Materials for automobiles

Lec 17

Plastics

Adhesives

Material Costs

Plastics : Thermoplastics

Thermoplastics
• Thermoplastics have the simplest molecular structure, with chemically independent macromolecules • By heating, they are softened or melted, then shaped, formed , welded, and solidified when cooled. • Multiple cycles of heating and cooling can be repeated without severe damage, allowing reprocessing and recycling.
• Often some additives or fillers are added to the thermoplastic to improve specific properties such as thermal or chemical stability, UV resistance, etc. • Composites are obtained by using short, long or continuous fibres. • Alloys of compatible thermoplastics allow applications to benefit from the attractive properties of each polymer while masking their defects. • Some thermoplastics are crosslinkable and are used industrially in their two forms, thermoplastic and thermoset; for example, the polyethylenes or the vinylacetate-ethylene copolymers (VAE) (the links created between the chains limit their mobility and possibilities of relative displacement).
Thermoplastic consumption is roughly 80% or more of the total plastic consumption.

Plastics : Thermoplastics

	Thermoplastics :Advantages / Disadvantages
Advantages	• The softening or melting by heating allows welding and thermoforming. • The processing cycles are very short because of the absence of the chemical reaction of crosslinking. • Processing is easier to monitor, because there is only a physical transformation. • Thermoplastics don't release gases or water vapour if they are correctly dried before processing. • The wastes are partially reusable as virgin matter because of the reversibility of the physical softening or melting.
Disadvantages	• When the temperature rises, the modulus retention decreases, due to the absence of chemical links between macromolecules. • For the same reason, the creep and relaxation behaviours are not as good as for the thermosets. • During a fire, fusibility favours dripping and annihilates final residual physical cohesion.

Plastics : Thermoplastics

PE, PP, PVC, PS ABS, SAN PA, PC, PMMA, POM, PPE, PET, PBT PSU, PEI, PPS ETFE, PEEK LCP, PTFE, PFA, FEP, PI PBI	commodity thermoplastics copolymers with more specific applications engineering thermoplastics engineering thermoplastics with more specific performances high-tech uses, limited consumption high-tech uses, more limited consumption highly targeted uses and very restricted consumption.

Plastics : Thermoplastic Elastomers

	Thermoplastic elastomers (TPEs)
	• TPEs are copolymers or compounds of thermoplastics and rubber. The elasticity of TPEs comes: • either from the structure of the macromolecules with alternating soft and hard segments, the latter gathering together to constitute the nodes of a physical lattice; or • from a dispersed phase of soft elastomer, vulcanized or not, forming microscopic droplets in a continuous phase of a hard thermoplastic. This structure allows processing in accordance with thermoplastic techniques. The rubber provides elasticity.
	TPEs account for roughly 1% of total plastic consumption.
	They lead to a combination of interesting properties: • elasticity in a limited range of temperatures • ease of thermoplastic processing without curing and, often, without a mixing step • ease of recycling as for all the thermoplastics.
	On the other hand, their mechanical properties decrease as the temperature rises because of their thermoplasticity.

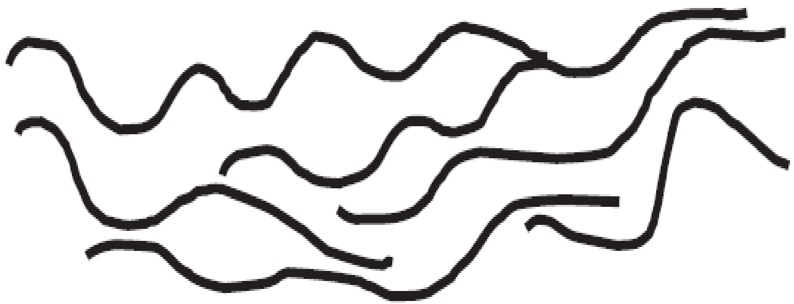


Figure 1.12. Schematic structure of a thermoplastic

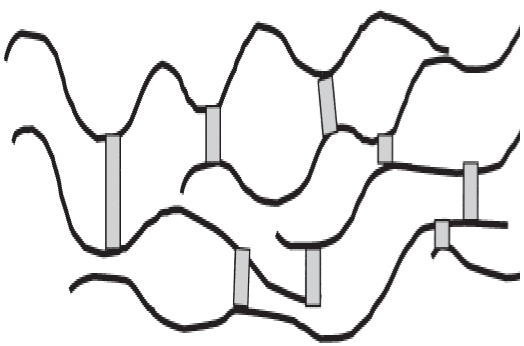


Figure 1.16. Thermoset after crosslinking

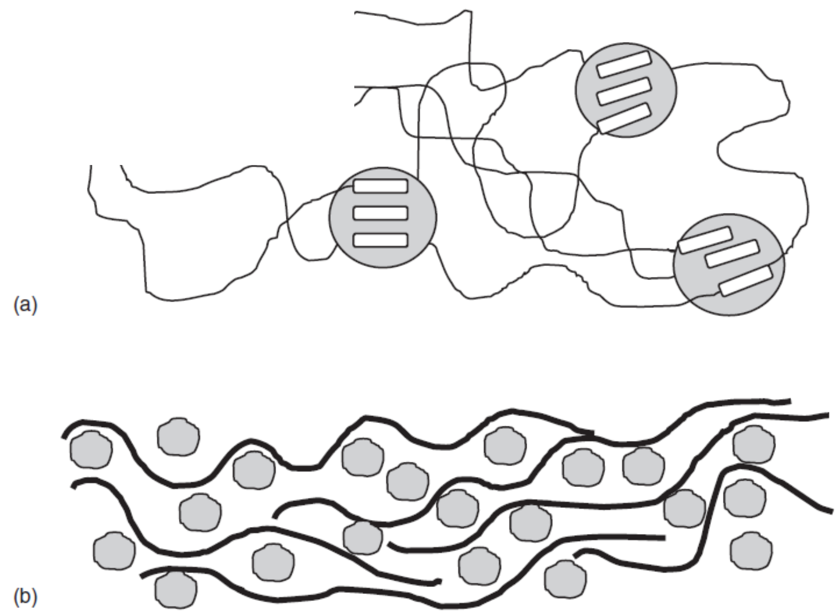


Figure 1.14. Schematic structure of TPEs: (a) Copolymer with hard segments arranged in domains; (b) compound of rubber particles dispersed in thermoplastic matrix

Table 1.11 Order of magnitude of some material costs (€/litre)

