CASE STUDY

Utmost sliding properties and abrasion resistance for best in class sliding parts

Summary

Product type: Injection and extrusion moldable UHMW-PE
Application: Office automation, sliding parts for electrical and electronic equipment, medical parts, food contact applications, automotive - bearing and gear parts, various switch components, glass run channel, rail parts
Key benefits: Excellent sliding properties | High abrasion resistance for maximum durability | Injection and extrusion moldable | High-performance that cannot be achieved with other engineering plastics | Suitable for the production of noiseless, greaseless parts

The Challenge

Plastics have widely replaced traditional engineering materials such as metal, wood, and rubber in many engineering applications due to lower production costs and higher strength to weight ratio. Commodity plastics generally do not offer the enhanced physical properties necessary for high-performance applications. Engineering plastics offer improved properties such as higher mechanical strength, heat resistance, rigidity, and chemical stability. The combination of good sliding properties and superior abrasion resistance has, however, remained elusive even with engineering plastics. Materials with good sliding properties but low abrasion resistance lack durability. Parts made from these materials wear out quickly requiring frequent replacement. On the other hand, materials with high-abrasion resistance but poor sliding properties, have a high coefficient of friction. Parts made from such materials do not move smoothly and often produce a squeaking noise during operation. The demand for maintenance-free and noiseless operation of modern home appliances and electric vehicles (EV) has highlighted the need for a plastic that offers high abrasion resistance with good sliding properties.

The Solution

Mitsui Chemicals offers LUBMER™, a pelleted ultra-high molecular weight polyethylene (UHMW-PE) that can be injection and extrusion molded. LUMBER™ is a very tough material, produced using Mitsui Chemical's proprietary polymerization technology. It has very high impact strength and is extremely resistant to chemicals such as alcohols, alkalis, oils, hydrogen peroxide, sulfuric and phosphoric acid. LUMBER™ shows low water absorption and is free of halogen and PFOA. In addition, LUBMER™ has excellent sliding properties and high abrasion resistance. It is self-lubricating with a low friction coefficient and good resistance to wear.

A study was conducted to compare the sliding properties and abrasion resistance of LUMBER™ to several other engineering plastics. The standard method for testing sliding wear resistance of plastics, JIS K 7218 was employed in which a counter material made from S45C steel is rotated over a sample plastic disc. The test was conducted at 23°C with a load of 15kg (0.75MPa), a rotating speed of 30m/min for a total distance of 3km. Figure 1 plots the abrasion loss from the sample disc against the kinetic coefficient of friction for the various materials tested during the study. A high coefficient of friction indicates poor sliding properties, and a high abrasion loss is indicative of low abrasion resistance. The results show that the coefficient of friction for LUMBER™ is significantly lower as compared to PA6, PBT, molybdenum sulfide modified PA6, PP and PA66. Its sliding properties are comparable to PTFE. The relative position along the vertical axis indicates that LUMBER™ has lower abrasion loss (higher abrasion resistance), as compared to all other materials tested, by at least an order of magnitude. It shows much better abrasion resistance than HDPE, POM and PA66.

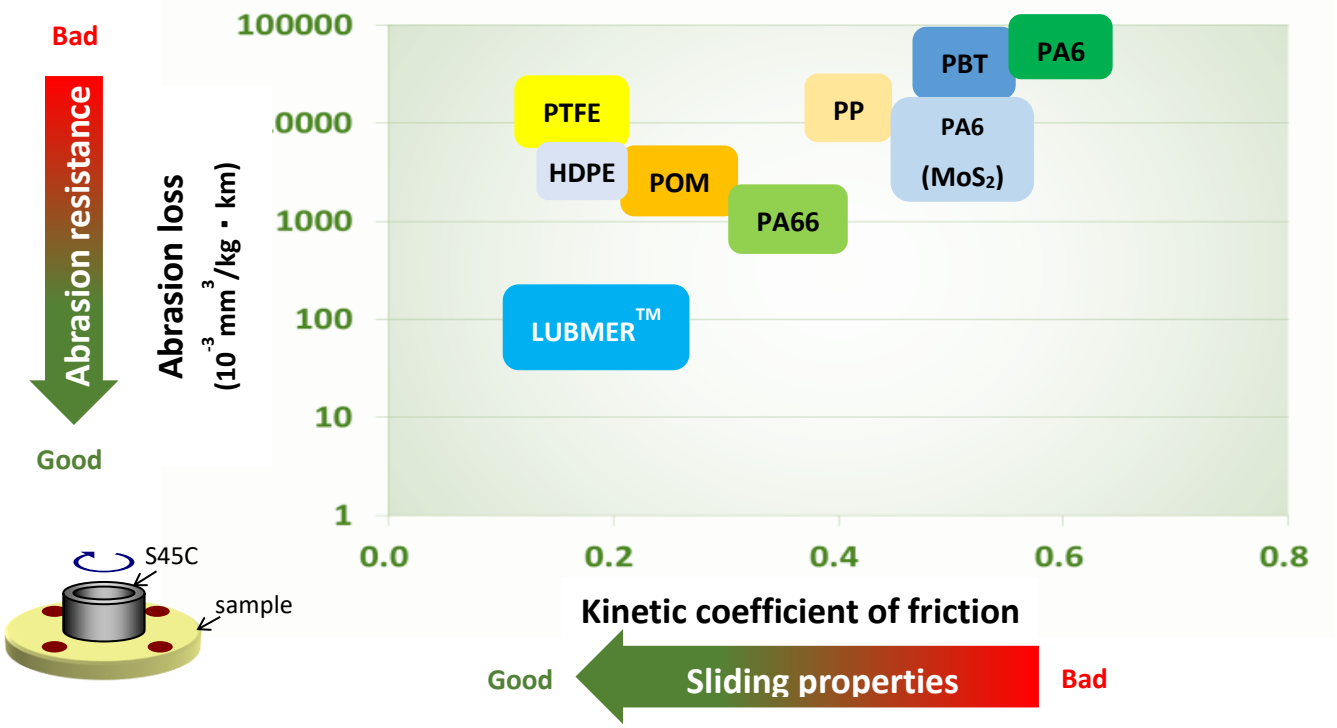

Figure 1: Comparison of abrasion resistance and sliding properties of LUMBER™ with nylon PBT, POM, HDPE and other materials

