SCREW & BARREL METALLURGY & SERVICE LIFE

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Topics of Discussion

- Current Requirements
- Screw & Barrel Wear
- Types of Wear
- Screw & Barrel Metallurgy
- Wear Solution - Bimetallic Barrel & Screw
- Screw & Barrel – Service Life
- Conclusion

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Current Requirements

- Demands of End Products of Extrusion & Molding are getting more stringent, needs
  - To use Better, High Performance Polymer
  - To use Blends of various Polymers and Additives
  - Better Strength and other Mechanical Properties
  - Better Transparency, Gloss, Optical & Surface Properties
  - Tighter Dimensional & Weight Control
  - Lower Price

Current Requirements

- Extrusion, Injection Molding and Blow Molding Machines requires to provide
  - Higher Output / Productivity
  - Flexibility to process various Polymers & Additives
  - Ability to process more & more fillers
  - Ability to process recycled polymers in many applications
  - Lower Power Consumption
  - Lower Process Waste

Current Requirements

- All these demands of End Products and Machines Performance leads to Higher Abrasion & Corrosion of Screw & Barrel
- We see more and faster wear with Screw & Barrel than what we used to see before 10 years with many applications
- Many Processors & OEMs are wondering how to handle this problem

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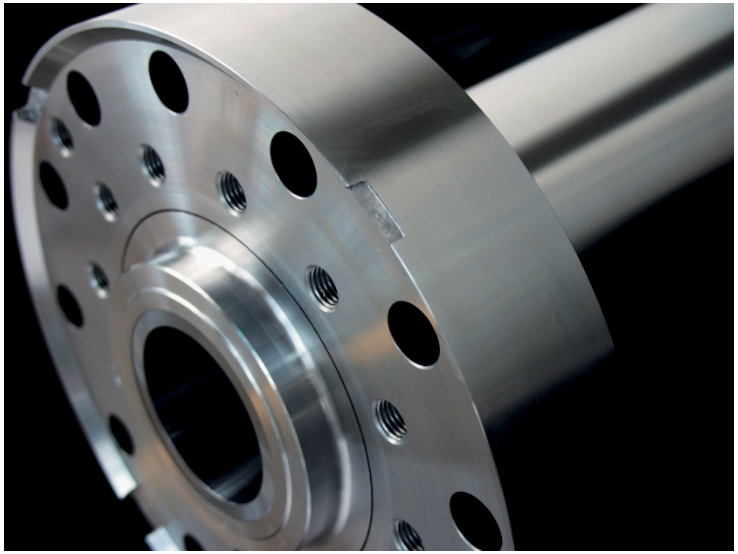
Barrel & Screw

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Screw & Barrel - Wear

- What happen in case of Wear?
  - When Screw & Barrel wears, the gap between them increases which increase back flow of the melt (Polymer) in side the Extruder / Molding Machine.
  - Rise of Melt Temperature and Residence Time
  - Reduction of Output / Plasticizing capacity

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Screw & Barrel - Wear

- Wear Sign in Extrusion are
  - Need to increase screw speed to achieve same amount of output
  - Over all reduction in output (specific output – kg/hr/rpm)
  - Rise in Melt Temperature
  - Inferior Dispersion
  - Degraded particles or some time un-melted particles
  - Higher thickness / GSM variation / Weight variation
  - Higher Power Consumption

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Screw & Barrel - Wear

- Wear Sign in Injection Molding are
  - Slippage of Screw
  - Longer Recovery Time
  - Longer Cycle Time
  - High Melt Temperature and Cooling Time
  - Inferior Dispersion
  - Degraded particles or some time un-melted particles
  - Surface defects like silver streaks, air voids, splay etc.