	Minimum	Maximum
Thermoplastics		
PE, PVC, PS, PP	0.8	4
ABS, SAN, SMA	3	5
PMMA, PC, PA, POM, PET, PBT, PPE	3	8
Speciality PA	7	12
PPS, PSU	7	30
PEI, PAI	20	40
PTFE	25	50
PEEK, LCP	20	120
ETFE, ECTFE, FEP, PFA	60	220
Thermosets		
DCPD	5	7
Epoxy	4	10
Melamine	3	5
Phenolic	3	10
Polyimide	80	260
Polycyanate	24	60
Polyurethane	4	9
Urea formaldehyde	2	3
Unsaturated polyester	3	7
Vinylester	5	9
Metals		
Steel	1.6	3.2
Special steel	10	16
Aluminium	3	6
Titanium	13	18
Copper	13	15
Nickel	45	54

6.1 TABLE A Thermoplastics (Exterior)

S.No	Property	Unit	Test Standard	Type 1 (Elastomer & Mineral Modified PP)	Type 2 (Elastomer & Mineral Modified PP)	Type 3 (20% Glass Reinforced PP)	Type 4 (ABS)	Type 5 (20% Talc Filled PP)
1	Density	g/cc	ASTM D792	0.97 ± 0.02	0.96 – 0.99	1.05 ± 0.02	1.04	1.06 ± 0.02
2	Filler Content	%	ISO 3451	12 ± 2	12 ± 2	20 ± 2	Unfilled	22 ± 2
3	Tensile Strength at Yield	Kg/cm^2	ASTM D638	Min 180	Min 100	Min 280	Min 460	Min 200
4	Elongation at break	%	ASTM D638	Min 200	Min 150	Min 5	Min 20	Min 40
5	Flexural Strength	Kg/cm^2	ASTM D790	Min 225	Min 200	Min 350	Min 650	Min 290
6	Flexural Modulus	Kg/cm^2	ASTM D790	Min 13500	Min 10000	Min 26000	Min 19200	Min 25000
7	Notched Izod Impact Strength at 23°C	Kg.cm/cm	ASTM D256	No Break (> 50)	No Break (> 50)	Min 5	Min 25	Min 17
8	HDT at 0.45Mpa	°C	ASTM D648	Min 112	Min 65	Min 125	Min 95	Min 118
9	Weathering Resistance to get Gray Scale Rating 4*	Hrs	SAE J1960	2000	2000	2000	300	2000
10	Flammability rating	Rating	UL 94	HB	HB	HB	HB	HB
11	Component Test Requirements	--	--	To meet section 8	To meet section 8	To meet section 8	To meet section 8	To meet section 8

* - The weathered panels shall have no cracking, crazing, and no chalking or blooming effects.

6.2 TABLE B SMC Exterior

S.No	Property	Unit	Test Standard	SMC (30% GF UP)	Light Weight SMC
1	Density	g/cc	ISO 1183	1.7 – 1.95	1.35 – 1.5
2	Filler Content	%	ISO 3451	30 ± 5	40 ± 5
3	Tensile Strength	Mpa	ISO 527	Min 70	65 - 85
4	Tensile Modulus	Gpa	ISO 527	Min 8	7 - 9
5	Flexural Strength	Mpa	ISO 178	Min 130	120 - 160
6	Flexural Modulus	Gpa	ISO 178	Min 8	7 - 9
7	Charpy Impact Strength	Kj/m^2	ISO 179	Min 60	50 - 60
8	HDT at 1.82Mpa	°C	ISO 75-2A	Min 200	Min 200
9	Molding Shrinkage	%	ISO 2577	0.02 – 0.07	0.03 - 1
10	Flammability	Rating	UL 94	HB	HB
11	Component Test Requirements	--	--	To meet section 8	To meet section 8

8. Component Test Requirements

8.1 Heat Resistance, Humidity Resistance & Hot-cold Cycling Resistance

TEST CONDITIONS*:*

Test	Test Parameters
Heat Resistance	80 ± 2°C for 168hrs
Humidity Resistance	Leave the test piece inside a wet chamber set to temperature of +40 ± 2°C and relative humidity of 93 ± 2% for 168 ± 2Hrs.
Hot cold Cycling Resistance	5 Cycles of the following. 80 ± 2°C for 3hrs 23 ± 2°C & 50 ± 5% RH for 1hr -30 ± 2°C for 3hrs 23 ± 2°C & 50 ± 5% RH for 1hr 38±2°C & 98±2% RH for 16hr
Hot Cold Cycling Resistance for parts pertaining to AVIA Cabin	The complete test assembly shall then be subjected to the following test cycle. (17 ± 0.5h) at –40°C ± 3K (72 ± 1h) at +80°C ± 2.5K (24 ± 1h) at +40°C ± 2K and 93±2% RH (7±0.5h) at –40°C ± 3K (24 ± 1h) at +40°C ± 2K and 93±2% RH Repeat Cycle

5.1 TABLE 1 – THERMOPLASTIC MATERIALS Interior

S.No	Property	Unit	Test Standard	Type A (Mineral Filled PP)	Type B (Mineral Filled PP)	Type C (ABS)	Type D (ABS)
1	Density	g/cc	ASTM D792	1.04 ± 0.02	1.04 ± 0.02	1.04 ± 0.01	1.04
2	Filler Content	%	ISO 3451	22 ± 2	20 ± 2	Unfilled	Unfilled
3	Tensile strength at Yield	Kg/cm^2	ASTM D638	Min 200	Min 290	Min 430	Min 460
4	Elongation at break	%	ASTM D638	Min 30	Min 50	Min 18	Min 20
5	Flexural Strength	Kg/cm^2	ASTM D790	Min 290	Min 450	Min 620	Min 650
6	Flexural Modulus	Kg/cm^2	ASTM D790	Min 20000	Min 27000	Min 22000	Min 19200
7	Notched Izod Impact Strength at 23°C	Kg.cm/cm	ASTM D256	Min 25	Min 5	Min 45	Min 25
8	HDT at 0.45Mpa	°C	ASTM D648	Min 125	Min 135	Min 97	Min 95
9	Mold Shrinkage	%	ASTM D955	0.9 ± 0.1	1.2 ± 0.1	0.4 – 0.8	0.4 – 0.6
10	Flammability	Rating	UL 94	HB	HB	HB	HB
11	Rockwell Hardness	R Scale	ASTM D785	-	Min 100	-	-
12	Color Fastness / Weathering Resistance / Gray Scale Rating 4 / Rating 7	Hrs	6.11	1000	1000	96	300
13	Component Test Requirements	--	--	To meet Section 6	To meet Section 6	To meet Section 6	To meet Section 6

