COMPUTER TOOLS FOR FACE SEAL ANALYSES DEVELOPED AT JOHN CRANE

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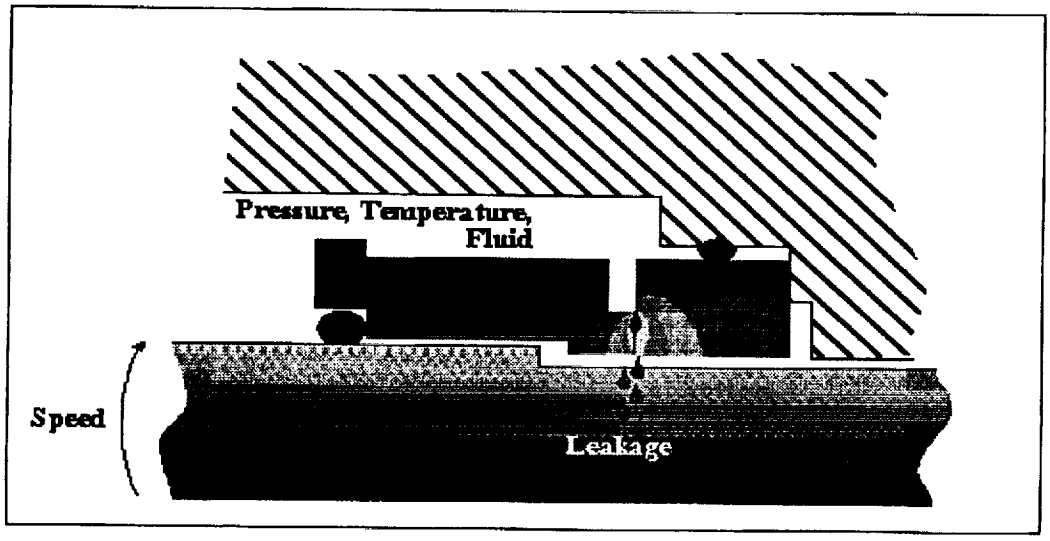
PROGRAM PURPOSES

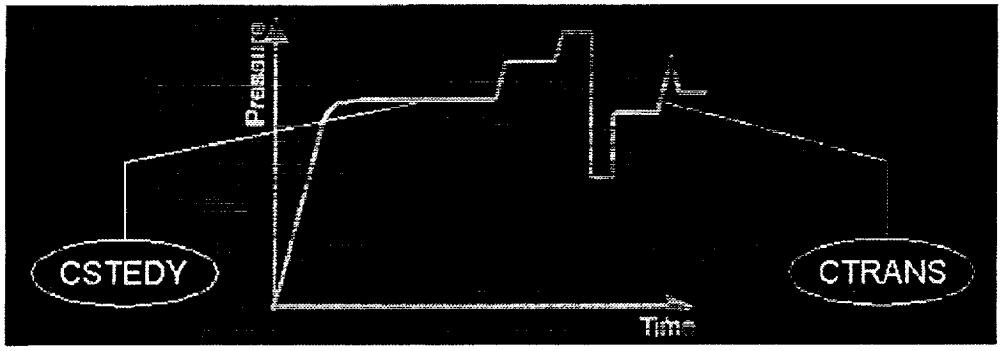
- New product optimization
- Existing seals on new application
- Existing seals on off-duty conditions
- Trouble-shooting

PROGRAM FUNCTIONS

- Take into account the combined effects of pressure, temperature, speed, fluid sealed, materials and seal geometry on seal distortion, temperature distribution, operating film thickness, friction and leakage



DIFFERENT CODES FOR DIFFERENT APPLICATIONS



- Steady-state
- Liquids or gas
- Conventional flat face
- Active lift grooves

- Transient
- Liquids or gas
- Conventional flat face
- Active lift grooves

MAJOR ISSUES INVOLVED

- Interface forces
  - Wet seal
  - Gas seal
- Friction / Heat generation
- Heat transfer / Axisymmetric temperature distribution
- Axisymmetric pressure / Thermal distortion
- Leakage

