



Temperature Effects on Draw Bead Friction for Advanced High-Strength Steels

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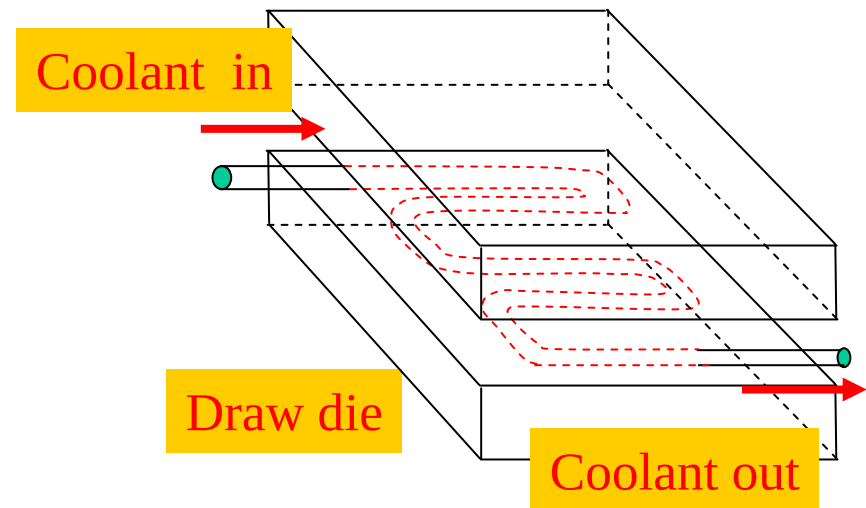
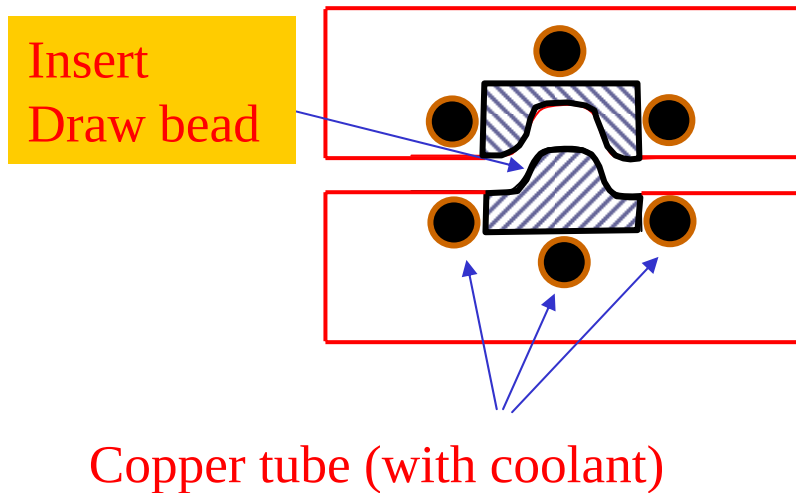


- Background
- Draw bead/die cooling and temperature acquisition system
 - Concept
 - Design and fabrication
 - Cyclic bend test
 - Efficiency validation
- Friction measurements
 - Effects of die temperatures
 - Effects of die materials
 - Effects of climate temperatures (Winter, Summer)
- Field validation-coating adhesion
- Summary



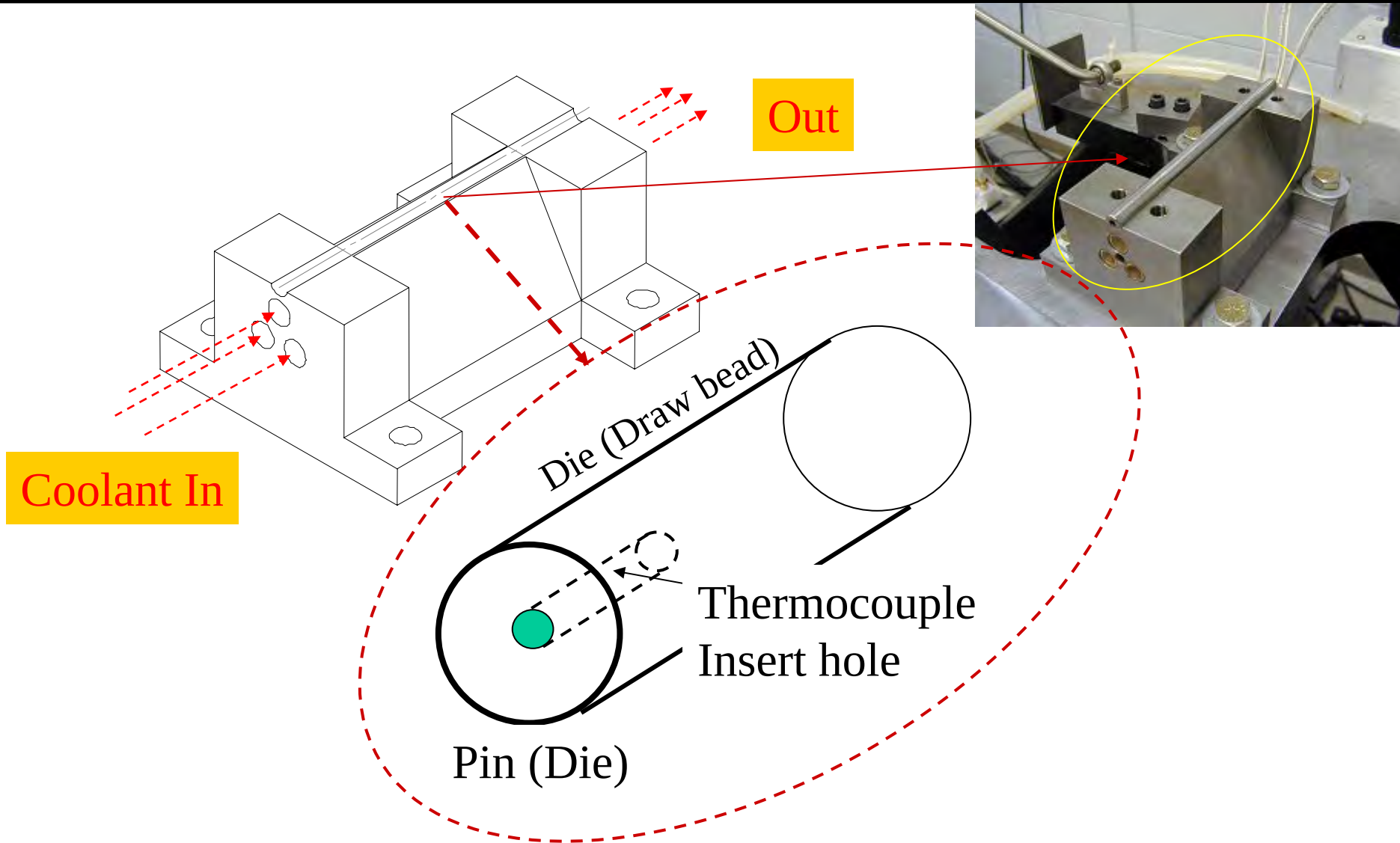
- Observed problems in stamping AHSS
 - Splitting around draw bead
 - High temperature of the panel and die surface
 - Coating adhesion and die surface build-up
 - Die wear
- Potential Cause
 - Higher friction
 - Lubrication and coating breakdown
 - Poor die surface treatment
- Targets
 - Prevent splitting
 - Reduce die surface temperature
 - Reduce coating adhesion
 - Providing a better die material or surface treatment