5.1 TABLE 1 – CONTINUED

Interior

S.No	Property	Unit	Test Standard	Type E (Mineral Filled PP)	Type F (HDPE)	Type G (ASA)
1	Density	g/cc	ASTM D792	Max 0.96	0.952	1.1
2	Filler Content	%	ISO 3451	10 ± 2	Unfilled	Unfilled
3	Tensile Strength at Yield	Kg/cm^2	ASTM D638	Min 200	Min 220	Min 550
4	Elongation at break	%	ASTM D638	Min 40	Min 1000	Min 15
5	Flexural Strength	Kg/cm^2	ASTM D790	Min 300	-	Min 800
6	Flexural Modulus	Kg/cm^2	ASTM D790	Min 20000	Min 9500	Min 26500
7	Notched Izod Impact Strength at 23°C	Kg.cm/cm	ASTM D256	Min 5	Min 14	Min 9.5
8	HDT at 0.45Mpa	°C	ASTM D648	Min 125	Min 78	Min 76 (1.82Mpa)
9	Flammability	Rating	UL 94	HB	HB	HB
10	Color Fastness / Weathering Resistance – Gray Scale Rating 4	Hrs	6.11	1000	-	1000
11	ESCR	Hrs	ASTM D1693	-	Min 500	-
12	Component Test Requirements	--	--	To meet Section 6	To meet Section 6	To meet Section 6

Plastics Thermosets

	Thermosets
	Thermosets before hardening, like thermoplastics, are independent macromolecules. But in their final state, after hardening, they have a three-dimensional structure obtained by chemical crosslinking produced after (spray-up moulding or filament winding) or during the processing (compression or injection moulding, for example).
	Thermoset consumption is roughly 12–20% of the total plastic consumption.
Advantages	• Infusibility: thermosets are degraded by heat without passing through the liquid state. This improves some aspects of fire behaviour: except for particular cases, they do not drip during a fire • When the temperature increases the modulus retention is better, • Better general creep behaviour,
Disadvantages	• The chemical reaction of crosslinking takes a considerable time that lengthens the production cycles and, often, requires heating • The processing is often more difficult to monitor, • Certain polymers release gases, in particular water vapour • The wastes are not reusable as virgin matter because of the irreversibility of the hardening reaction. At best, they can be used like fillers after grinding. • The infusibility prevents assembly by welding.

PROPERTY MODIFICATIONS

By using bulk fillers, reinforced fillers, additives and blends.

BULK FILLERS: Mica, talc, calcium carbonate, asbestos, metallic powders, graphite, molybdenum disulphide

REINFORCING FILLERS: Glass fibres, carbon fibres, aramid fibres, boron fibres and synthetic fibres.

Properties of Modified Plastics

- **Better dimensional stability – reduction in warping shrinkage and creep**
- **Low co-efficient of thermal expansion**
- **Re-tension of mechanical properties over a much wider temperature range**
- **Low co-efficient of friction and therefore improvement in wear resistant property**
- **Higher stiffness and rigidity**
- **Higher impact strength at higher & lower temperatures**
- **Improvement in flexural strength and modulus**
- **Higher heat distortion temperature**
- **Imparting electrical and thermal conductivity**

FIVE MAJOR GROUPS OF ENGINEERING PLASTICS

Crystalline materials

- Polyamides
- Polyesters
- Acetals

Amorphous materials

- Polycarbonates
- Modified Phenylene

Polyamides (Nylons)

- The Polyamides (nylons) were the first materials to be recognized as engineering thermoplastics.

- Polyamides are polymers characterized by the amide group (CONH) as a part of the main polymer chain.

- Chemically the polyamides are divided into two types:

  Based on diamines and dibasic acids

  Based on amino acids or lactams.

- Aliphatic polyamides such as nylons 66, 6, 10 and 11 are linear polymers and thus thermoplastic.

Structure of Polyamides

Polyamide 6	$-[\ HN\ (CH_2)_6\ CO\ ]-_n$
Polyamide 6,6	$-[\ HN\ (CH_2)_6\ NH\text{-}CO\ (CH_2)_4\ CO]-n$
Polyamide 11	$-[\ HN\ (CH_2)_{10}\ CO\ ]-_n$
Polyamide 12	$-[\ HN\ (CH_2)_{11}\ CO\ ]-_n$

PROPERTIES

- **Good combination of mechanical properties like Fatigue creep strength, stiffness, toughness and resilience**
- **Good abrasion resistance**
- **Self lubricating characteristics**
- **Suitable for prolonged, service temperature from -40^{0}C to 120^{0}C**
- **Good electrical insulator, but the electrical properties are influenced by moisture content**
- **Resistance to fuels, oils, fats, most solvents and chemicals**
- **Low permeability to gas and vapours**
- **Non-toxic**
- **Easy processable by conventional processing techniques like injection, extrusion, blow and rotational moulding.**

APPLICATIONS OF POLYAMIDES

Automobile Industry

- Radiator fan
- Radiator grill
- Instrument housings
- Speedometer gears
- Fuel, oil filter housing
- Electrical junction box
- Head/Tail lamp housing
- Front fork bush
- Steering column bush

BLENDS OF POLYAMIDES

PA Blends	Applications
PA/ABS BLENDS • Impact and abrasion resistance • Chemical and heat resistance • Low moisture absorption • Good processability and surface finish	Automotive, chemical, electrical, consumer and sport industries.
PA/ELASTOMER (EPDM/EPR) BLENDS • Low temperature impact strength • Good processability • The moulded articles can suppress vibration even at subzero temperature	Automotive, home appliances, sport, business equipments and consumer products.
PA/PP BLENDS ➢ Shows good processability ➢ Reduced water absorption ➢ Low density (ie. Low cost per volume ➢ Improvement in paintability	Automotive, building, furniture & industrial

POLYACETALS

- Acetalpolymers are properly called polyoxymethylene (POM).
- These resins are linear unbranched molecular chains derived from the monomer formaldehyde. The structure of homopolymer and copolymer are as follows:

$$---- CH_2 - O - CH_2 - O - CH_2 - O - CH_2 ------$$

Polyacetal homopolymer

$$---- CH_2 - O - CH_2 - CH_2 - O - CH_2 ------$$

Polyacetal Copolymer

PROPERTIES

- Excellent combination of toughness, rigidity, fatigue, strength and yield strength (spring like qualities)
- Good wear resistance
- Low co-efficient of friction
- Service Temperature Range 90 - 120^0 .C
- Good dimensional stability over wide temperature -40^0.C to 65^0 .C
- Good moisture and chemical resistance
- Good electrical insulation
- Easy processable with conventional technique
- Excellent dimensional accuracy and post moulding stability

