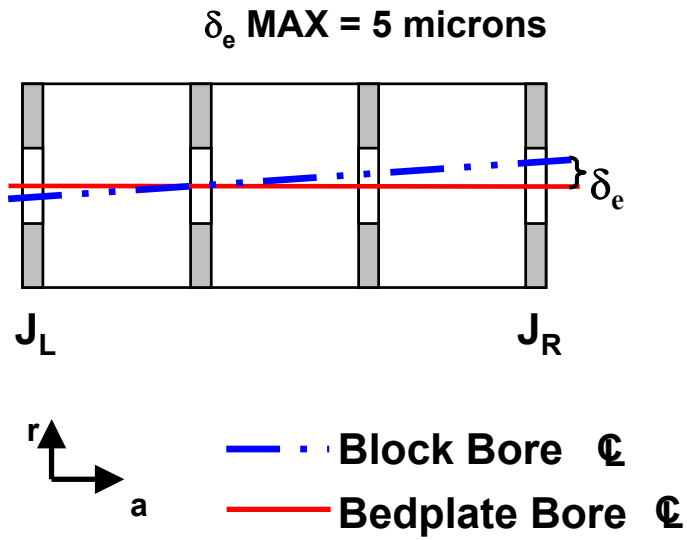
Block

Bedplate

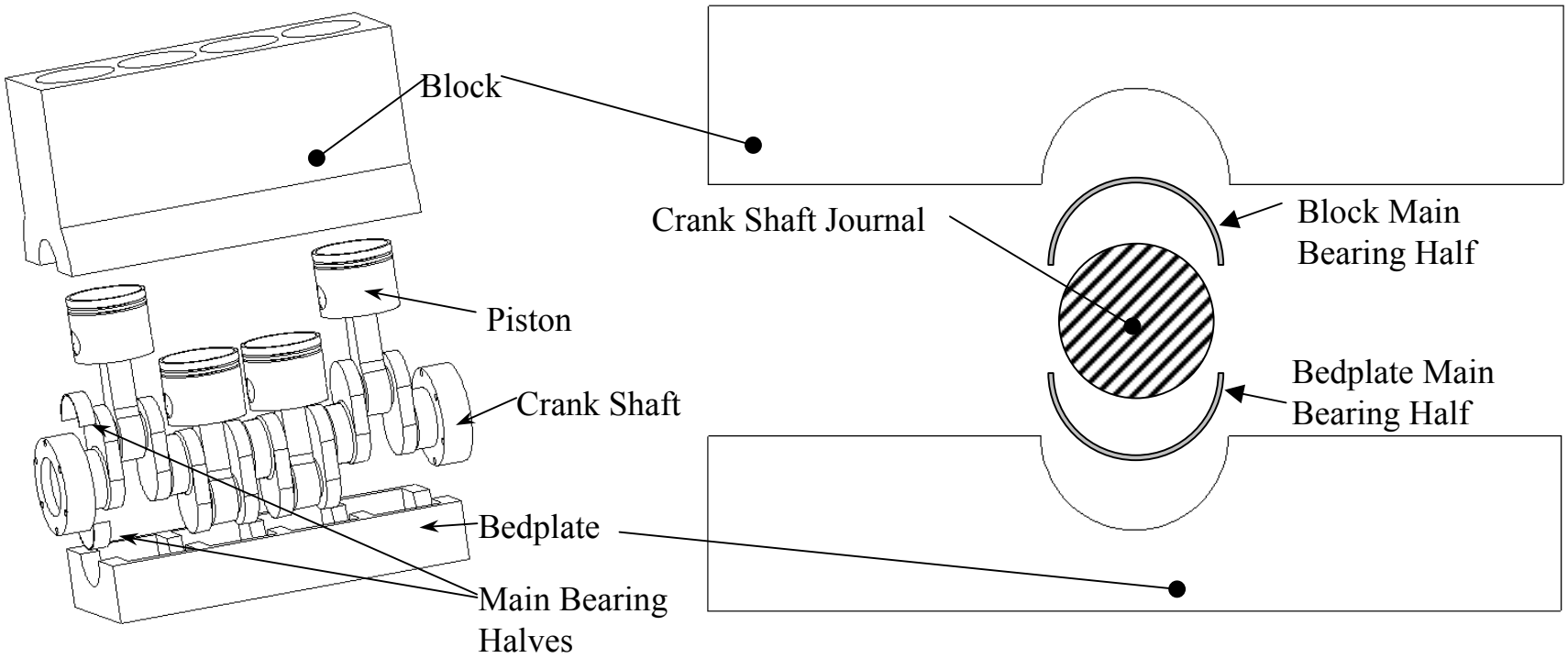
ASSEMBLY



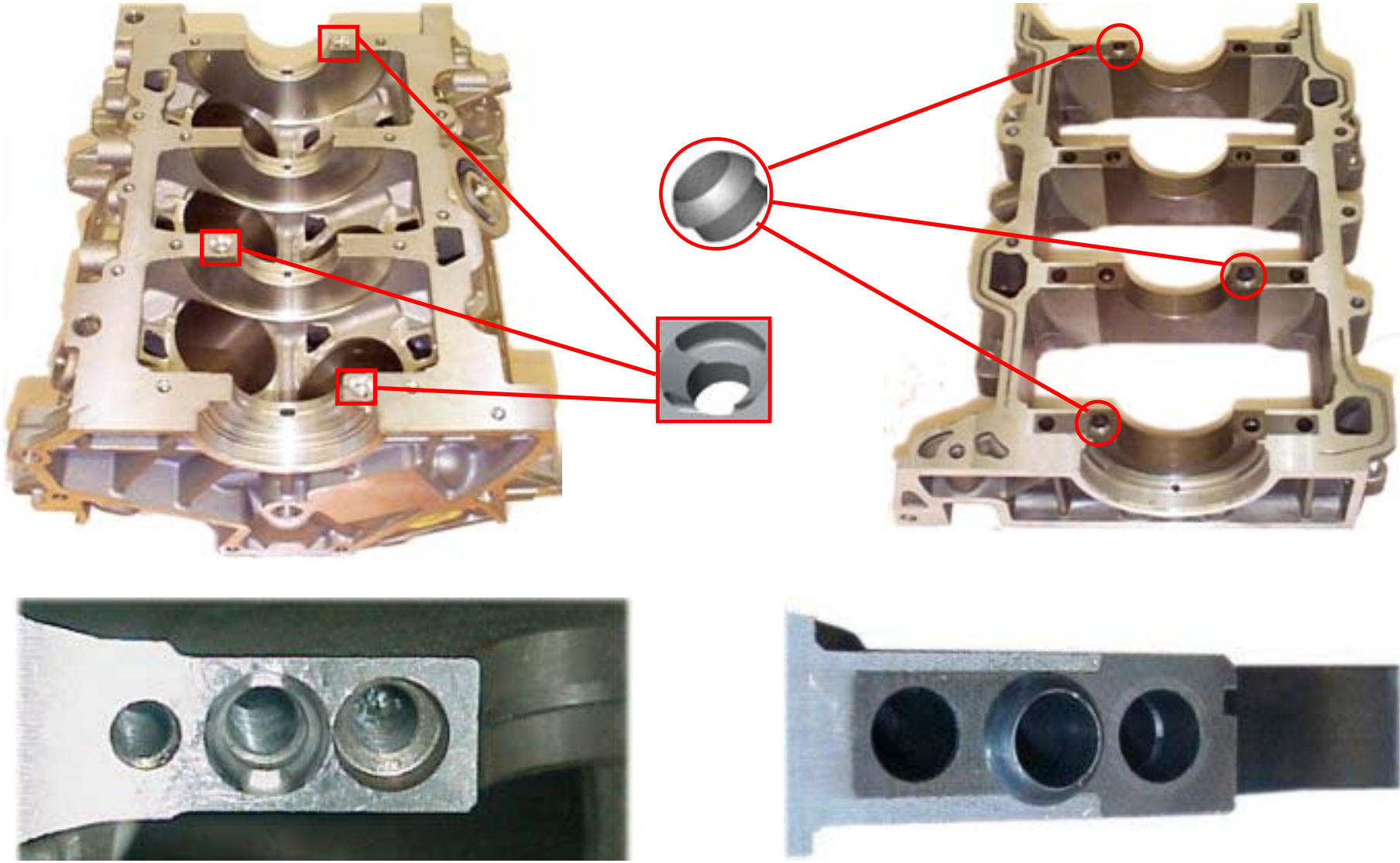
ERROR



Bearing assemblies in engines



Detail of Duratec™ QKC element placement



Results of Duratec™ QKC Research

MANUFACTURING:

Engine Manufacturing Process With Pinned Joint

Op. #10
- Mill Joint Face
- Drill/Bore **16 Holes**
- Drill Bolt Holes

→

Op. #30
- Drill Bolt Holes

→

Op. #50
- Press in **8 Dowels**
- Assemble
- Load Bolts
- Torque Bolts

→

Op. #100
- Semi-finish crank bores
- Finish crank bores

Modified Engine Manufacturing Process Using Kinni-Mate Coupling

Op. #10
- Mill Joint Face
- Drill/Bore **3 Peg** Holes
- Drill Bolt Holes & Form **3 Conical Grooves**