Water cooled draw bead /die system

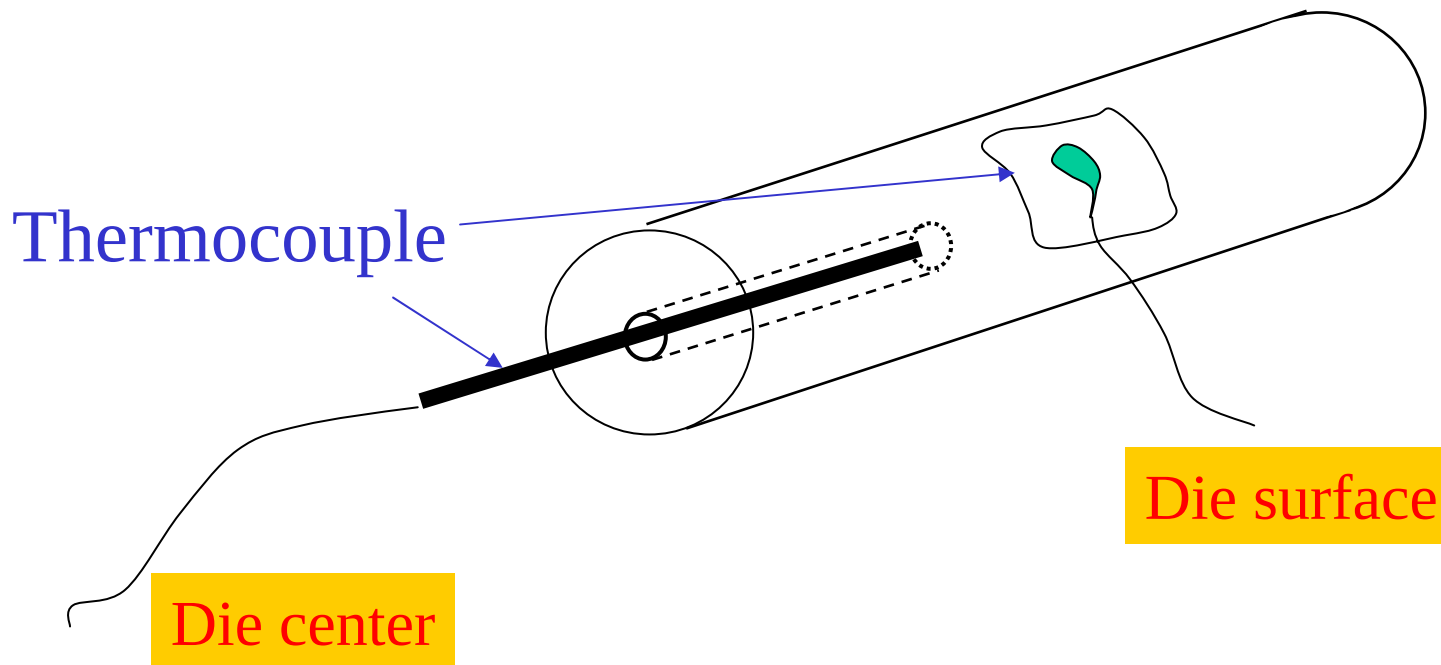




- Draw bead/die cooling system
- Temperature acquisition system

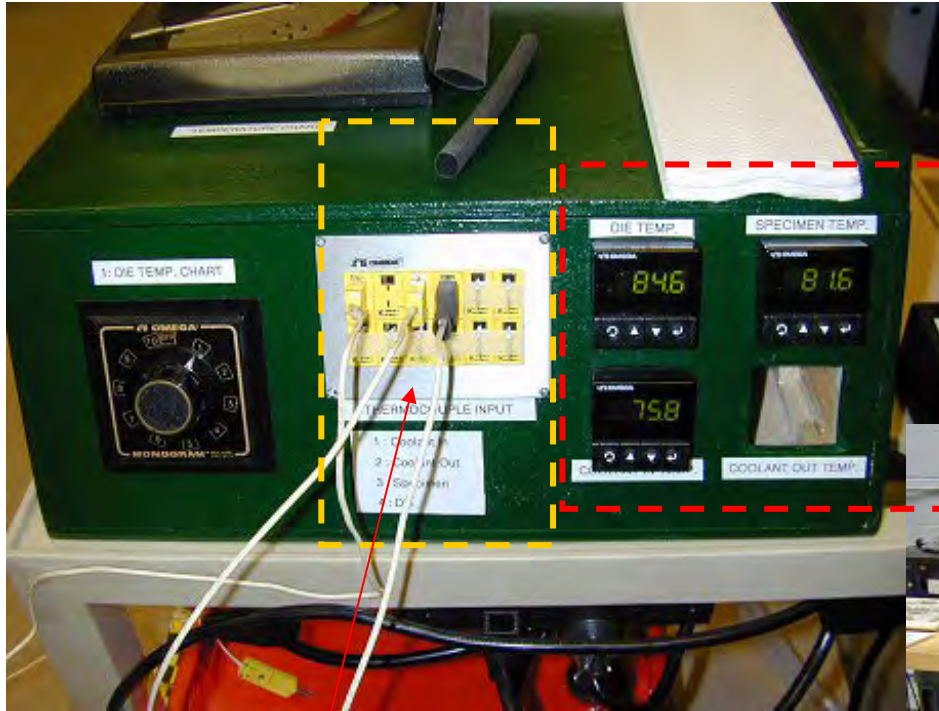


- Die center: Insert the thermocouple into the center hole
- Die surface: Attach the thermocouple on top of the die (pin)