APPLICATIONS OF POLYACETALS

- Gears
- Bearing boxes and bushes
- Switch relays, terminal blocks and coil formers
- Blower fans, ventilation fans and pump parts
- Parts for office machines, house hold appliances and bathroom fittings
- Hinges
- Springs, snap fittings, screw
- Curtain rail runners
- Aerosol nozzles
- Nuclear engineering applications
- Plumbing fittings and components for pneumatic systems
- Automobile components such as radiator heater tapes, water filter bodies, fuel contact applications
- In irrigation system used in the areas of compression fittings, jets and sprayers
- Clock and watch parts

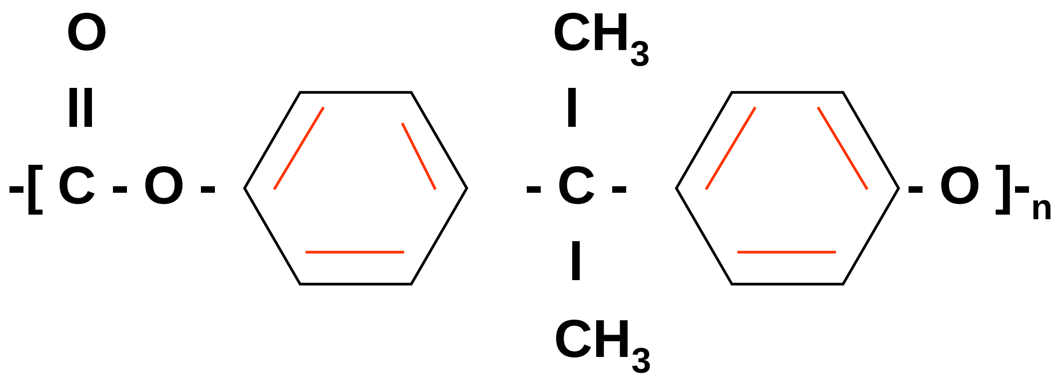
POLYACETAL BLENDS

POM/TPU BLENDS

- High impact strength
- High fatigue, flexural and tensile strength
- Low water absorbency
- Good resistance to oils, greases and many chemicals
- Most blends contain 10-30 wt. % of TPU
- Blends have co-continuous morphology for good performance

POLYCARBONATE

Polycarbonate is a linear polyester of carbonic acid in Which dihydric phenols are lined through carbonate groups. The commercial grades of polycarbonate is manufactured from bisphenol-A and phosgene. The structure of polycarbonate is:

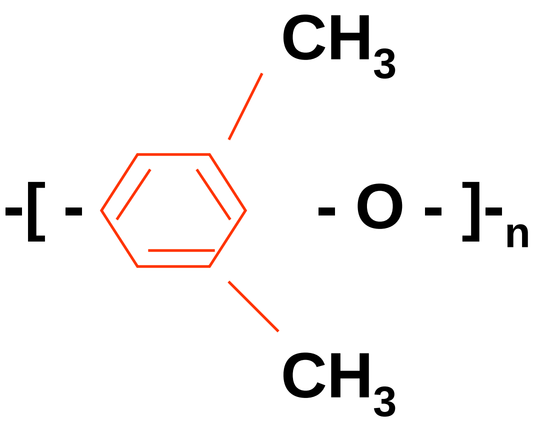


POLYCARBONATE BLENDS

Blend	APPLICATIONS
PC/ABS BLENDS Moulding characteristics High impact strength at low temperature	
PC/ASA BLENDS Rigidity and dimensional stability Outstanding resistance to high temperature ageing Good resistance to UV radiation	
PC/SMA BLENDS Superior toughness Heat resistance Outstanding processability	Automotive, medical and electronic

POLYPHENYLENE OXIDE - PPO

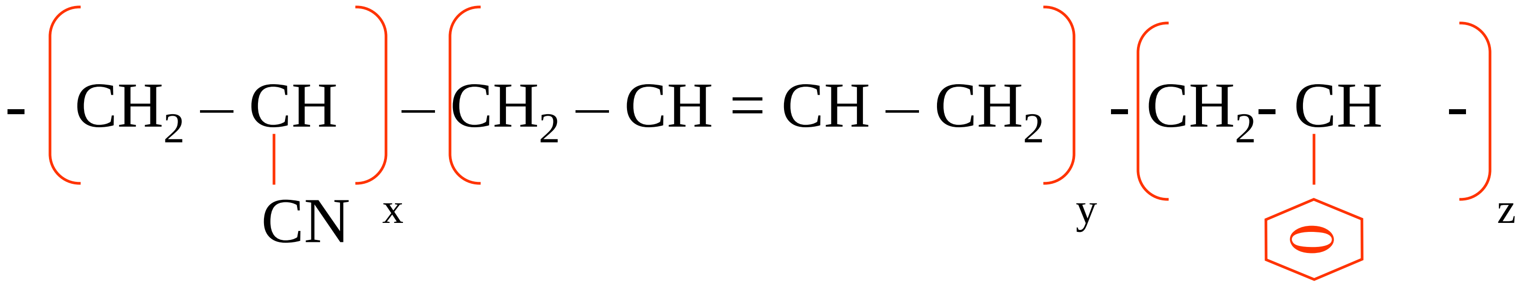
The chemical formulation is based on the oxidative coupling of substituted phenols and the elimination of a molecule of water. The full chemical name of PPO is poly [1, 4 – (2, 6-dimethyl phenyl) ether].



PPO is used in blends with other Polymers. The neat Polymer is not suitable for injection moulding because of its high melt viscosity.

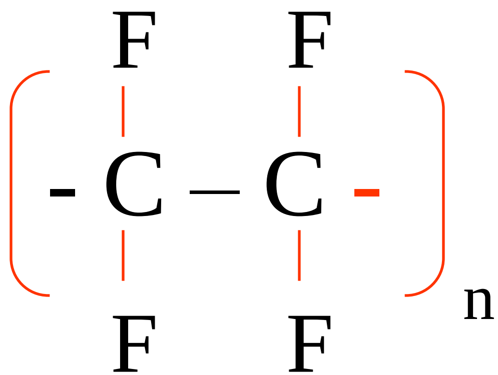
	PPO
Properties	•High Heat Resistance •Excellent Impact Strength •Exceptional dielectric and dissipation characteristics •Flame Retardancy •Exceptional low moisture absorption
Blends of Polyphenylene Oxide	PPO/PS blends, PPO/PA blends Polyphenylene Oxide is completely miscible with Polystyrene in all proportions.
Applications	Automotive: • Fenders, dash- boards, • Head lamp systems, • Instrument and Control Panels, • Mud-guards, • Wheel Covers & • Fuse Blocks etc.

