Gloss of PVC Profiles: How to Control the Surface Finish?

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SCOPE

• Gloss definition.
• Gloss Dependent Factors
  – Effect of melt temperature
  – Effect of PVC Mw
  – Effect of filler type
  – Effect of E-PVC
  – Effect of Impact modifier type
  – Gloss - melt strength relationship
• Surface fracture
• Conclusions
LIGHT REFLECTION LAW

Angle Reflection = Angle Incidence
Smooth Glossy Surface

Light Scattering
Rough Matte Surface
List of Gloss Dependent Factors

• **Tooling:**
  – Die design (thickness sections) and die-land length
  – Surface texture of the die
  – Temperature of die lip

• **Formulation**
  – Lubricants type and balance
  – Modifier Type
  – Process aid type and addition level
  – Filler type and addition level

• **Rheology**
  – Gelation level
  – Melt strength
  – Melt elasticity
  – Surface Melt fracture
• Melt temperature increase leads to gelation level increase (shear rate dependence), hence higher gloss
• PPCC or E-PVC (10% loading) give rise to similar gloss increase (Form. F & G)
• Significant higher gloss with PPCC + E-PVC (Form. H)
Effect of Gelation Degree on Gloss
(Gloss Unit @ 60° angle)

- S-PVC K-65
- S-PVC K-68
- 10% E-PVC
- PPCC instead of GCC
- PPCC + E-PVC
Filler Type Effect on Gloss

- Glossier surface with PPCC
- Higher melt temperature reached with PPCC (more shear heating related to smaller PS)
- Faster fusion, and higher degree of gelation
- Fusion rate and thermal history affect surface finish: gloss increasing with degree gelation
Emulsion-PVC Effect on Gloss

- Effect of E-PVC (10% loading) on melt temperature not significant
- Gloss improvement attributed to promotion of melt slipping in the die thanks to emulsifier residuals
Acrylic Impact Modifier Effect on Gloss

- Rubber Particle size affects Gloss
- But effect of rubber chemical make-up and core/shell Mw, on melt strength and elasticity must be taken into account
Effect of Impact Modifier Chemical Make-up

- Two categories of Impact Modifiers:
  - Shear stress dependent Elastic Strain and Compliance
  - Shear Stress independent recoverable Shear Strain: linear relationship between gloss and melt temperature
Rheotens Melt Strength and Gloss vs Processing-Aid Loading

Break Stress, $10^5$ Pa

Gloss Unit @ 75° Angle

- Low Mw Process-Aid
- High Mw Process-Aid
Gloss – Melt Strength Relationship

- Strong correlation between melt strength and PA content
- Gloss is correlated to melt strength: gloss increases with an increase in melt strength
- Greater efficiency of low Mw PA in promoting fusion.
- Greater efficiency of high Mw PA in increasing melt strength

![Graph showing the relationship between Gloss Unit @ 75° angle and Break Stress, 10^5 Pa for Low Mw PA and High Mw PA.](image)
Correlation between Gloss and Melt Strength

- Strong correlation between melt strength and gloss
- Consistent with a melt fracture mechanism of gloss reduction:
  - Melt strength is a measure of the integrity of the melt
  - Low melt strength material prone to melt fracture and thus would exhibit low gloss.
SMOOTH and ROUGH SURFACE FINISHES

GLOSSY

MATTE
CONCLUSIONS

• Controlling Gloss requires control of melt strength and elasticity
• Melt strength and melt elasticity is a function of melt temperature, gelation degree, Mw and loading of Processing-Aid, and type and loading of Impact Modifier
• Low melt strength materials tend to display low gloss, because of surface fracture
• Gloss consistency across different extrusion lines can be achieved thru the use of impact modifiers that impart stress independent recoverable shear strain.
Thank you.