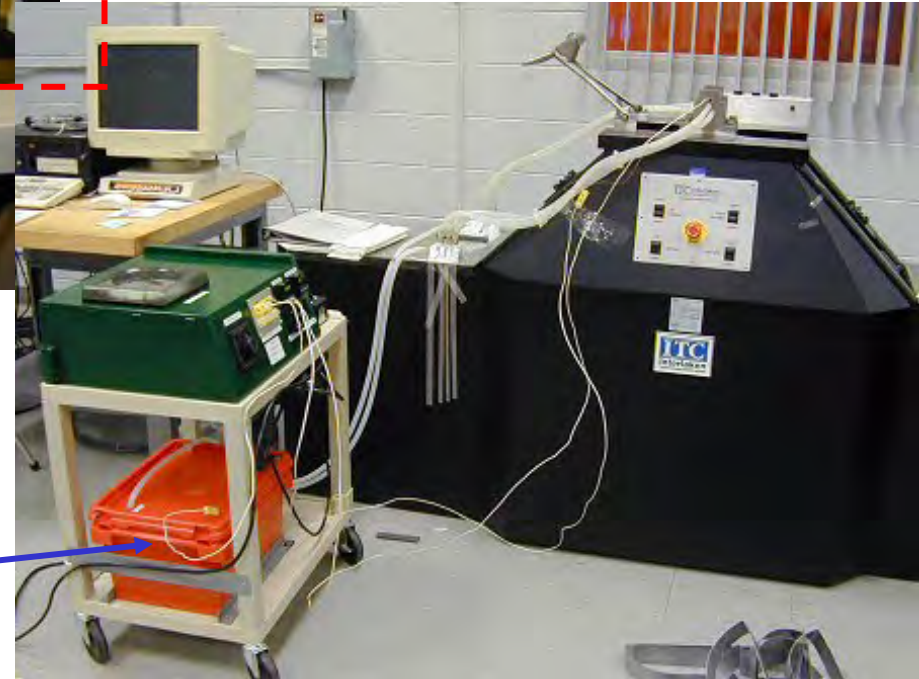
Temperature acquisition system



Temperature Readout

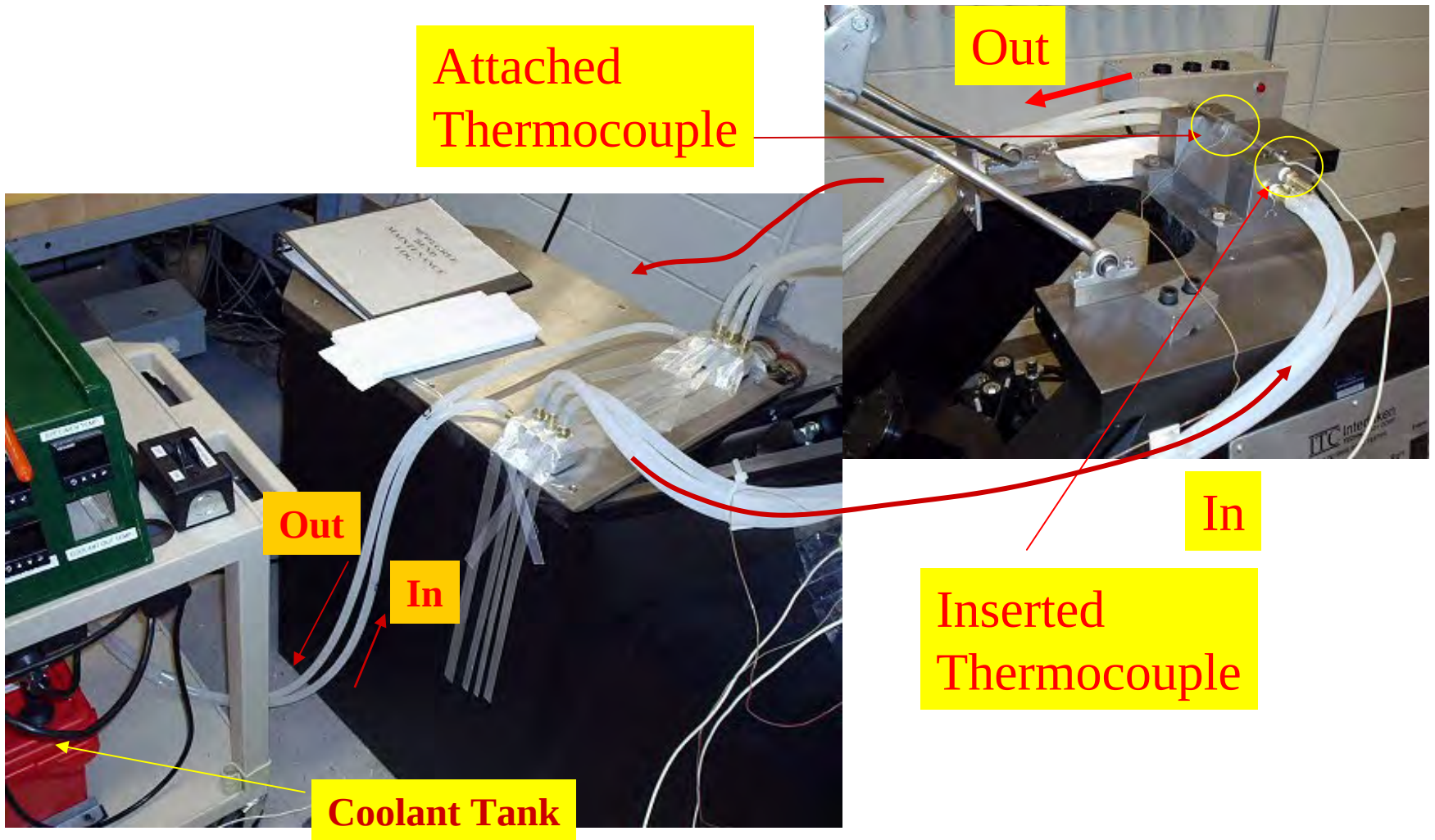
Thermocouple panel

Coolant tank

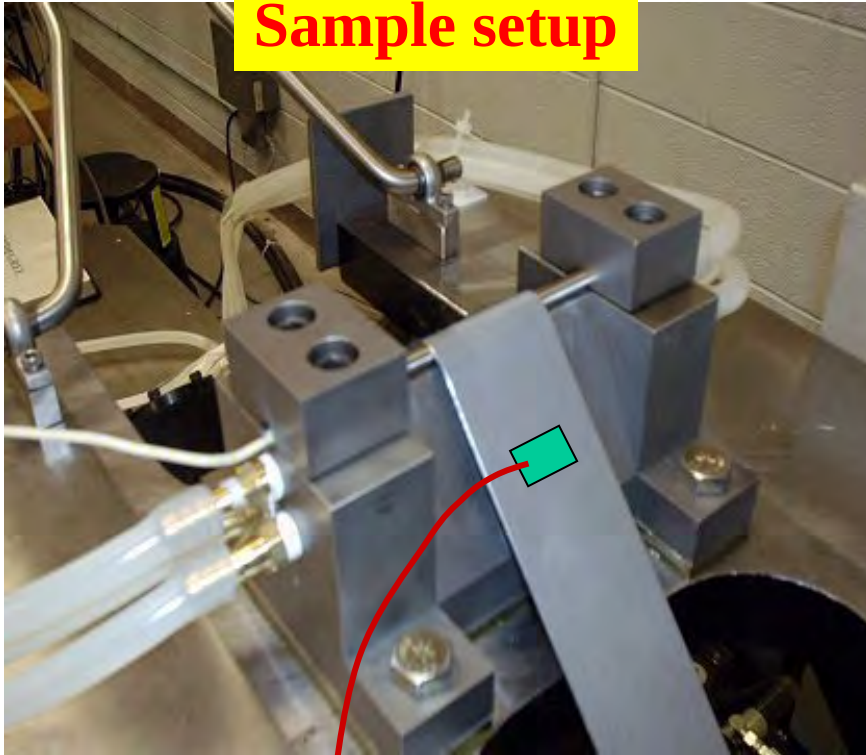




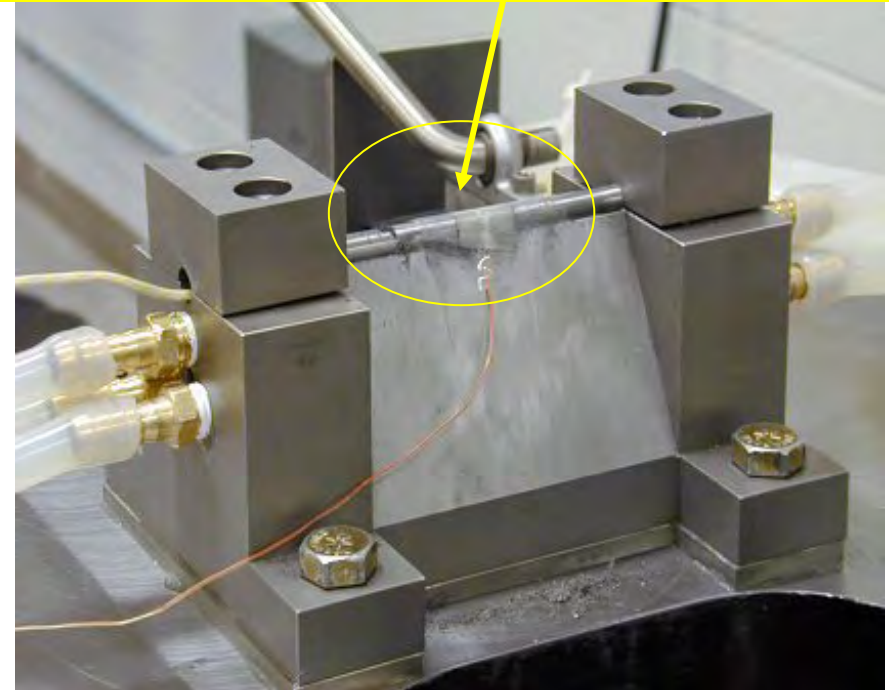
Draw bead/die cooling system



Sample setup



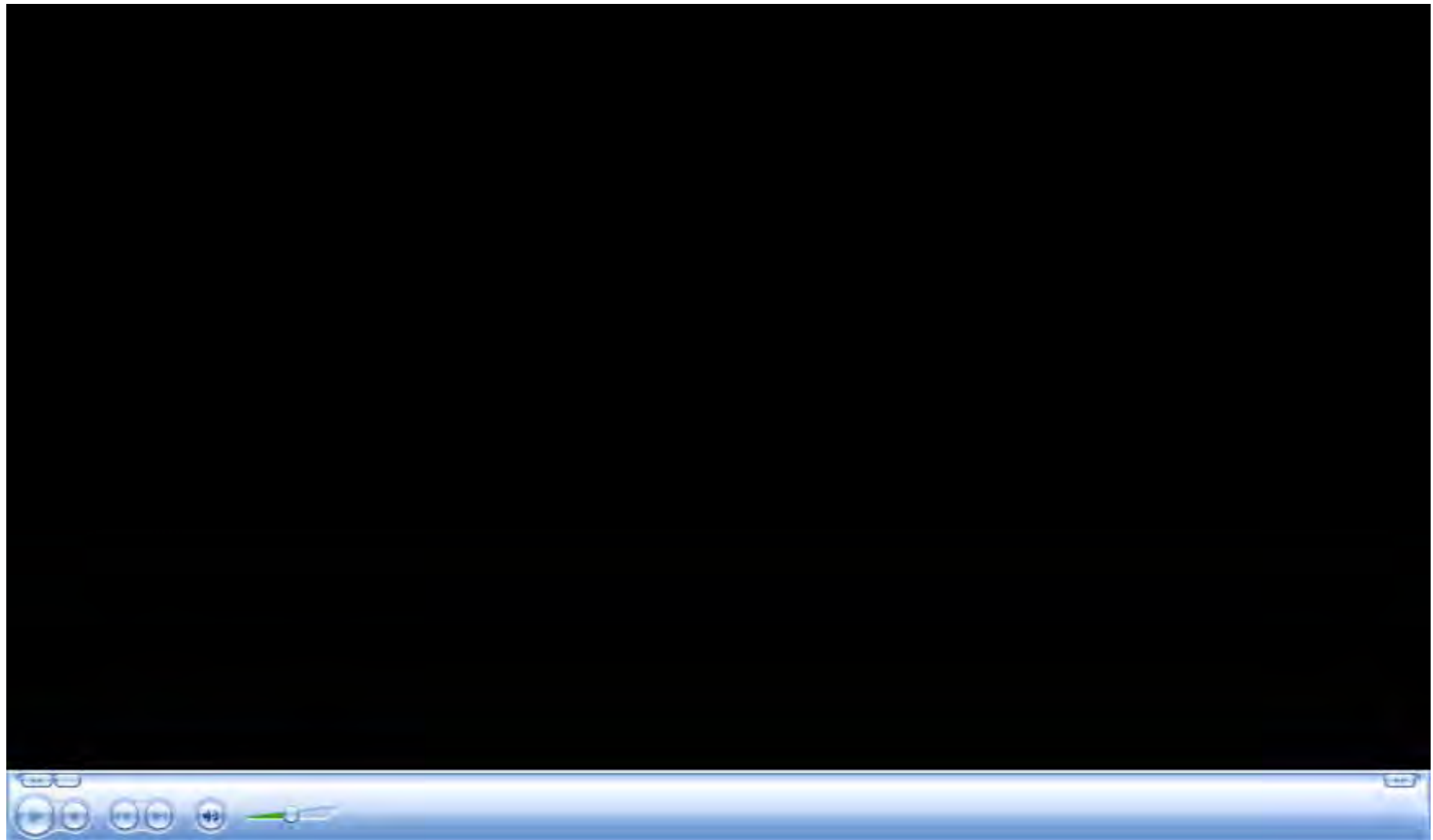
Die surface temp. measurement



Thermocouple for sample surface Temp.