ACRYLONITRILE BUTADIENE STYRENE (ABS)



PROPERTIES	APPLICATIONS
•Good combination of mechanical, thermal and chemical properties •Low cost of all engineering thermoplastics •High impact strength •Low continuous use temperature •High thermal expansion •Limited weather resistance •Poor solvent resistance •Low water absorption •Easy processable by injection, extrusion and vacuum forming •Electroplatable	Telephone casings Housing for domestic appliances eg. Vaccum cleaners, TV cabinets, etc. Luggage cases Safety helmets Car fascia and instrument panels Toys Furniture Food mixture housings Automobile radiator grills Refrigerator door and tank liners Automotive front and assembly

POLYTETRA FLUOROETHYLENE (PTFE)



Properties	Applications
• Inert to all chemicals • Excellent weatherability and not attacked by bio-organisms • Anti-stick and low friction • Stable at high temperature (upto 250 Deg.C) • Tough at low temperature (down to –160 Dec.C.) • Self extinguishing • Stable electrical properties and non-tracking • Difficult to process by conventional methods • Processed by sintering technique • Easy machinable	• High and low temperature electrical and electronic insulation • Bearings • Wear resistant, low friction surfaces • Chemical process equipments • Valves • Pump impellers • Gaskets • Non-stick cockwares

MECHANICAL PROPERTIES OF UNFILLED AND FILLED PLASTICS

S.No.	Polymer	Nature of fiber	Wt %	Tensile strength (psi)	Elongation (%)	Flexural modulus (psi x $10^{5)}$	Izod Impact Strength (ft.lb.in[1])
1.	Polyamide 66	None	0	11800	60	4.1	0.9
		GF	40	31000	2 – 3	16.0	2.9
		CF	40	40000	3 – 4	34.0	1.6
2.	Polysulphone	None	0	10200	50 –100	3.9	1.3
		GF	30	18000	3	12.0	1.8
		CF	30	19000	2 - 3	25.5	1.1
3.	Polypropylene	None	0	5000	200 – 700	2.0	0.5
		GF	30	9800	2 – 3	8.0	1.6
4.	Polycarbonate	None	0	9500	90	3.4	2.7
		GF	30	16000	4 – 6	12.0	3.7
5.	Polyphenylene oxid	None	0	9500	60	3.6	1.2
		GF	30	18500	3 – 4	11.5	1.7

HDT FOR UNFILLED AND FILLED PLASTICS

S.No	Polymer	Heat Distortion Temperature ºC (at 264 psi)	
		Unfilled	30% GF filled
1.	Polypropylene	55 – 60	146
2.	Polybutylene terephthalate	55	200 – 212
3.	Polyethylene terephthalate	68	221
4.	Polycarbonate	140	149
5.	Polysulphone	174	185
6.	Polyphenylene oxide	130	155
7.	Polyamide 6	70	215
8.	Polyamide 6,6	104	255
9.	Polyphenylene sulphide	135	260
10.	Polyether ether ketone	160	315

CO-EFFICIENT OF LINEAR THERMAL EXPANISON FOR

UNFILLED AND FILLED PLASTICS

S.No.	Polymer	Co-efficient of Linear Thermal Expansion ($in^{-1}\ {}^oF^{-1} \times 10^{-5}$)	
		Unfilled	30% GF filled
1.	Polypropylene	3.8	2.0
2.	Polybutylene terephthalate	4.6	1.2 – 5.4
3.	Polycarbonate	3.73	1.25
4.	Polysulphone	3.1	1.4
5.	Polyamide 6	4.6	1.7

DIELECTRIC STRENGTH AND ARC RESISTANCE FOR UNFILLED AND FILLED PLASTICS

S.No.	Polymer	Nature of Fibre	Wt.%	Dielectric strength ($Vmil^{-1}$)	Arc Resistance (S)
1.	Polyphenylene sulphide	None GF	0 30	400 – 500 550 – 600	70 – 80 100 – 120
2.	Polycarbonate	None GF	0 30	390 – 410 450 – 480	110 – 120 110 – 120
3.	Polyamide 6	None GF	0 30	360 – 370 400 – 480	130 – 140 125 – 135

MOULD SHRINKAGE

FOR UNFILLED AND FILLED PLASTICS

S.No.	Polymer	Mould Shrinkage (mm/mm)	
		Unfilled	30% GF filled
1.	Polypropylene	0.01 – 0.025	0.002 – 0.008
2.	Polybutylene terephthalate	0.017 – 0.023	0.002 – 0.006
3.	Polycarbonate	0.007	0.0025
4.	Polysulphone	0.007 – 0.008	0.002 – 0.003
5.	Polyphenylene oxide	0.005 – 0.007	0.002 – 0.004
6.	Polyamide 6	0.016	0.0045

Adhesives : Types (Thread locking)

Functions of a threaded assembly

1. Create clamp force
2. Maintain clamp force
3. Allow disassembly

Why do threaded assemblies fail?

Clamp force is not maintained

Threaded assemblies loosen because of:

A. **Gaps:** In order to make the assembly possible, nuts and bolts must have some tolerance, which creates gaps between the threads.

Parts tolerance

B. **Vibration & side-to-side movement:** These gaps allow the parts to move from side-to-side when exposed to vibration.

Vibration and loosening

C. **Expansion/contraction & loosening:** Expansion and contraction can also cause side-to-side movement. This, in addition to vibration, leads to loosening and ultimately disassembly of parts.

Stretching of the bolt beyond its yield point and thermal expansion/contraction of parts lead to lack of structural rigidity and relaxation of parts.

Adhesives : Types (Thread locking)

Shortcomings of locking devices

Split ring or spring washers

Increased friction reduces clamp load; will not ensure reliable threadlocking under dynamic loads.

Tab washers, split pins, castle nuts

Expensive and time-consuming methods, they often impose challenges to line up their components appropriately (i.e., tabs, cotter pins).

Tooth or ribbed flanged bolts

Prevent self-loosening, but are expensive; need larger flange-bearing surfaces and may damage the surfaces.

Nylon nut

More expensive than a standard nut, nylon inserts increase friction, which results in inaccurate torque.

Adhesives : Types (Thread locking)

How does a Loctite® threadlocker work?

Fill Gaps

Loctite® threadlockers are single-component adhesives that cure in the absence of air and in contact with active metal to form a tough thermoset plastic. They completely fill all voids between the interfacing threads, which makes the assembly a unitized component and ultimately prevents loosening.

Loctite® threadlocker between the interfacing threads

Seal Threads

Another property of Loctite® threadlockers is thread sealing. This property is especially important when assembling through-bolts in an oil reservoir or cooling jacket in order to keep the fluids sealed in and corrosion out. Examples of this application are common, but not limited, to gearboxes and internal combustion engines.

Engagement area of rusty bolt that did NOT have Loctite® threadlocker applied

Engagement area of rusty bolt that DID have Loctite® threadlocker applied

Adhesives : Types (Thread locking)

Why use Loctite® threadlockers?