INTERFACE FORCES

- **Force equilibrium**
  - Closing force = Opening force
- **Hydrostatic pressure**
  - Single liquid phase/Gas film
  - Two phase liquid/vapor
- **Hydrodynamic pressure**
  - Liquid phase
  - Periodic groove gas film
- **Contact pressure**

FRICTION / HEAT GENERATION

- **Viscous shearing**
  - Fluid shear in direction of sliding
  - Isoviscous through film thickness
- **Asperity sliding**
  - Contact pressure
  - Boundary friction

HEAT TRANSFER / TEMPERATURE DISTRIBUTION

- Heat source at interface only
- Heat normally dissipated through seal components to the product
- Thermal resistance
  - Fluid film negligible
  - Seal components (conduction)
  - Product boundary heat transfer coefficient (convection)
- Axisymmetric temperature distribution

AXISYMMETRIC PRESSURE / THERMAL DISTORTION

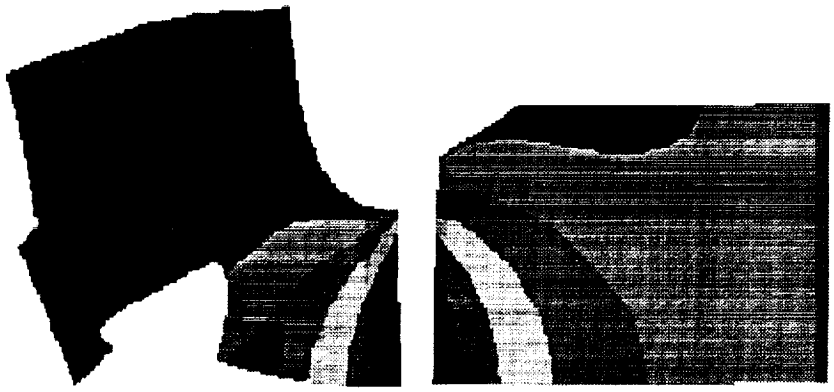
- Pressure distortion
  - Face distortion (toroidal, bending, local compression)
- Thermal distortion
  - Face distortion (toroidal, local expansion)
  - Radial expansion
- Centrifugal distortion
  - Distortion and stress significant at high speeds

LEAKAGE

■ Based on Poisseuille flow

$$Q \propto \frac{r \cdot h^3}{12 \cdot \mu} \cdot \frac{\partial P}{\partial r}$$