Test demo



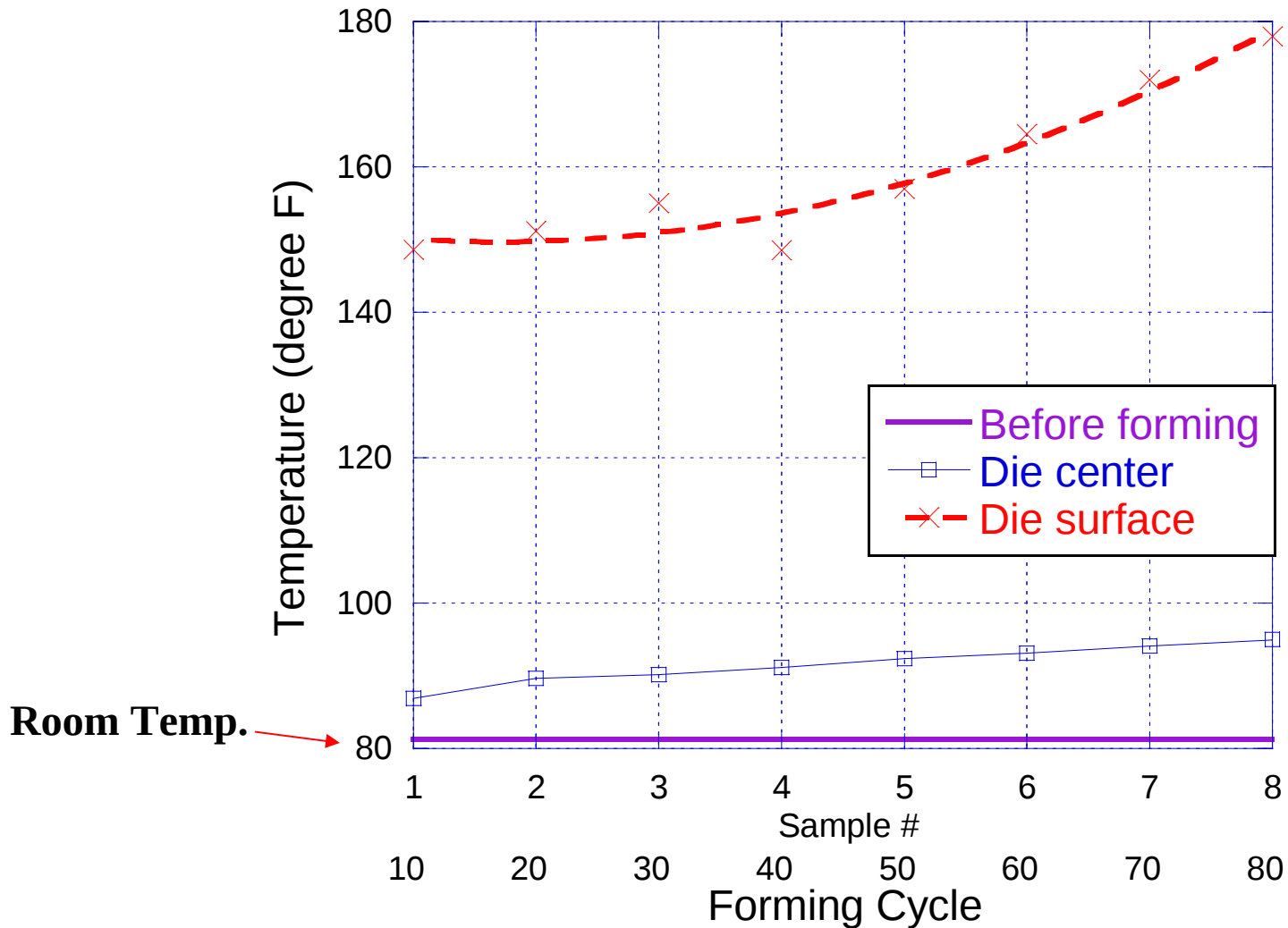


- DP 590, HDGA, 1 mm
- Cyclic test : 10 cycles or as needed
- Lubrication condition : As-received vs. 61AUS
- Specimen temperature : Room