Screw & Barrel - Wear

- Penalty of Wear
  - Lower Output / Productivity
  - Poor Product Quality
  - Higher Wastage / Rejection
  - Higher Power Consumption
  - Higher Production Cost
  - Lower Contribution
  - Lower Profitability

Types of Wear

- There are three different types of wears are observed with Screw & Barrel
  - Adhesive Wear
  - Abrasive Wear
  - Corrosive Wear

Types of Wear – Adhesive Wear

- Wear occur due to metal to metal contact of Screw & Barrel while screw is rotating
- Reasons of Adhesive Wear (Galling)
  - Cantilever mounting of the screw
  - Buckling of screw due to back pressure
  - Screw Design, Polymer used & Process Parameter
  - Screw & Barrel Straightness & Manufacturing tolerances
  - Screw & Barrel Concentricity / Alignment

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Types of Wear – Abrasive Wear

- Wear occur through contact of Foreign or Abrasive Particle of Resin with Screw & Barrel
- Reasons of Abrasive Wear
  - Buckling of screw due to back pressure
  - Screw Design & Process Parameter
  - Nature of Polymer (mLL is abrasive than LD)
  - Some additives are also very aggressive to metal wear , e.g. CaCO3, TiO2, Silica, Glass Fibers, Metal Particles etc.

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Types of Wear – Corrosive Wear

- Wear occur through corrosion of Screw & Barrel when it comes in contact with Polymer / Additives / Gases
- Reasons of Corrosive Wear
  - Mainly due to corrosive nature of Polymers & Additives
  - Screw Design & Process Parameter
  - Some polymers are corrosive in nature, e.g. Acid Copolymer is corrosive than LDPE or CPVC corrosive than RPVC
  - Some additives are corrosive in nature, Halogen Free Flame Retardants, Ink of Recycled Printed Films etc.