Loctite® Benefits

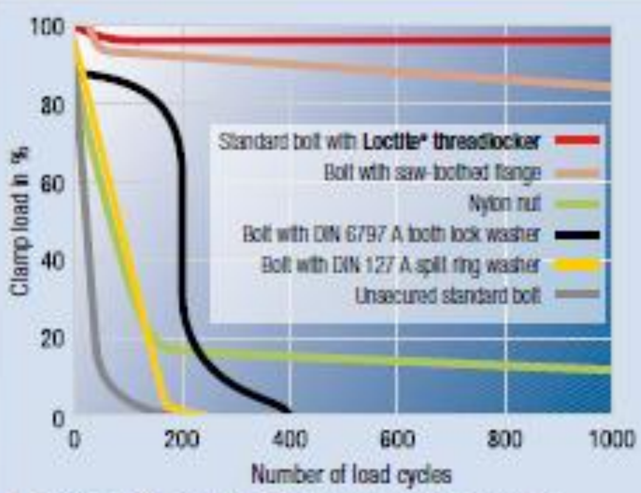
Better Performance

- **Reliable assembly:** Lock against vibration, shock and thermal cycling – plus seal against corrosion and galling.
- **Easy disassembly** using hand tools when low- or medium-grade formula is selected.
- **Outperform locking devices:** Better clamp load retention compared to all mechanical locking devices.

Cost Savings

- **Failure:** Reliable threaded assemblies reduce costly downtimes.
- **Inventory:** "One size fits all," universally applicable for a wide range of fastener sizes.
- **Processing:** Ease of automation reduces assembly costs and increases throughput.
- **Material Cost:** Lower cost per unit compared to most locking devices.

Vibration loosening test



Note: *Results from the Transverse Vibration Test (Junkers Machine) that assesses fasteners' resistance to vibration loosening.*

Cost per locking application

Fastener Size	Split Ring Washer	Loctite® Threadlocker
3/8"	2¢	2¢
5/8"	9¢	5¢
7/8"	25¢	7¢

Note: *Washer pricing based on 100 units purchased at an industrial distributor. Loctite® pricing based on 50 ml bottle price and number of drops required per application.*

Adhesives : Types (Thread locking)

Loctite® 2045™ Dri-Loc® – Designed for plated and stainless steel fasteners. High dried adhesion, high strength, fast cure, high temperature (400°F). Meets GME151 and WX200.

Loctite® STS™ Dri-Loc® – Sealing and medium strength threadlocking, fast cure. Meets GM6124m, Chrysler MScc 76-b.

Loctite® BRASS-LOC® Products

Loctite® 2020™ Brass-Loc® – Low to medium strength; will not corrode brass. Also works on plated finishes and stainless steel.

Loctite® DRI-LOC® Activator

Loctite® P-2™ Dri-Loc® – Small microcapsules, excellent for all size fasteners, especially fine threads.

Loctite® P-3™ Dri-Loc® – Works best with 2045™ and STS™. NOT suggested for fine threads and small fasteners.

cants
t that will provide "constant
alant that will provide gap
alant, with "constant
t, with "constant

GM6175M.

Loctite® 2045™ Dri-Loc® – Designed for plated and stainless steel fasteners. High dried adhesion, high strength, fast cure, high temperature (400°F). Meets GME151 and WX200.

Loctite® STS™ Dri-Loc® – Sealing and medium strength threadlocking, fast cure. Meets GM6124m, Chrysler MScc 76-b.

Loctite® BRASS-LOC® Products

Loctite® 2020™ Brass-Loc® – Low to medium strength; will not corrode brass. Also works on plated finishes and stainless steel.

Loctite® DRI-LOC® Activator

Loctite® P-2™ Dri-Loc® – Small microcapsules, excellent for all size fasteners, especially fine threads.

Loctite® P-3™ Dri-Loc® – Works best with 2045™ and STS™. NOT suggested for fine threads and small fasteners.

Loctite® Pre-Applied Lubricants

Loctite® Anti-Seize – To prevent galling and corrosion of metals, especially stainless steel and aluminum.

Loctite® DRI-SEAL™ Products

Loctite® 513™ Dri-Seal™ – High temperature (350°F) sealant for me
NSF approved. Flow-coatable.

Loctite® 513HV™ Dri-Seal™ – High viscosity, high temperature (350
metal and plastics. NSF approved. Flow-coatable.

Loctite® 5030™ Dri-Seal™ – UL-approved sealant for propane, simil
503™ VIBRA-SEAL®.

Adhesives : Types (porosity sealant)

POROSITY SEALING

Loctite® Resinol® AT – Low viscosity liquid sealant that is readily soluble in water for supreme washability and cleanliness. The refined monomer composition also provides excellent integrity in aggressive chemical environments and elevated temperatures in its polymer form.

Loctite® Resinol® RTC™ – Self-curing anaerobic sealant formulated with a unique proprietary surfactant monomer washable in plain water. RTC has no "soap" blended into the sealant resulting in a more chemical- and temperature-resistant polymer.

Loctite® Resinol® 88C™ – Low viscosity liquid sealant that cures at elevated temperatures and is readily soluble in water for exceptional part cleanliness after the vacuum impregnation process.

Loctite® Resinol® 90C™ – Single-component, water-washable, heat cure sealant that cures to a polymer at elevated temperatures (>80°C) for impregnation of porous materials, especially castings.

Loctite® Resinol® 90R™ – Low viscosity heat cure sealant that is formulated with a chemistry that allows the material to be washed from the surface of the casting and later separated and reused in the process tank.

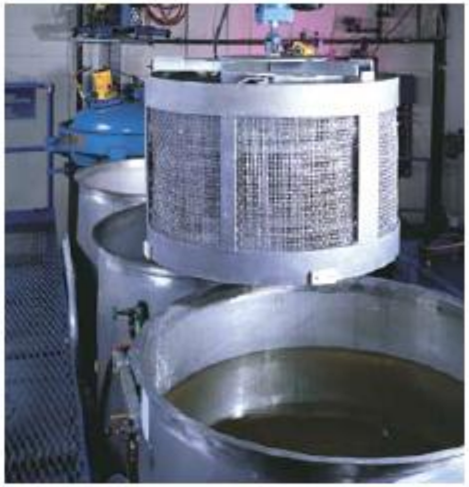
Loctite® 5110™ – Electrical grade anaerobic sealant in which no solvents exist and ionic contaminants are minimized in its monomer (liquid) state, providing excellent insulating properties in its polymer form. This material also maintains its integrity in harsh chemical environments. Specifically optimized to cure in confined spaces of non-metallic components.