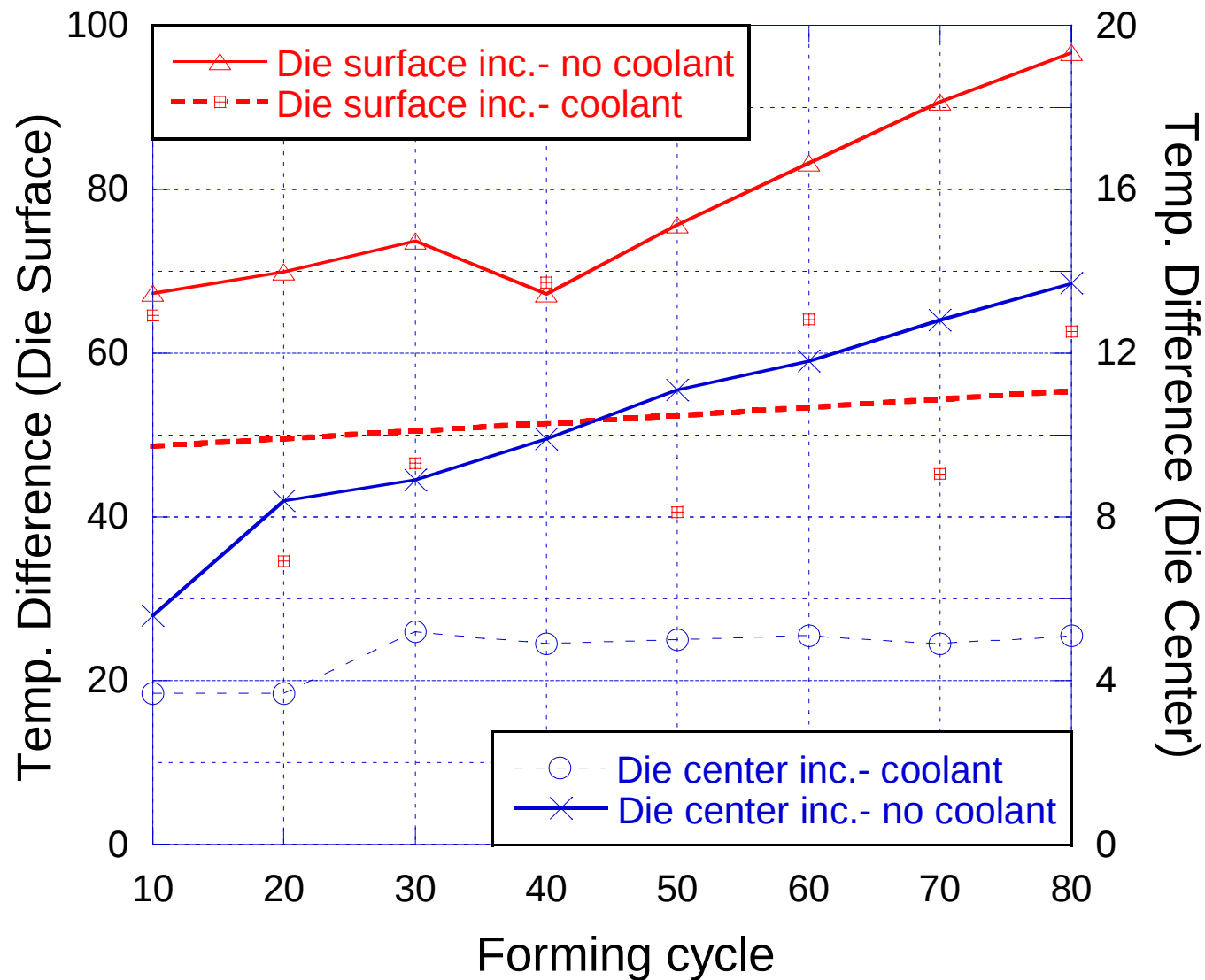


Variation of Die Temperature without Coolant



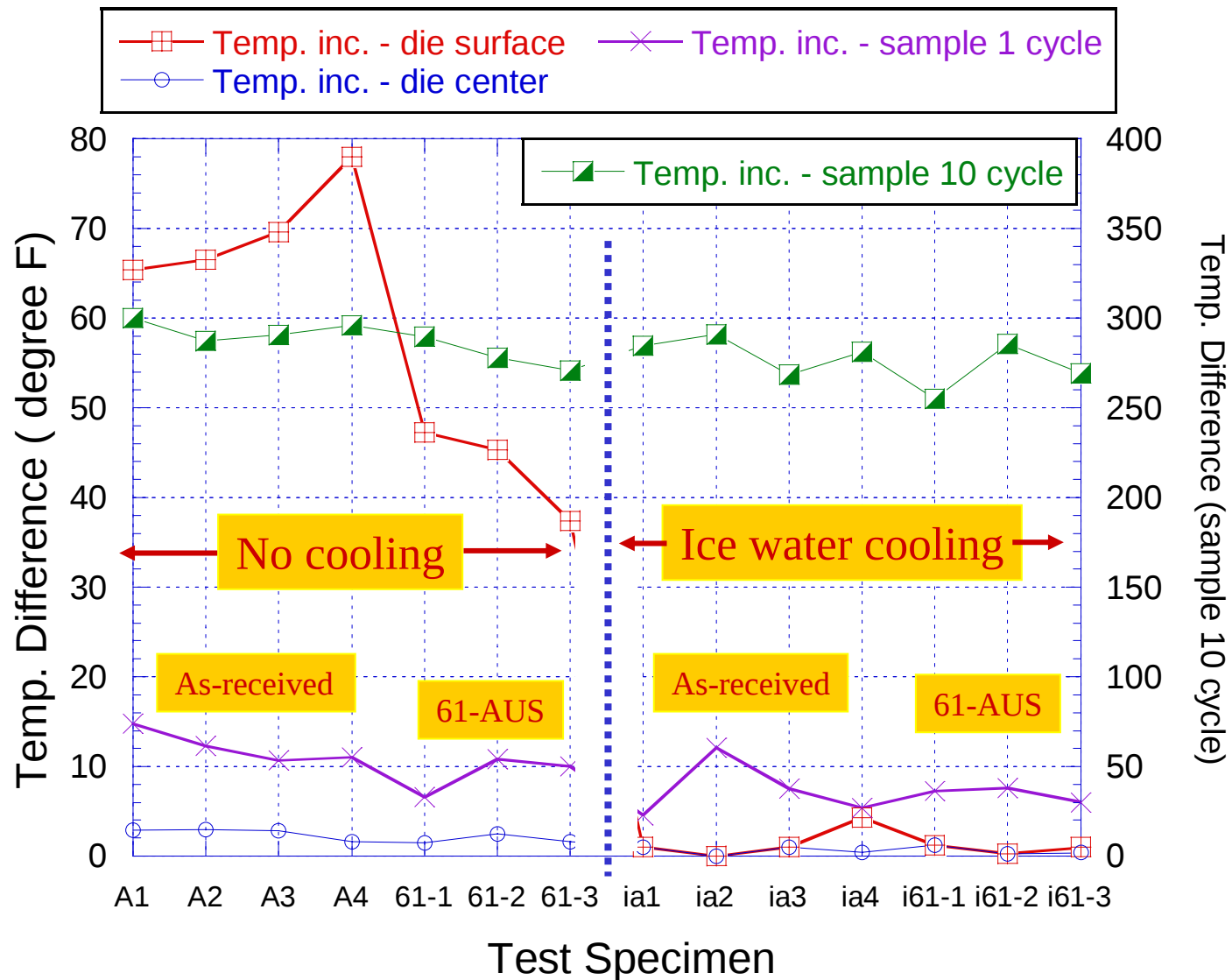


Efficiency of the cooling system





Effects of coolant - Ice water





Effects of coolant Die surface pick up

Zinc powdering - No coolant



Less powdering - With coolant





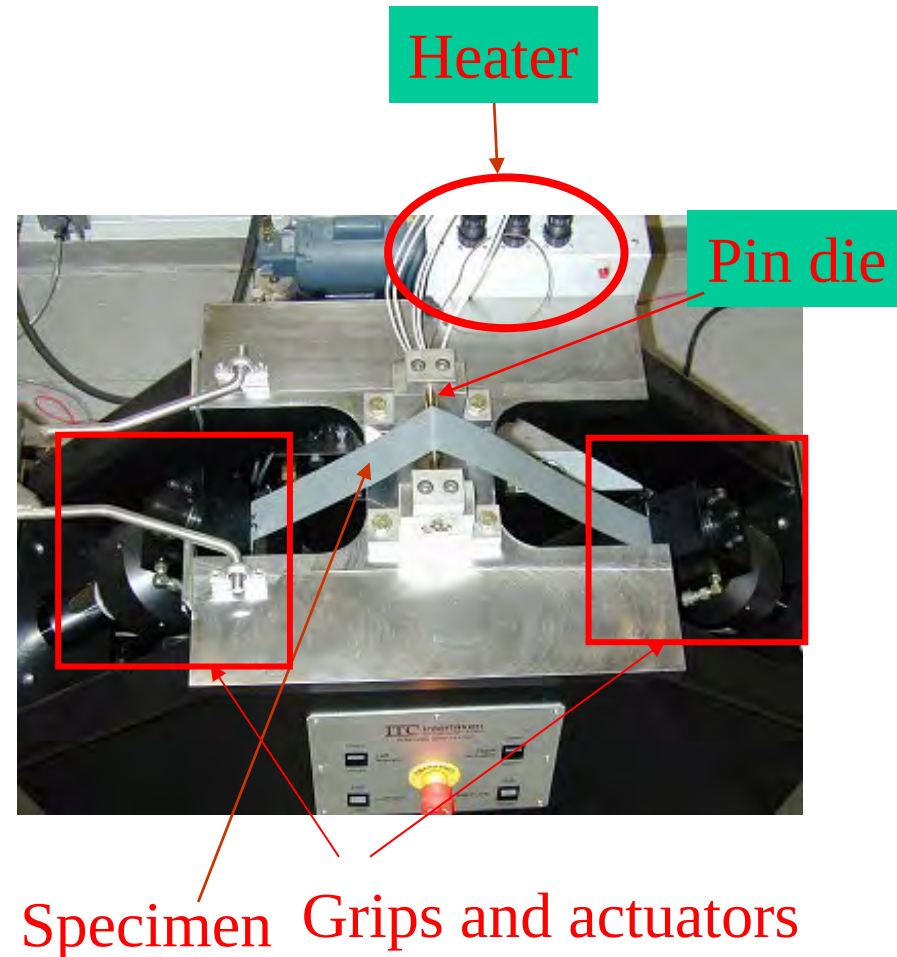
Friction Measurements

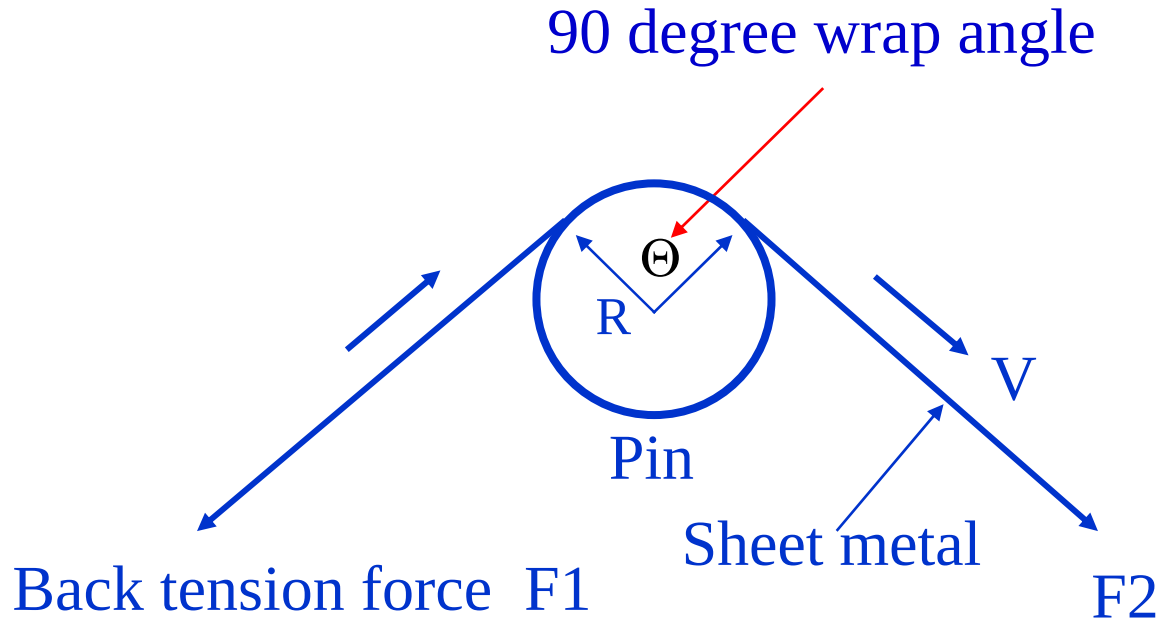




90 degree bend (BUT) test

- Machine
 - Bending Under Tension test (BUT)
 - 90 degree bend test
- Fixed Din radius: 4.75 (mm)
- Sliding speed: 4.11 (m/min)
- Material
 - DP590, HDGA, 1 mm
- Lubrication condition: 61AUS
- Effects of back tension force
 - 65%, 80%, 100% and 120% of yield strength
- Effects of Die temperature
 - Room, 112, 150, 200 F
- Effects of Die material
 - **D2 Flame Hardening**
 - **Cast Iron + Chrome Plating**
 - **Cast Iron + Iron Nitriding**



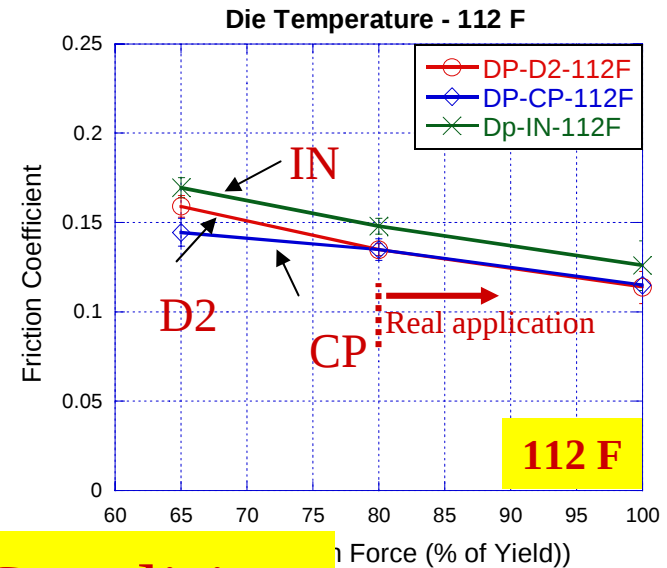
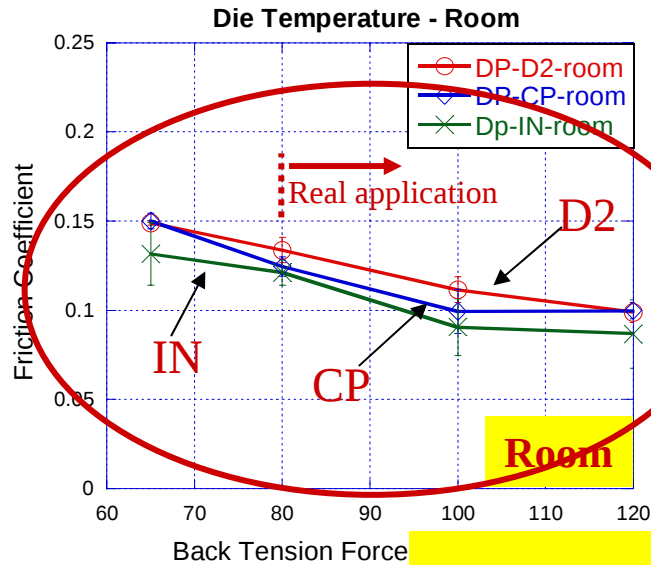


$$\bar{\mu} = 2(F_2 - F_1 - F_b) / \Theta(F_1 + F_2) \quad (\text{friction model, Wilson et al. 1991})$$