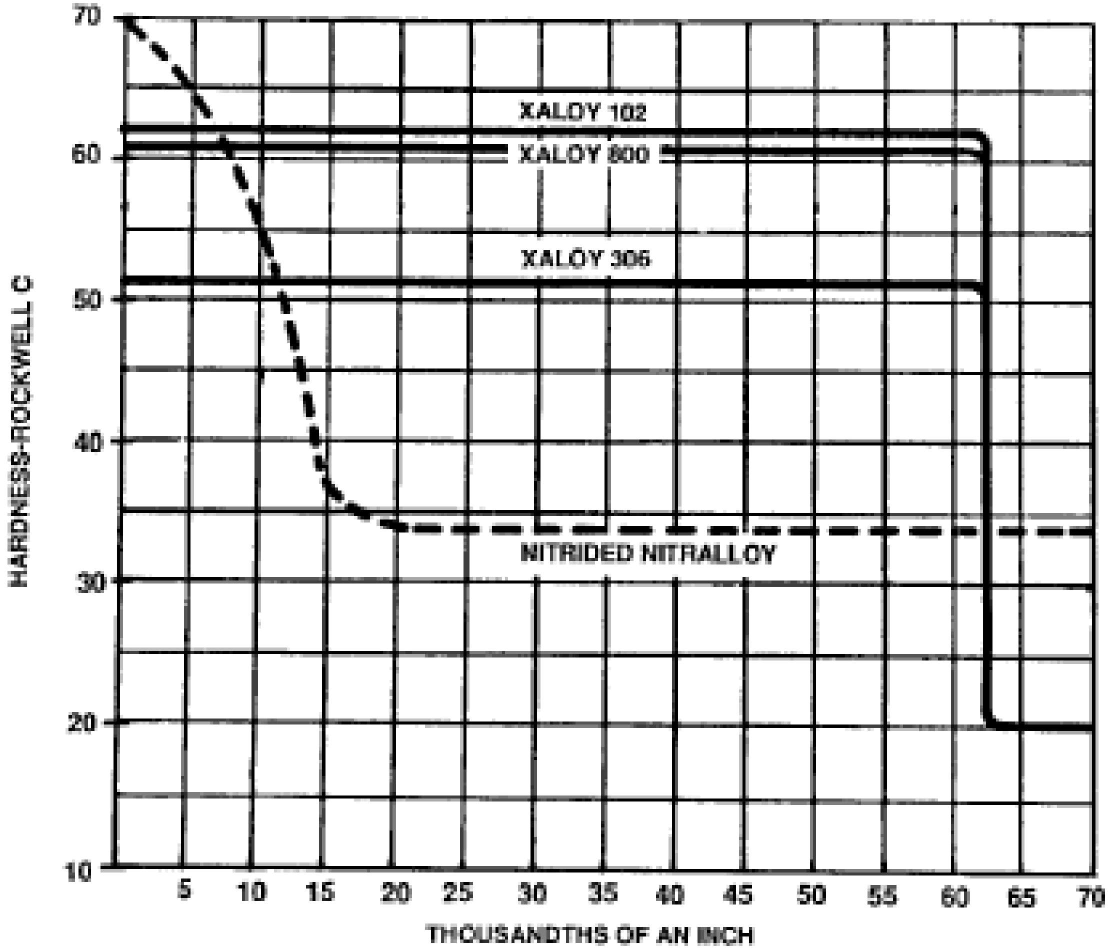
Screw & Barrel – Metallurgy

- In general, any screw & barrel is bound to wear in any machine. Amount of wear can be different. Selection of metallurgy is a major tool under control for machine manufacturer.
- Options of Screw & Barrel steel used in industry are
  - Screw
    - AISI4140/CP – Very rare application
    - AISI4140/Flame Hardened/CP – Very limited application, not in Asia
    - Nitriding Steel – Most Commonly used Steel
    - Tool Steel – Increasing usage, for dia. less than 50 mm
    - Bimetallic Screw – Increasing usage, for dia. above 50 mm
  - Barrel
    - Nitriding Steel – Most Commonly used Steel
    - Tool Steel – Rarely used for small dia.
    - Bimetallic Barrel – Getting standard with many applications

Screw & Barrel – Metallurgy

- Nitriding Steel is most commonly used in India for manufacturing of Screw & Barrel
- Skin Hardening is done through either Gas Nitriding or Ion Nitriding
- Hardness can go high up to 70 HRc, normally finished parts Hardness in the range of 60 – 68 HRc
- Hard Skin depth in the range of 0.4 – 0.6 mm
- Easy and economic process, serve many applications