Loctite® Flexseal™ 5100™ – Self-curing, electrical grade anaerobic sealant that cures to form a tough, flexible, thermoset plastic with excellent environmental resistance. Due to its flexible characteristics, this product is exceptional for sealing interfaces or voids between dissimilar materials.

Loctite® PM 5120™ – Powder metal sealant used for improving aesthetics when preceding a plating, painting, or coating operation.

Loctite® PMS-50E™ – Tough and durable anaerobic sealant designed to provide superior solvent and temperature resistance in extremely demanding environments. Only product with E85 fuel approval.

Loctite® PMS-10E™ – Self-curing anaerobic sealant widely used for high volume OEM manufacturing operations such as automotive castings and powder metal parts, and fiber-reinforced composites.



Adhesives : Types (Auto Exteriors)

Body and Exterior

Henkel has developed a full line of solutions for the body and exterior of a vehicle.

- Loctite® adhesives for bonding to low surface energy substrates
- Terocore® structural parts and foams for reinforcement and NVH protection improvement
- Terophon® acoustic parts for cavity sound blocking and isolation and dampening
- Terophon® liquid-applied sound deadeners
- Teroson® acrylics and waxes for cavity, underbody and transport protection
- Teroson® adhesives for hem flange and anti-flutter applications
- Teroson® anti-chip coating for underbody and rocker panel
- Teroson® glazing adhesives for glass and polycarbonate bonding
- Teroson® sealants and sealing tapes for seams and joints in the body or paint shop
- Teroson® structural adhesives for body bonding

Adhesives : Types (Auto Interiors)

Interior

From adhesives and cleaning systems to sealants and corrosion protection, Henkel offers a variety of products for interior applications.

- Autophoretic® corrosion protection coatings for seating components
- Loctite® instant adhesives and Macromelt® hot melts for trim bonding
- Loctite® threadlockers for component security
- P3® cleaning systems for plastic parts before painting
- Terophon® acoustic systems for body dampening
- Teroson® adhesives for body panel modules, headliners and other trim cover laminates
- Teroson® sealants and adhesives for door panels and water-shedders

Adhesives

Henkel manufactures a vast line of advanced-technology adhesives in industries such as:

- Automotive
- Truck and bus
- Agriculture equipment
- On/off-road heavy equipment

The chemistries in the Henkel adhesives product line include acrylic, butyl, cyanoacrylate, epoxy, methyl methacrylate, modified silane, polyamide and polyurethane. The adhesives also are available in a variety of product types including hot-melt, water-based, instant-cure and light-cure versions.

Adhesives product line:

- Anti-flutter bonding
- Flange bonding
- Glass bonding
- Plastic and composite bonding
- Plastics foil lamination
- Structural metal bonding
- Textile and foam lamination
- Weld bonding

Adhesives : Types (Gaskets FIP)

Gaskets

Henkel's gasketing product line improves assembly efficiency, quality and reliability while reducing costs. The company combines both product and process design expertise to develop customized solutions for each application.

Gasketing product line:

- Acrylic, acrylate, silicone and polyether gaskets
- High-performance liquid gasketing
- RTV-cured, heat-cured, UV-cured technology

GASKETING & SEALING

Loctite® liquid gaskets are low cost, high quality alternatives to molded rubber, paper, metal and other hard gaskets. Liquid gaskets can provide up to 95% material savings over hard gaskets while offering the engineer flexibility in design to use lower cost manufacturing methods.

Formed-In-Place Gaskets

Loctite® 5900™ – Heavy Body RTV Silicone – Superior flexibility and adhesion. Provides instant seal. Excellent fluid resistance. Non-corrosive, low odor, low volatility. Black in color.

Loctite® 5904™ – RTV Silicone – Provides the performance of 5900™ while offering more robust resistance to other fluids including water/glycol.

Loctite® 5910™ – RTV Silicone – Superior flexibility and adhesion. Excellent fluid resistance. Medium body and easy to dispense. Non-corrosive, low odor, low

Cured-In-Place Gaskets

Loctite® 5033™ – A UV or visible light- and moisture-curing silicone with high aspec ratio and good adhesion to primary substrates.

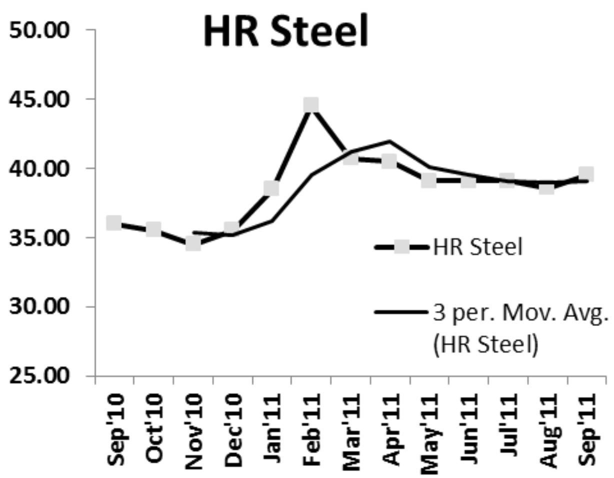
There are three types of flange gaskets.

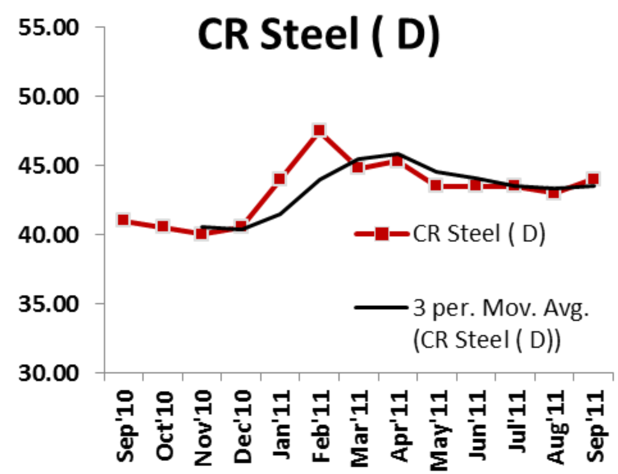
1. Conventional pre-cut compression gaskets are made from paper, rubber, cork, metal or other materials.
2. Formed-in-Place (FIP) gaskets are applied as a liquid sealant to one of the flange surfaces before the parts are assembled. After assembly, the FIP gasket spreads and cures between the flanges, filling gaps, scratches, and surface irregularities to provide a durable seal.
3. Cured-in-Place (CIP) gaskets are applied as liquids by tracing machines that dispense the gasket material in precise beads to one of the flanges. The material is cured by ultraviolet (UV) light or heat to form an elastomeric material with adhesion to the flange surface. Sealing is achieved through compression of the cured gasket during flange assembly.