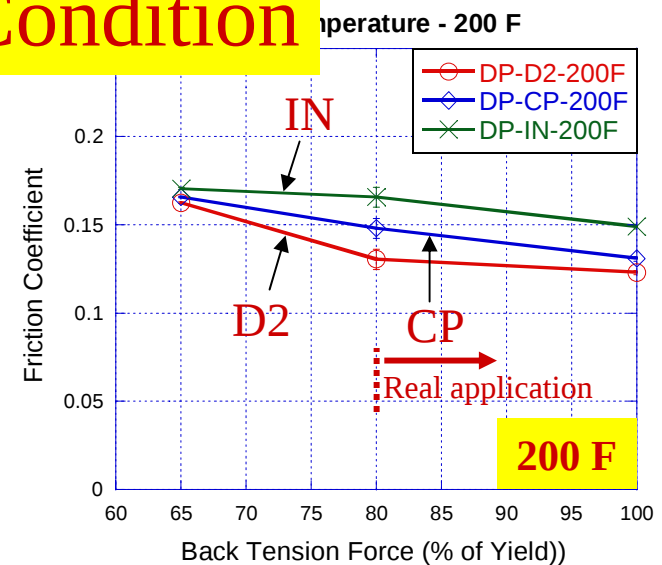
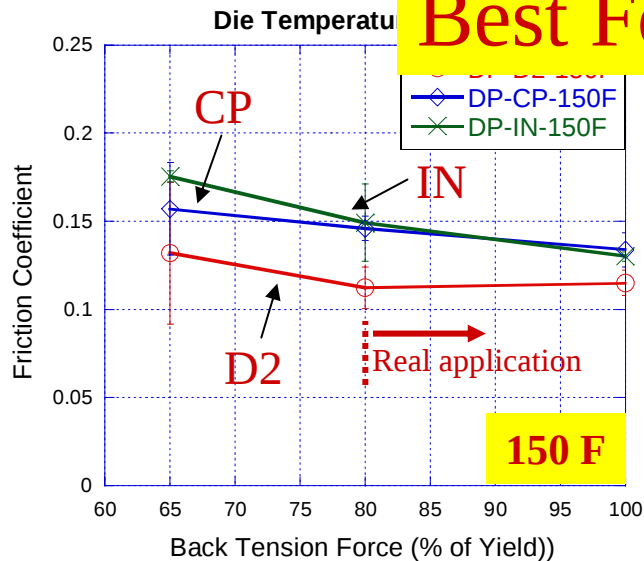
$$F_b = \frac{\sigma_y t^2 w}{2R} \quad (\text{Swift 1948})$$



Effects of die materials

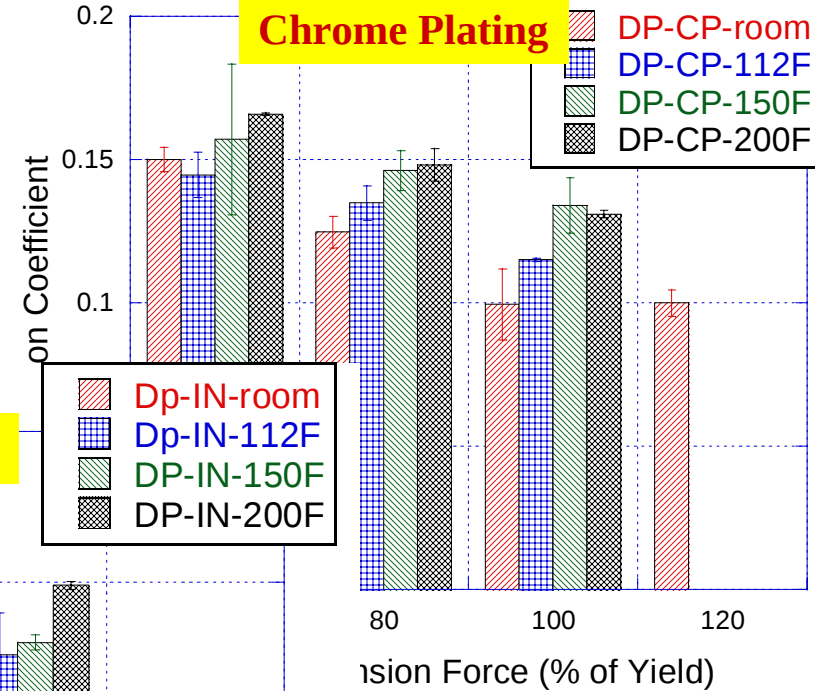
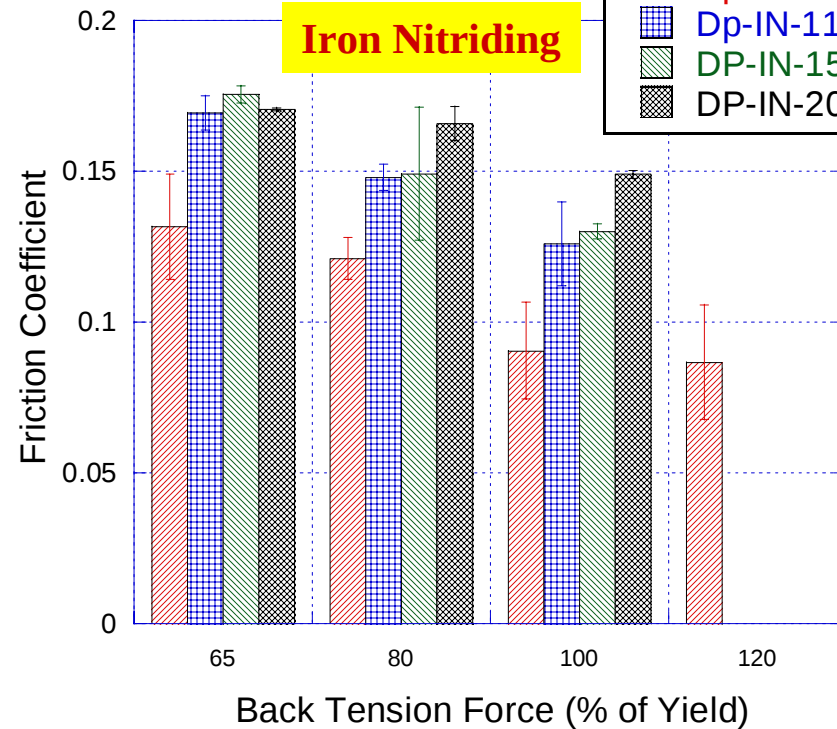
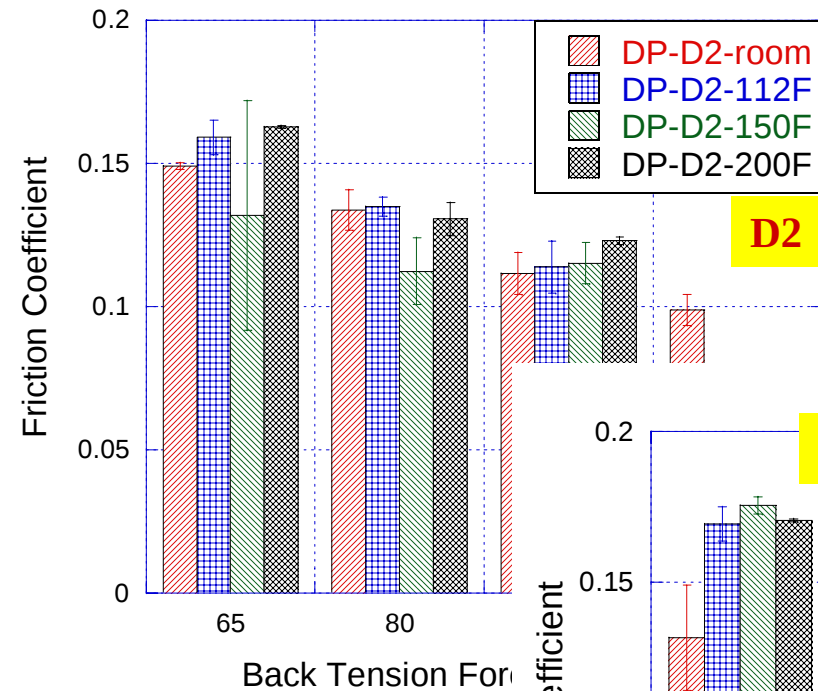