Screw & Barrel – Metallurgy

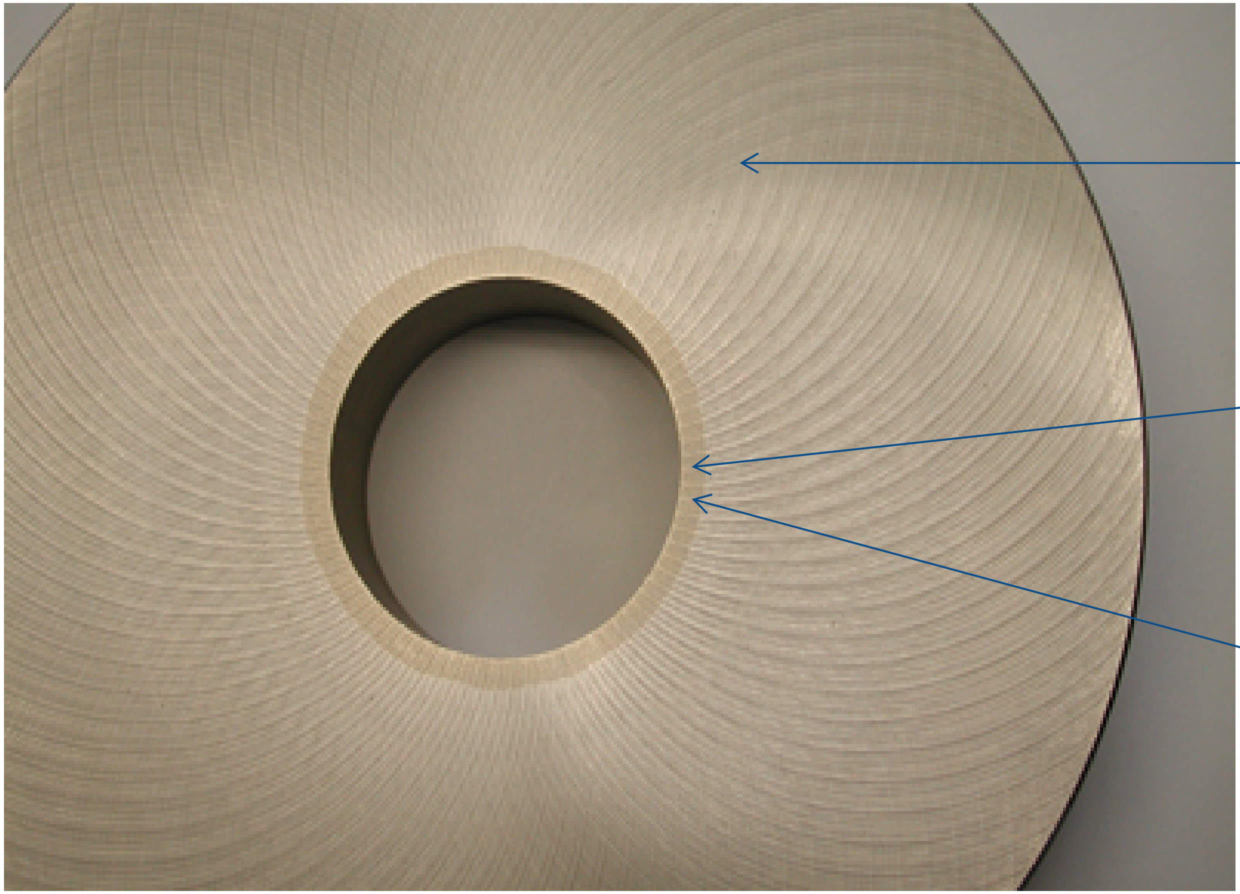


HARDNESS VS. DISTANCE FROM THE BORE SURFACE

Screw & Barrel – Metallurgy

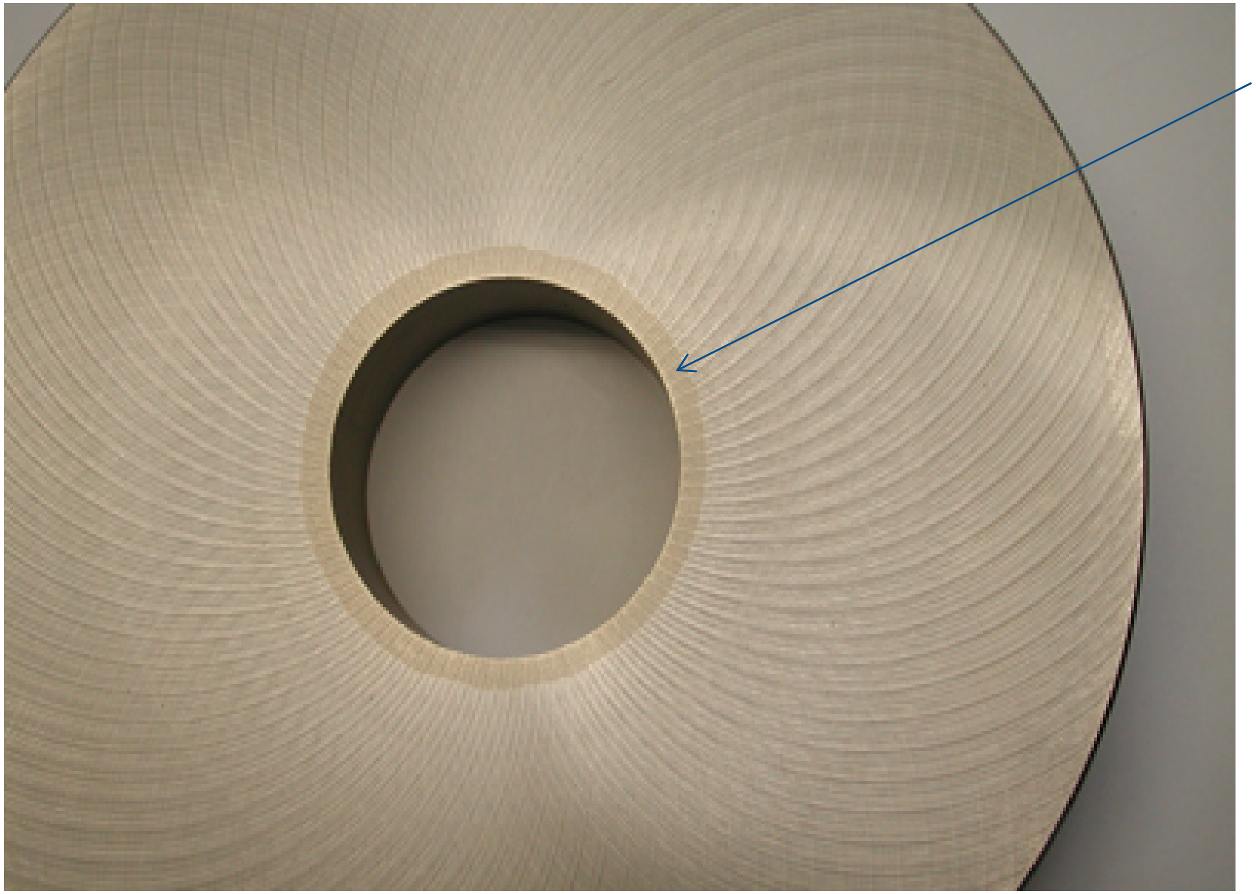
- However, many applications & economy of the business demand to increase the service life of Nitrided Screw & Barrel
- The option is to use Bimetallic Barrel & Screw
- Bimetallic Barrel & Screw can offers 3 to 7 times higher abrasion resistance compare to Nitriding Steel depending on grade of Bimetallic Parts.
- Right metallurgy and manufacturing process of Bimetallic Barrel & Screw decide the performance