Figure 2 shows the abrasion marks on four sample discs after the ring abrasion test. PA6, POM and PBT all show deep groves on the disc due to high abrasion loss. The LUMBER™ disc, however, shows no visible abrasion marks with the numerical value of material loss being only a very small fraction of abrasion loss from POM, PBT and PA6.

LUMBER™	PA6	POM	PBT
			
Abrasion loss **85** (×10⁻³mm³/kg・km)	Abrasion loss **55,000** (×10⁻³mm³/kg・km)	Abrasion loss **2,300** (×10⁻³mm³/kg・km)	Abrasion loss **37,800** (×10⁻³mm³/kg・km)
Does not wear out	Easy to wear out		

Figure 2: Comparison of abrasion marks on sample discs after the ring abrasion test (JIS K 7218)

Materials with high kinetic friction coefficients can produce the stick-slip effect when rubbing against each other. The surfaces move with a jerking motion as they stick and then slip instead of sliding smoothly. The stick-slip effect produces a squeaking noise indicating that the two surfaces are not sliding smoothly against each other.

The study also measured the coefficient of friction between different combinations of plastics and metal using the ring abrasion test. PA6, POM and S45C steel rings were tested against sample discs made from LUMBER™, PA6 and POM. Table 1 shows the coefficients of friction measured for various combination. The results show that PA6 and POM samples have high friction coefficients with PA6, POM and S45C; the high friction between the surfaces results in a squeaking sound. LUMBER™ slides noiselessly against PA6, POM and S45C steel with low friction coefficients.

	Ring		
Sample disc	**PA6**	**POM**	**S45C**
LUMBER™	0.24	0.13	0.17
PA6	2.15 Squeaking noise	1.41 Squeaking noise	0.52 Squeaking noise
POM	1.41 Squeaking noise	0.49 Squeaking noise	0.27 Squeaking noise

Table 1: Coefficients of friction for combinations of LUMBER™, PA6, POM and S45C

Benefits and motivation to adopt LUMBER™ (examples for automotive applications)

LUBMER™ can be used in numerous industries including automobiles, office automation, sliding parts for electrical and electronic equipment, medical parts, and food contact applications.

It can be injection or extrusion molded on standard machines with ease. Table 2 compares the machine parameters for injection molding a plate with dimensions 120mm×130mm×3mm using POM and various graders of LUMBER™.

Parameter			L3000 L4000 L4640	L5000	LS4140	POM
Cylinder temp. (℃)		C1	210	240	220	50
		C2	230～240	260	240	180
		C3	230～240	260	240	200
		Nozzle	240	260	240	200
Injection pressure	MPa		50	95	50	85
Injection time	sec		2~4	2~4	2~4	4.21
Injection speed	mm/s		50	80	40	90
Keeping pressure	MPa		45	65	40	650
Keeping pressure time	sec		10	20	5~10	12
Cooling time	sec		15~20	20~25	15~20	30
Mold temp.	℃		24～60(water cooling)			70

Table 2: Injection molding conditions for a plate with dimensions 120mm×130mm×3mm

Sample applications of LUMBER™ include bearing and gear parts, various switch components, glass run channel for car windows, seatbelt through anchor and leaf spring cushioning material.

Also, LUBMER™ is a strong and lightweight material ideal for production of durable automotive parts that must function noiselessly without the need for greasing.

Gears made from POM wear out over time due to high abrasion loss leading to equipment failure. Gears made from LUMBER™ show improved sliding properties with less wear to increase the working life of the equipment. In addition, switches, and mechanical automobile parts, made with POM, require the use of grease to function smoothly. Replacing these parts with those made from LUBMER™ eliminates the stick-slip, and the associated squeaking noise, without the need for a grease coating process. HDPE is generally used as cushioning material on automotive leaf spring plates. Under severe abrasive conditions, HDPE can wear out and eventually crack leading to leaf spring failure. LUMBER™ offers higher durability and excellent abrasion resistance which can withstand extreme conditions without wearing out or cracking. Table 3 summarizes the benefits and motivation to adopt LUMBER™ in various automotive applications.

Application	Benefits and motivation to adopt LUMBER™			
	Noiseless	Greaseless	Durability	Lightweight
Gear parts	☑	☑	☑	☑
Bearing Parts	☑	☑	☑	☑
Switch parts	☑	☑	☑	☑
Glass run channel (GRC)	☑	-	☑	☑
Seat belt through anchor	☑	-	☑	☑

Table 3: Benefits and motivation to adopt LUMBER™ for various automotive applications

Conclusion

LUBMER™, as an injection and extrusion moldable UHMW-PE, with excellent sliding properties, shows vastly superior abrasion resistance when compared to PA and POM. Its sliding properties are comparable to PTFE, LUBMER™ complying also with strict safety regulations. The combination of high abrasion resistance and low kinetic friction coefficient, offered by LUMBER™, cannot be achieved with other engineering plastics. Due to these properties, LUMBER™ is ideal for the production of noiseless, greaseless parts that offer improved durability.

LUBMER™ can be used in numerous industries including automobiles, office automation, sliding parts for electrical and electronic equipment, medical parts, and food contact applications.