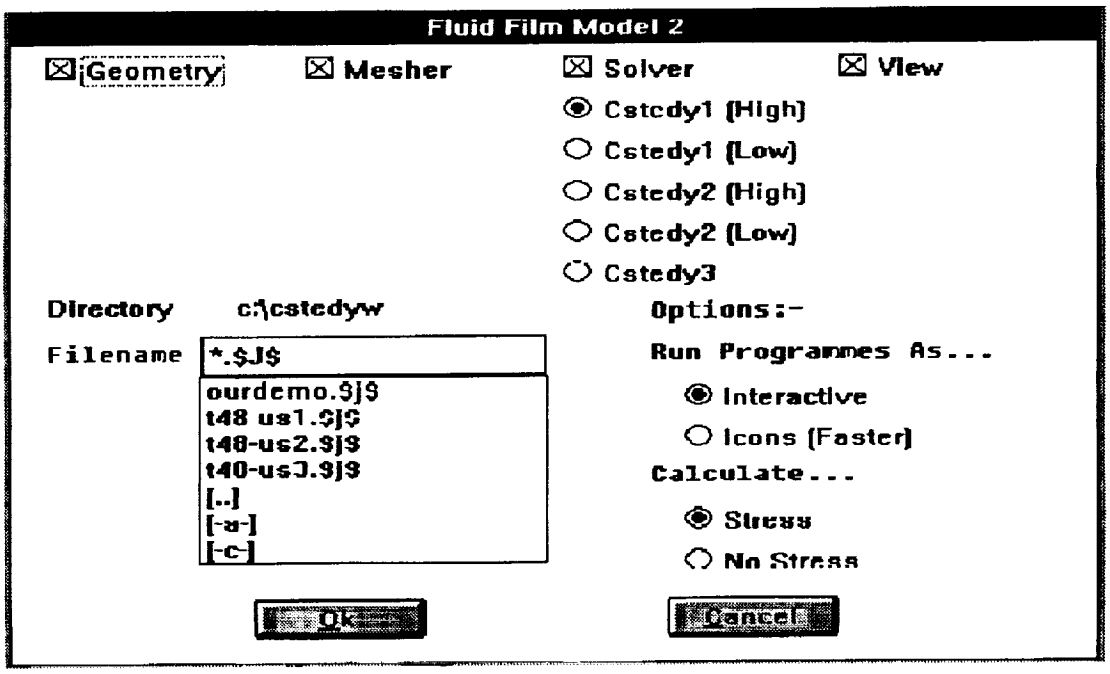
FULLY INTEGRATED SOLUTION



Leakage

Friction power

PROGRAM INTERFACE



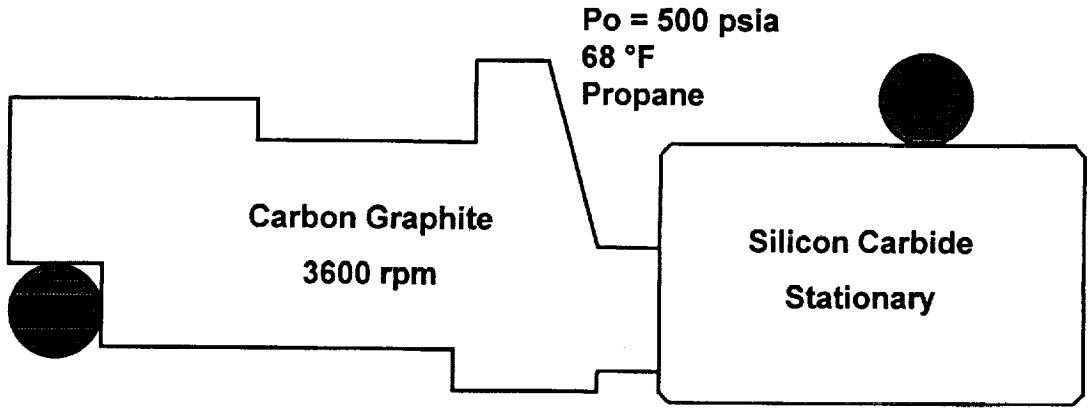
PROGRAM MODULES

- **CSTEDY**
  - Conventional face (no face grooves / hydropads)
  - Liquid, vapor and 2-phase films
  - Single and multi-component fluid database
  - 2D generic face grooves (e.g. spiral grooves)
  - Gas film
- **CTRANS**
  - Transient loading and speed
  - Liquid or gas films