Wear Solution -Bimetallic Barrel



- Two metals
- High tensile strength backing steel
- Anti-abrasive / corrosive alloys lining
- Hard Face Layer of average 1.5 mm Thickness

Wear Solution -Bimetallic Barrel



- Various Grades
- X-102
- X-200
- X-306
- X-800 (Tungsten Carbide)

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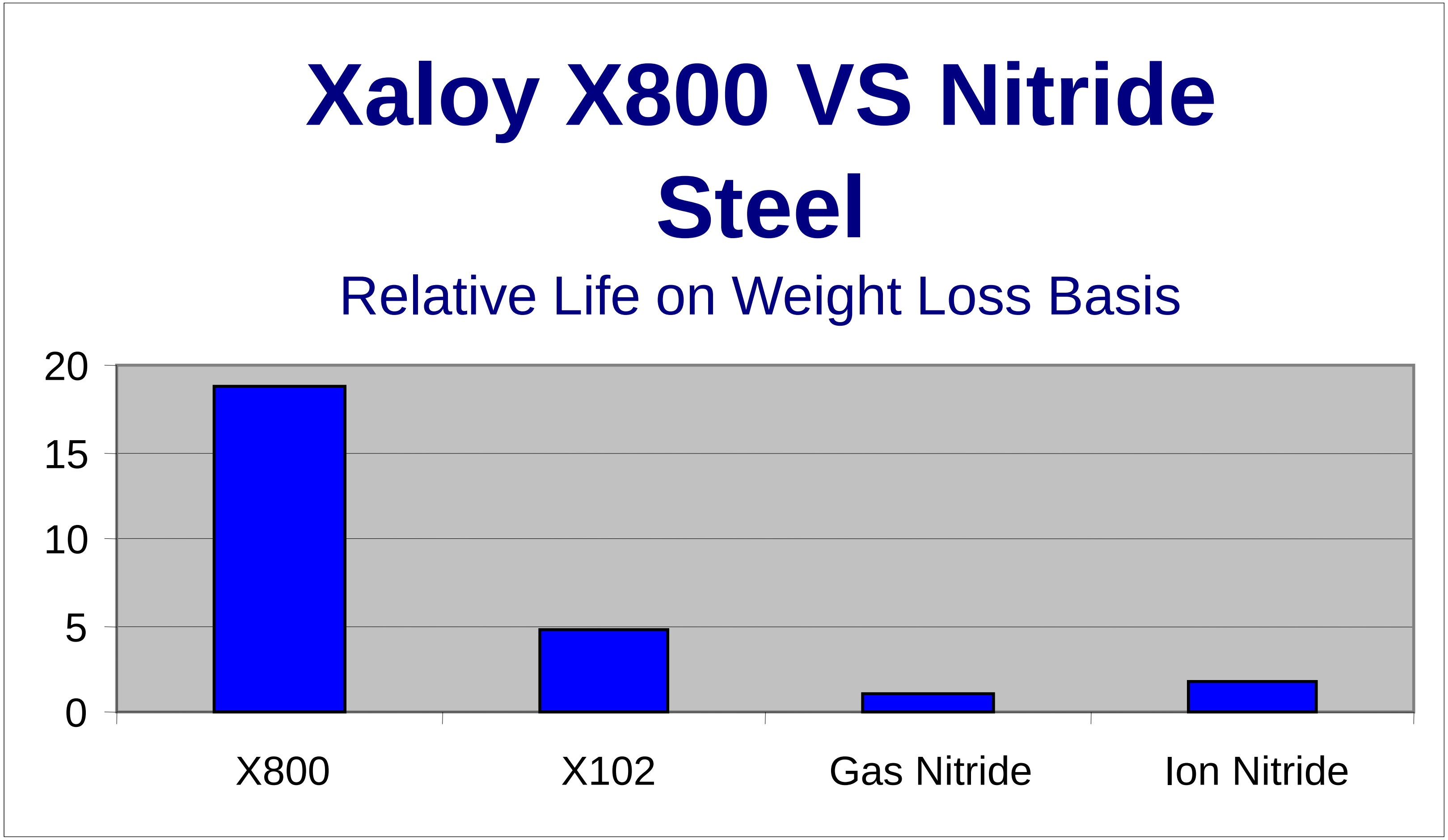
Wear Solution -Bimetallic Barrel