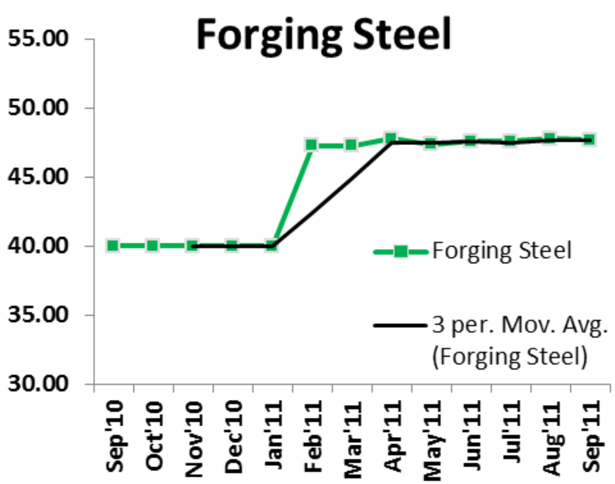
MATERIALS COST

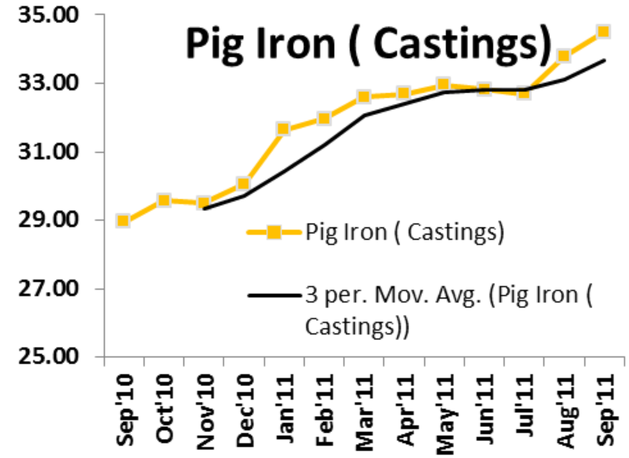
Material	Cost : Rs./Kg
BSK 46	41
SG iron	65
Gray CI	55
En8(bright bar) Black Bar	52 Less Rs. 4/kg
En 19 Black Bar	73/ Less Rs. 4/ kg
En353	68 (black bar
20 Mn Cr5	48 (black bar)
Spring steel En45A conversion of Spring leafs	44 Rs. 9/ kg
Harden & Temper – SQF Other	20/kg 15/kg
GCF Carburizing	25/ kg
Iso anneal	6/ kg

MATERIALS COST : FERROUS (RS/ KG)

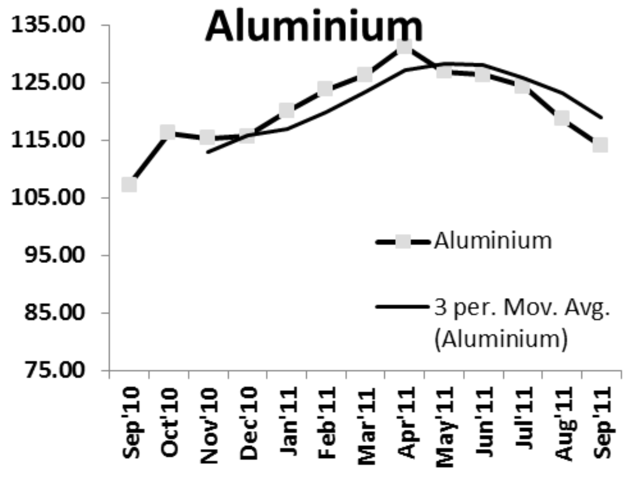


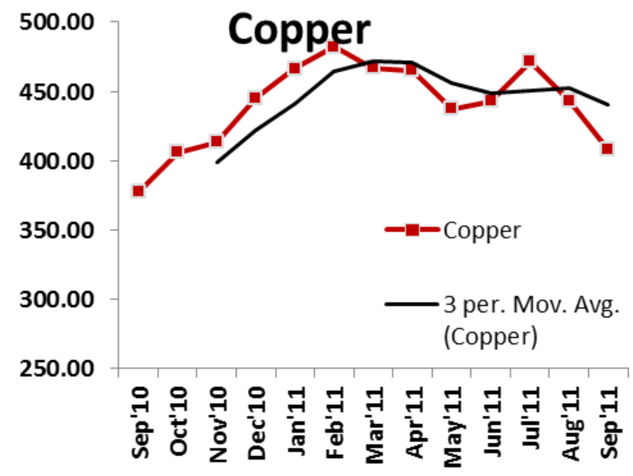


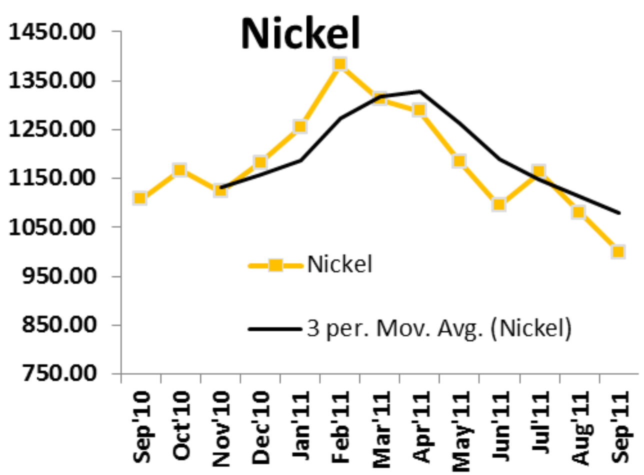


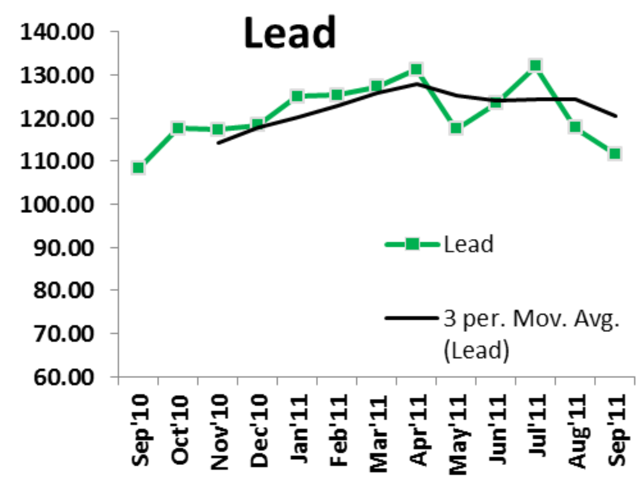


MATERIAL COST NON FERROUS (RS/KG)









MATERIAL COST: NON METALLIC (RS/ KG)