SOLUTION OUTPUT

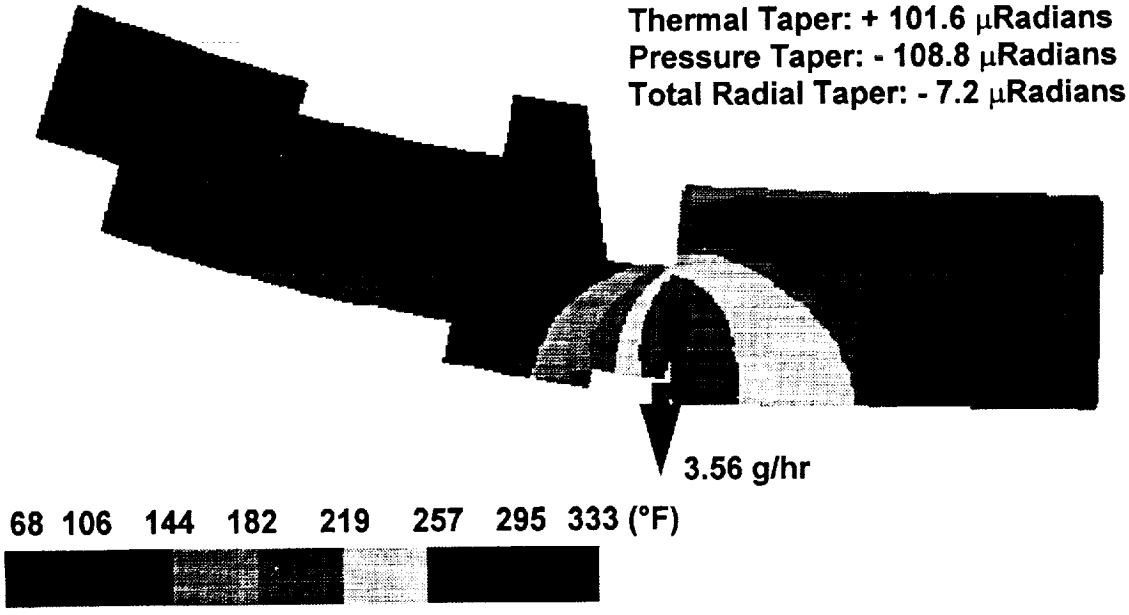
- Temperatures
- Distortions
- Film thickness
- Leakage
- Heat generation
- Interface pressures
- Stresses