→

Op. #30
- Drill Bolt Holes

→

Op. #50
- Press **3 Pegs in BP**
- Assemble
- Load Bolts
- Torque Bolts

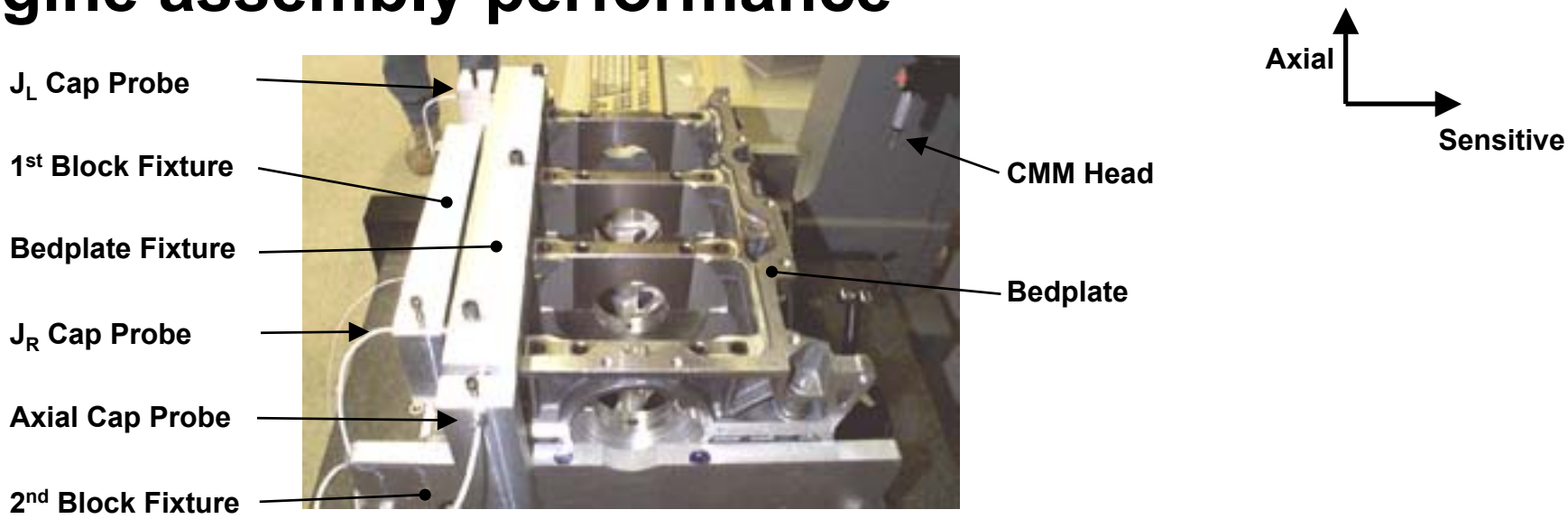
→

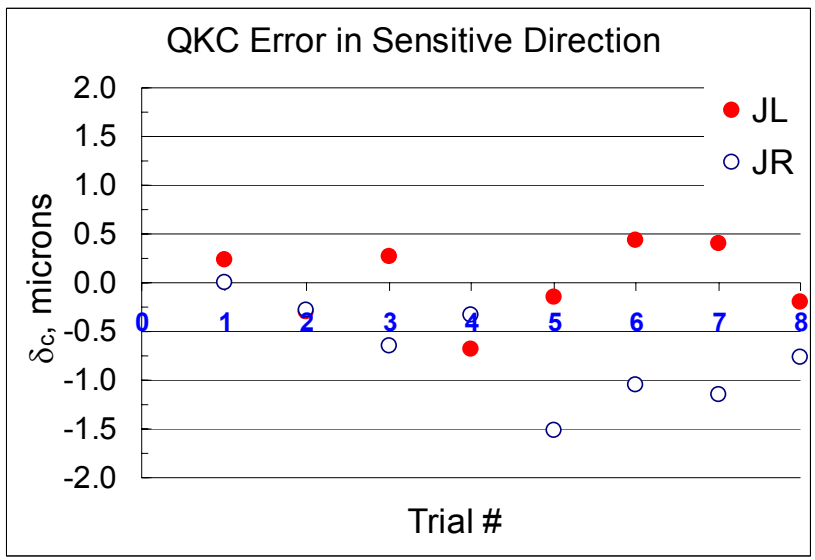
Op. #100
- Semi-finish crank bores
- Finish crank bores

DESIGN:

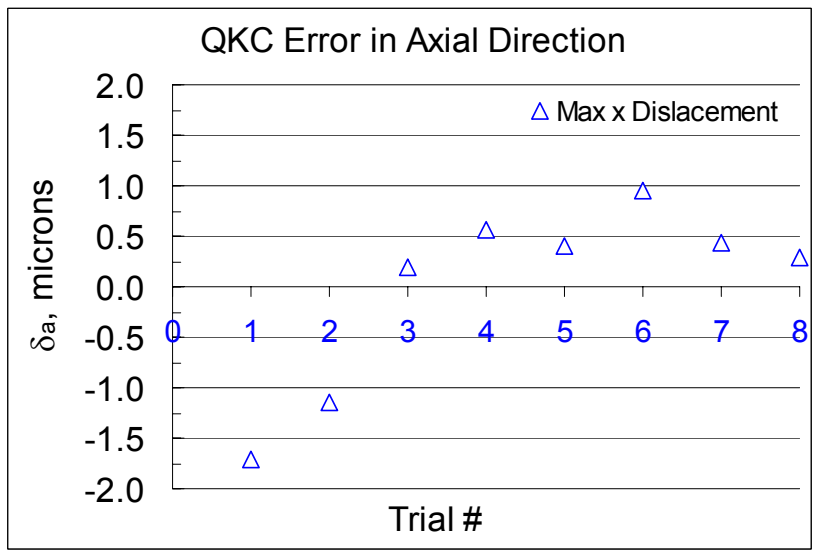
ITEM	QKC	Pinned Joints
# Precision Pieces	3	8
# Precision Features	3	16
Feature Placement Tolerance	+/- 0.08mm	+/- 0.04mm
Average Centerline Repeatability	0.65 μm	4.85 μm
Normalized $/Engine	0.64	1

Engine assembly performance





$(\text{Range}/_2)|_{AVG} = 0.65\ \mu m$



$(\text{Range}/_2) = 1.35\ \mu m$