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
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
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
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
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
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.
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
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

Hardness-Rockwell C

Thousands of an Inch

NITRIDED NITRALLOY

XALOY 102
XALOY 800
XALOY 306
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)
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

Xaloy X800 VS Nitride Steel
Relative Life on Weight Loss Basis

- X800
- X102
- Gas Nitride
- Ion Nitride
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
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
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
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
Screw & Barrel Service Life

• There are many parameters which affect the overall 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
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
THANK YOU

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