A CSTEDY EXAMPLE

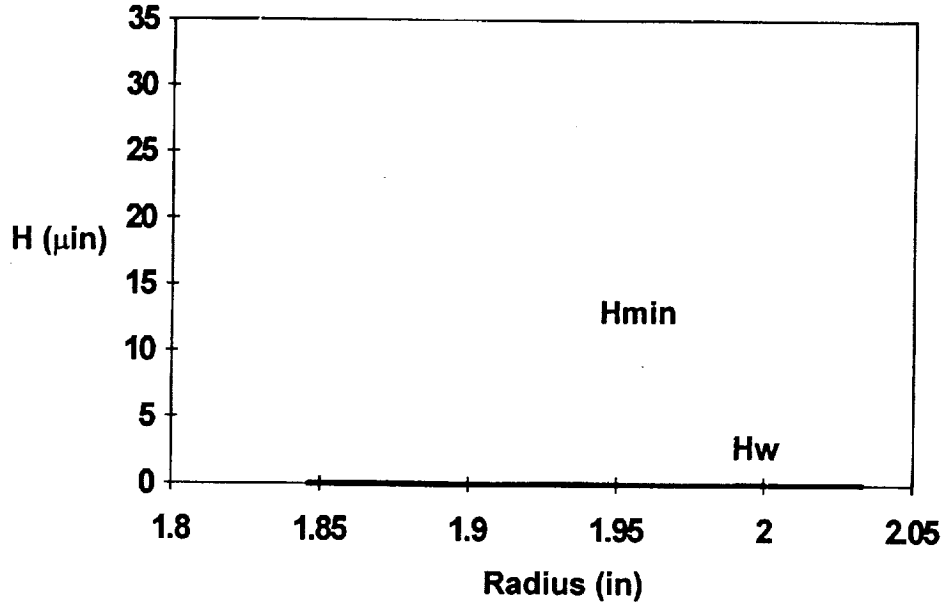


AUTOMESH

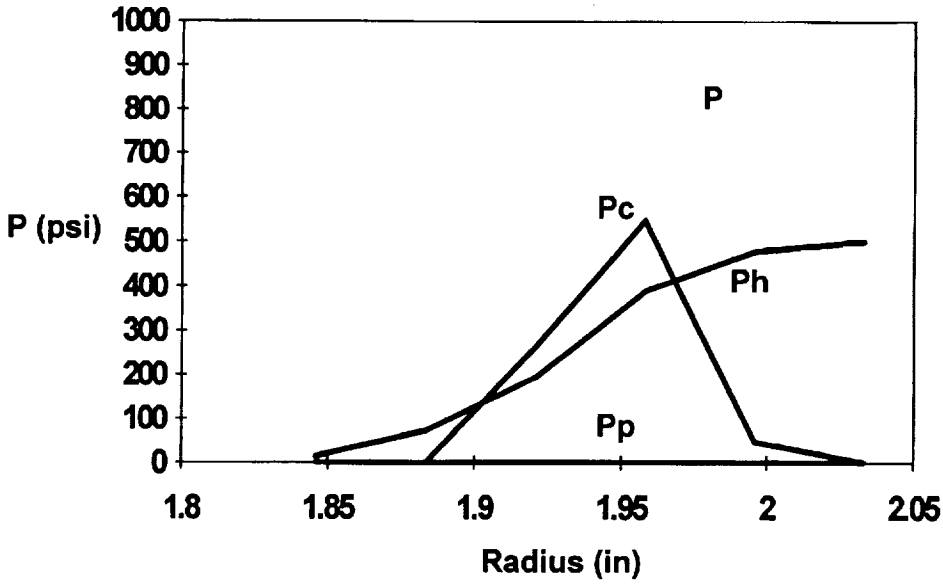
DISTORTION, LEAKAGE AND TEMPERATURE CONTOUR



FILM THICKNESS DISTRIBUTION

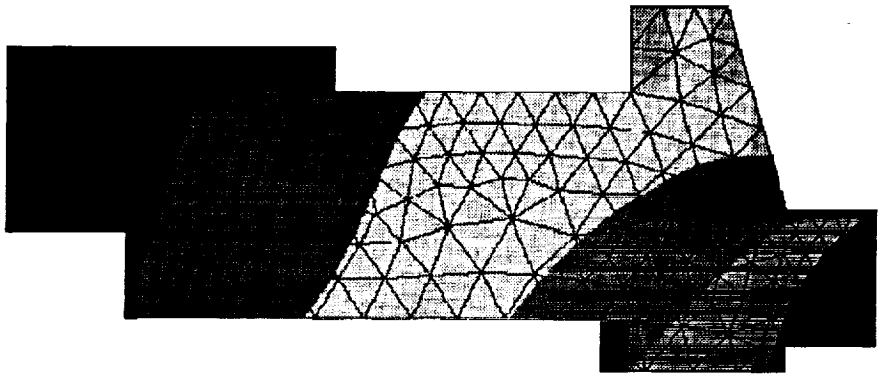


INTERFACE PRESSURE DISTRIBUTIONS



STRESS CONTOUR (P.R.)

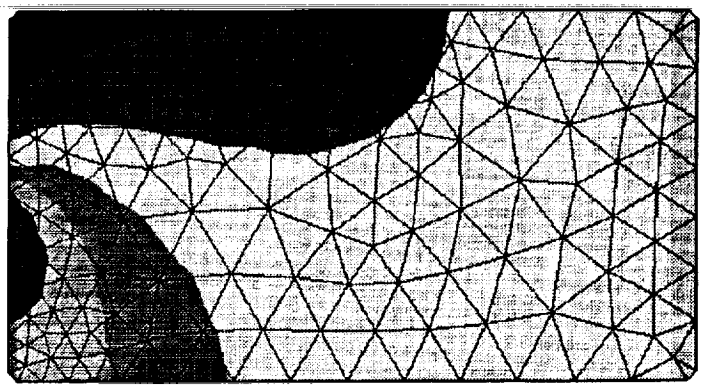
Hoop Stress



-4.2 -3.7 -3.2 -2.7 -2.3 -1.8 -1.3 -0.8 (kpsi)

STRESS CONTOUR (M.R.)

Hoop Stress



-1.3 1.9 5.2 8.5 11.8 15.1 18.4 21.7 (kpsi)