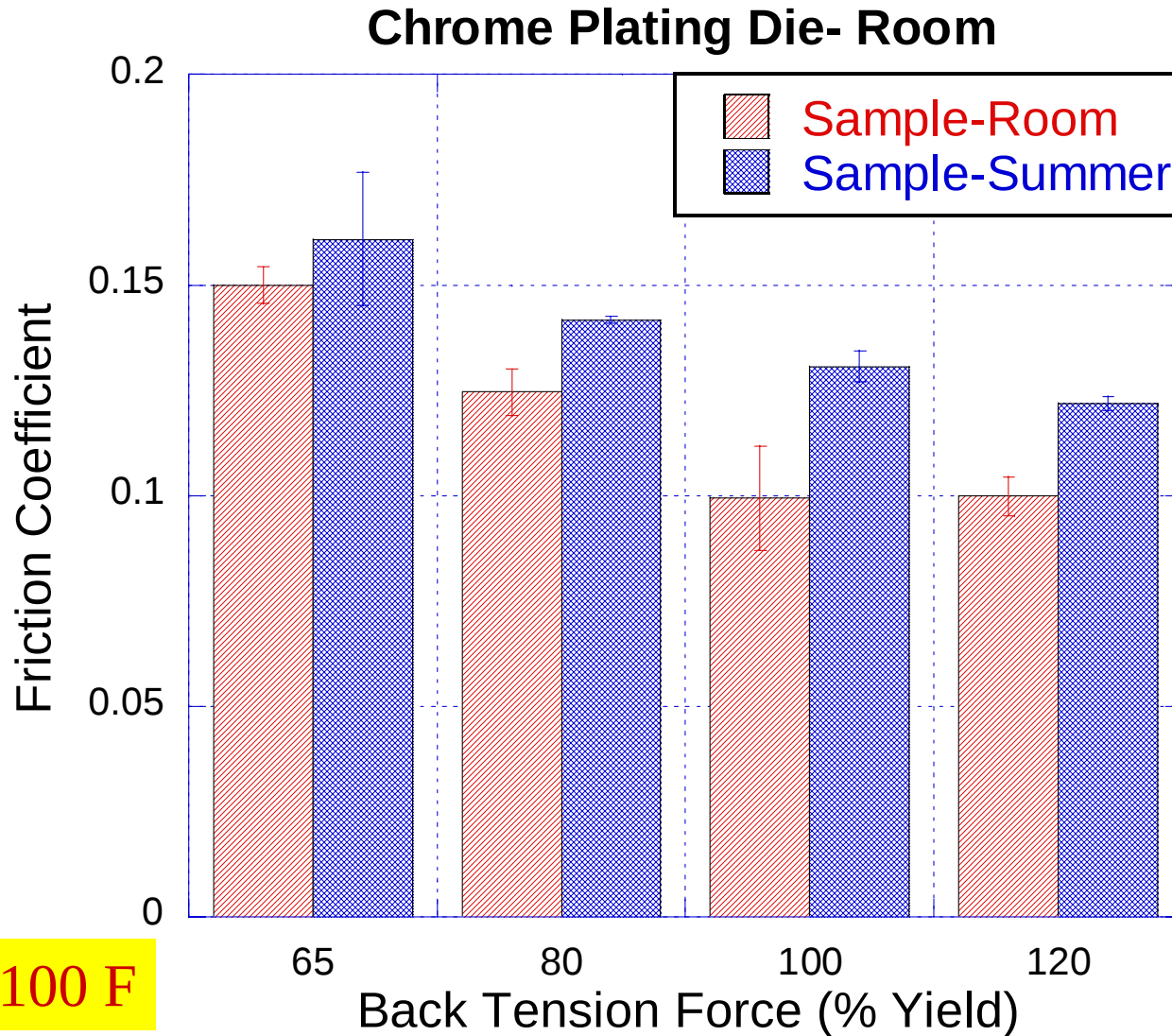
Best Forming Condition



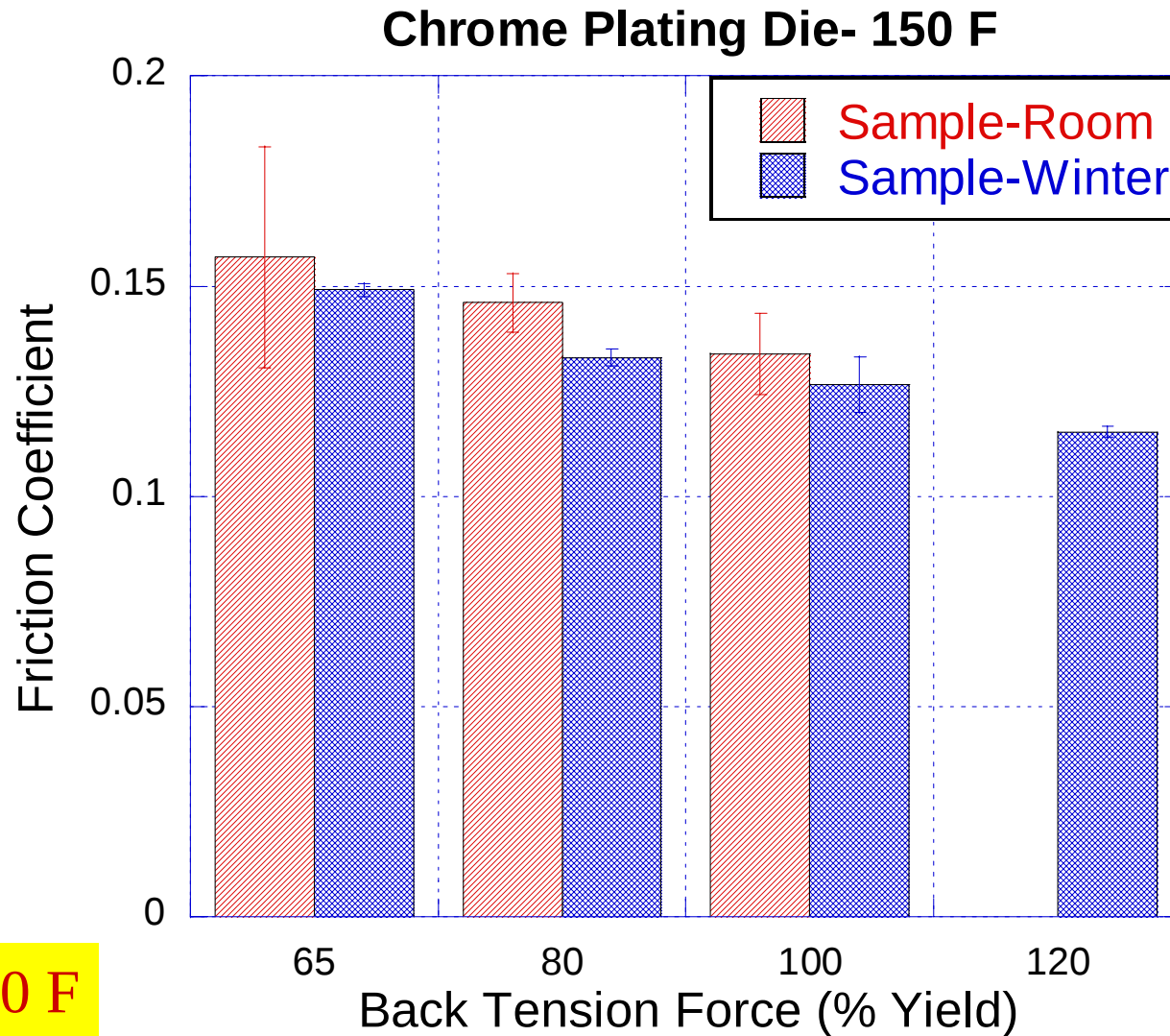


Effects of die temperatures





Summer: 100 F



Winter: 60 F



Field Validation

Coating adhesion





Field validation

Coating adhesion

DP590, HDGA, 1 mm
7 Cycles, As-received lubrication

Duplication of Production Panel
around sidewall and draw bead area



D2 Flame Hardening Die



Room temp. Die

7 cycles

7 cycles

7 cycles

Chrome Plating
+Coolant

D2 Flame Hardening
(Baseline)