- X-102 : Iron base matrix, Ferrite Boride / Carbide, 58 – 62 HRs
- X-200 : Iron base matrix, Chromium Boride / Carbide, 64 - 69 HRs
- X-306 : Nickel base matrix, Chromium Boride, 48 – 56 HRs
- X-800 : Nickel base matrix, Tungsten Carbide, 58 – 66 HRs

Wear Solution -Bimetallic Barrel



Wear Solution – Tool Steel Screw

- Tool Steel Screw
  - D2Modified – Through Hardened Tool Steel, Offers good abrasion & good corrosion resistance, 58-62 HRc
  - NPR1 – Through Hardened Tool Steel, Offers very high abrasion & very high corrosion resistance, 58-62 HRc
  - N690 – Through Hardened Stainless Steel, Offers good abrasion & very high corrosion resistance, 52-56 HRc
- Powder Metallurgical (PM) Tool Steel
  - CPM 9V - Through Hardened PM Tool Steel, Offers extremely high abrasion & very high corrosion resistance, 52-55 HRc
  - CPM S90V - Through Hardened PM Tool Steel, Offers extremely high abrasion & extremely high corrosion resistance, 54-59 HRc

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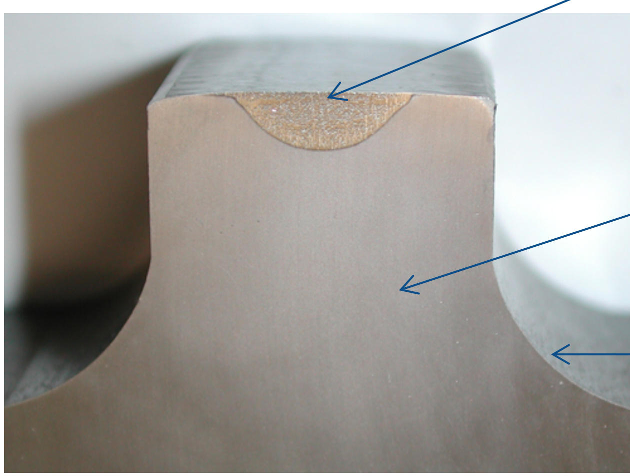
Wear Solution -Bimetallic Screw



- Bimetallic Screws has two Metals
- Anti Abrasive / Corrosive Hard Facing Layer, Ave. thickness of 1.5 mm
- Base material
- Root treatment