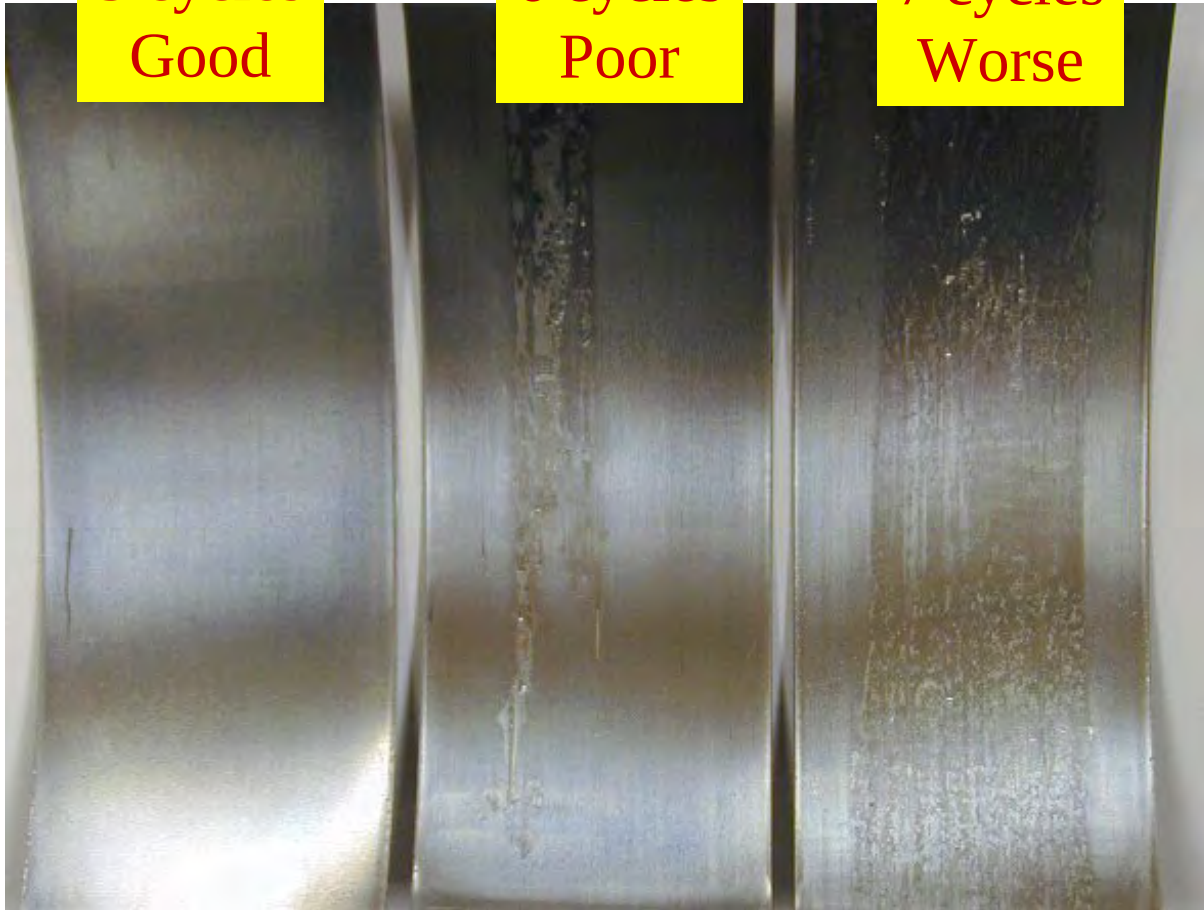
Chrome Plating



5 cycles
Good

6 cycles
Poor

7 cycles
Worse



D2 Flame Hardening



150 F Chrome Plating & Iron Nitriding

6 cycles
Good

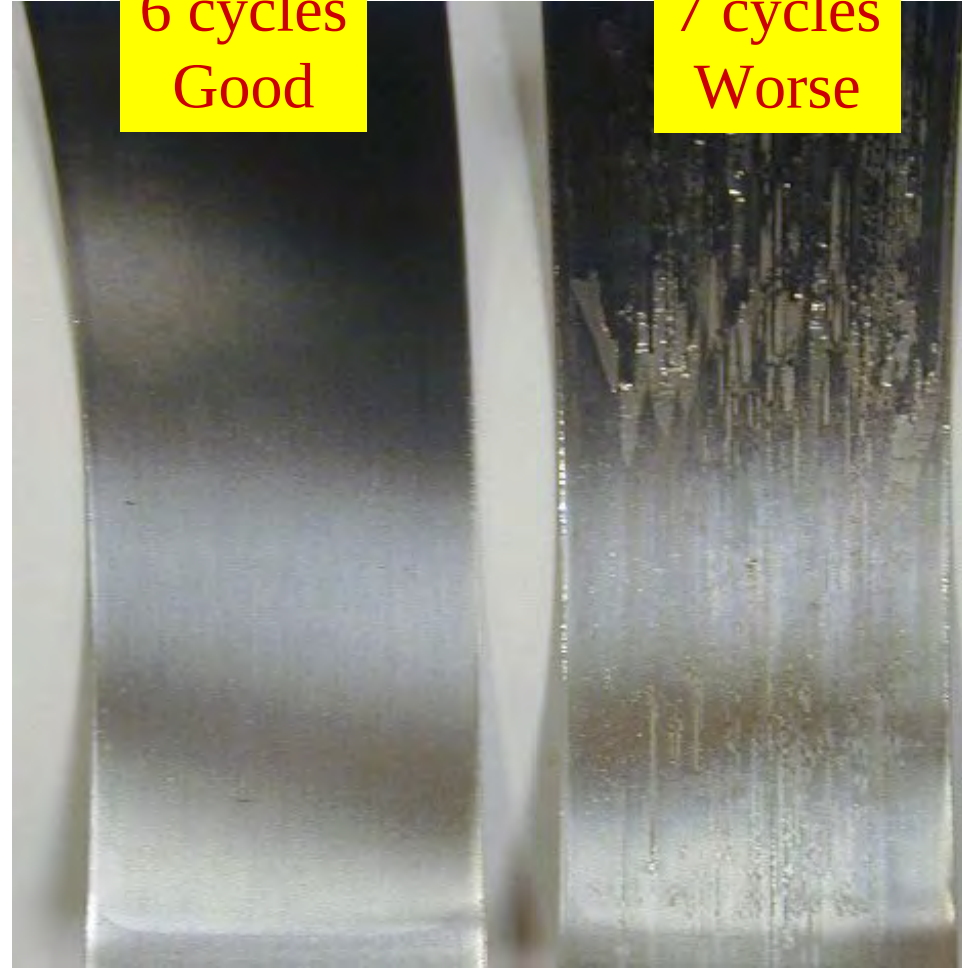
7 cycles
Poor



Chrome Plating

6 cycles
Good

7 cycles
Worse

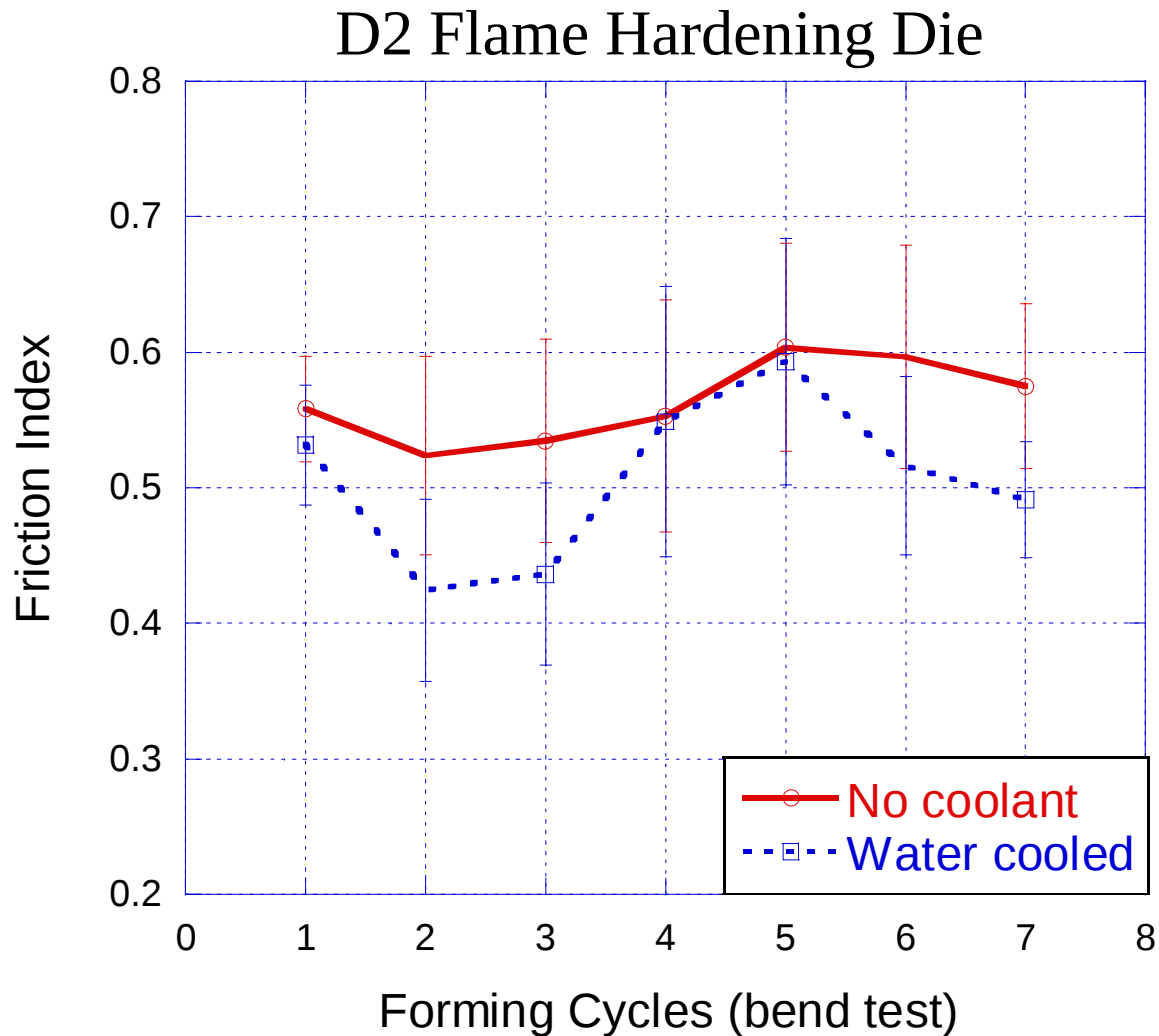


Iron Nitriding



Friction Index

Cyclic bend test



- Water cooled draw bead/die system has been developed and effectively proven to reduce the die temperature
- Implementing this draw bead/die cooling system can reduce coating adhesion/splitting issues during stamping
- The friction coefficient tends to increase with die temperature
- Lower specimen temperatures exhibited better frictional performance than those tested beyond ambient conditions (i.e. 60 versus 100 deg. F)
- Die surface treatments, like chrome plating, are highly recommended for stamping AHSS