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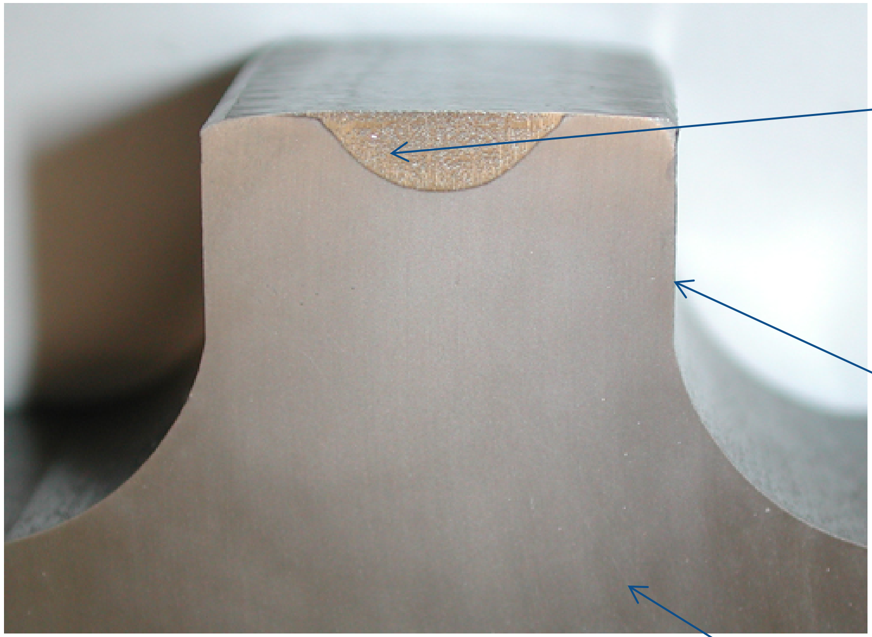
Wear Solution -Bimetallic Screw



- Hard Facing Layer - Cobalt Base – Stellite 6, Stellite 12, Nickel Base - X-183, X-830
- Root treatment, Chrome Plating when AISI4140 or AISI4340, Nitriding when SACM645
- Base Steel, AISI4140, 4340, SACM645, Stainless Steel

Wear Solution -Bimetallic Screw

- Hard Facing Material
  - Stellite 6 – Cobalt Base, 38-42 HRs, Galling a lot, Now least preferred
  - Stellite 12 – Cobalt Base, 44-48 HRs
  - X-183, Nickel Base, Chromium Boride, 46-52 HRc, Very Good Abrasion and Corrosion Resistance
  - X-830, Nickel Base, Tungsten Carbide, 48-55 HRc, Extremely High Abrasion and Corrosion Resistance
- Root Treatment
  - Chrome Plating, 0.03 to 0.10 mm, 50 to 65 HRc
  - Nitriding, 0.3 to 0.5 mm, 65 to 68 HRc
  - Encapsulation and fusion of TC, 60 to 68 HRc

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SCREW WITH HVOF COATING

- Screw with HVOF Coating
  - HVOF (High Velocity Oxygen Fuel) process can be used to coat Screw Flight OD & total Encapsulation of Screw
  - It is coating process and not the hard facing process
  - Tungsten Carbide, 0.125 mm to 0.250 mm Thickness
  - Problem of Adhesion, Coating is brittle in nature
  - Coating is prone to crack and nicked under torsional force, which generate rapid deterioration of the base steel which also encourage faster “Shelling Off” of the coating
- Fusion process must be used to improve bonding (i.e. fusion) of coating with base material

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Screw & Barrel Service Life

- There are many parameters which affect the over all Wear process of Screw & Barrel, these are
  - Diameter & Length
  - Design of Screw & Barrel
  - Metallurgy of Screw & Barrel
  - Manufacturing of Screw & Barrel
  - Alignment of Screw & Barrel

Screw & Barrel Service Life

- Polymer & Additives
- Process Parameters
  - Speed
  - Temperature
  - Pressure
- Maintenance of screw & Barrel

Screw & Barrel Service Life

- Screw & Barrel Service Life
  - Nobody can predict exact service life of Screw & Barrel
  - There is no science to predict the service life of Screw & Barrel
  - One can predict screw & barrel life only when they were experienced before. Would say experience for same Size, Design, Metallurgy for very similar Application, Polymers, Process Parameters and Operating, Maintaining people

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Conclusion

- Any Screw & Barrel will wear, rate of wear can be different
- Nobody can predict exact life of Screw & Barrel
- Screw & Barrel wear reduce productivity, quality & profitability
- When life of Nitrided Screw & Barrel is not enough, Bimetallic is the only solution
- In many applications where there is high wear, using Nitrided Screw & Barrel offers more loss (hidden loss)
- Bimetallic Barrel & Screw may demand higher capital investment but offers better productivity, quality and Profitability

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THANK YOU

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