<u>Checklist: Design for Injection Molding</u>

by BP Nel Consulting Pty Ltd

1. Wall Thickness: Constant wherever possible. Minimum = 1mm, Maximum = 4mm.

2. Internal walls/ribs bosses wall thickness between 40-60% of external wall thickness.

3. Partline or Split Line: Try to make it flat on 1 surface where possible.

4. Draft Angles: Normally in the range of 0.5 to 3 degrees depending on part size, geometry and surface finish.

5. Undercuts: Try to eliminate since it makes tooling expensive and complicated.

6. Clips and live hinges: can “un-clip” and add development time to the tool. Try to use another mechanical method to assemble parts: example screws and bosses. Clip movement 0.75mm. Live Hinge thickness 0.5mm but make sure big cavities on both sides can be filled.

7. Shutoffs: Try to eliminate them if possible. If necessary remember ideal draft for shutoffs 1.5= degrees

8. Small Steel: Have to eliminate since it will cause downtime during production.

9. Shrinkage and Tolerances: try to use the same material where components have to match or fit together. When designing new parts eliminate: Holes in external surface, Long parts where length is 3x more than width. General clearances 0.2mm. Where parts fit together use big wedge drafts (7degrees)

10. Surface finish
What surface finishes do you get?
Polish, spark(EDM-Electrical Discharge Machining), Chemical etching, sandblast, machined

11. Material Selection
Guide for common materials in applications.

Material	Properties	Applications
Polycarbonate (PC)	High impact resistance, good clarity, good dimensional stability, heat resistant	Electronics housings, medical devices, safety glasses, lenses, automotive parts
Nylon 66 (PA66)	High strength, stiffness, wear resistance, good chemical resistance	Gears, bearings, fasteners, pipes, conveyor belts, cable ties

Acrylonitrile Butadiene Styrene (ABS)	Good balance of strength, toughness, and rigidity, good impact resistance, easy to machine and paint	Legos, appliance parts, casings, housings, toys, helmet shells
Polypropylene (PP)	Lightweight, flexible, good chemical resistance, low friction	Bottle caps, straws, living hinges, textiles, medical devices
Polyethylene Terephthalate Glycol (PETG)	High impact resistance, good clarity, chemical resistant, food-safe	Water bottles, food containers, trays, gears, medical devices
Polyethylene (PE)	Varies depending on type (HDPE, LDPE, LLDPE, etc.), but generally lightweight, flexible, and moisture resistant	Bags, films, geomembranes, pipes, bottles, toys
Polyvinyl Chloride (PVC)	Rigid, lightweight, good chemical resistance, water resistant, electrical insulator	Pipes, fittings, flooring, window blinds, medical devices, inflatable products
Polystyrene (PS)	Rigid, brittle, clear or opaque, inexpensive	Packaging, disposable cups, lids, trays, toys, building insulation
Polyoxymethylene (POMX)	High strength, stiffness, dimensional stability, good wear resistance, low friction	Gears, bearings, rollers, fasteners, medical devices

Additives include:

- Colorants/Pigments
- Fillers: These additives are used to modify the mechanical properties and reduce costs. Common filler materials include:
    - Glass, Carbon, Aramid fibers: Enhance stiffness and strength.
    - Talc: Improves stiffness, dimensional stability, and heat resistance.

- Calcium carbonate: Reduces cost and increases stiffness.
- Carbon black: Provides UV resistance and electrical conductivity.

Stabilizers: Additives used to protect the polymer from degradation due to heat, light, or chemical exposure. Examples include:

- UV stabilizers: Protect against ultraviolet radiation.
- Antioxidants: Prevent oxidation and degradation.
- Thermal stabilizers: Protect against heat-induced degradation.

Flame Retardants
Plasticizers
Antistatic Agents
Impact Modifiers
Release Agents
Foaming Agents

13. Design for Sustainability:

- "Design for Minimal Material Usage
- Use of Recyclable Materials
- Modular Design
- Biodegradable Materials

Biodegradable Material	**Description**	**Supplier**
Polylactic Acid (PLA)	Derived from renewable resources like corn starch or sugarcane, PLA is compostable and widely used in various applications.	- NatureWorks LLC -Corbion
Polyhydroxyalkanoates (PHA)	PHA is produced by microorganisms through fermentation of renewable feedstocks, offering versatility in properties.	- Danimer Scientific - Bio-on

Polybutylene Succinate (PBS)	PBS is a biodegradable polyester derived from renewable resources like succinic acid and 1,4-butanediol.	- Showa Denko - Mitsubishi Chemical Corporation
Polyhydroxybutyrate (PHB)	PHB is a biopolymer produced by bacteria through fermentation of renewable feedstocks, offering biodegradability in various environments.	- Tianan Biologic Material Co., Ltd. - Metabolix (Now Yield10 Bioscience)
Polyethylene Furanoate (PEF)	PEF is a bio-based polyester derived from plant sugars, offering enhanced barrier properties and biodegradability.	- Avantium
Starch-Based Bioplastics	Bioplastics derived from starch offer compostable and biodegradable solutions, suitable for various applications.	- Novamont - Floreon
Polyesters from Renewable Resources	Bio-based polyesters like ecoflex® and ecovio® offer sustainable alternatives to conventional plastics, derived from renewable feedstocks.	- BASF - DuPont
Aliphatic Polyesters	Aliphatic polyesters like Capa™ polycaprolactone (PCL) offer biodegradability and renewable sourcing, suitable for injection molding.	- Perstorp - Corbion

14. Mold/Tool Design Basics:

- Types of injection molds (e.g., single-cavity, multi-cavity, family molds).
- Components of an injection mold (e.g., cavity, core, ejector pins, runners, gates).
- Mold materials: H13 and P20.
- Minimize runner length

15. Moldflow analysis basics

With moldflow analysis we can predict die following:

- Optimum injection location
- Balance the runner system (only available in specialised Software)
- Fill confidence and quality of the molded part
- Fill time - Cycle time
- Pressure requirements
- Cooling requirements
- Where there will be Weld lines
- Where there will be Air traps

16. Assembly Process tips and techniques

1. Always think of how parts will be assembled. My advice is to do the assembly of parts the exact same way a factory would do it. In what order and if there is space to do that.
2. Also make sure that there are space for tools to fix screws - you need space for a socket wrench or screwdriver
3. Clips need space for operation
4. Ad fillets where appropriate to make plastic flow less turbulent. Let me give you examples of where it is appropriate to add fillets.
5. Always interference checks
6. Always do a draft check
7. In Fusion there are a minimum radius check - very useful to design for a minimum cutter size
8. Accessibility Analysis

17. Future Trends in injection molding

Here are some recent trends and future directions in injection molding:

- Industry 4.0 Integration
- Advanced Materials
- Additive Manufacturing Integration
- Micro Injection Molding
- Multi-Material Molding
- Energy Efficiency

- Digital Twin Technology
- Circular Economy Initiatives
- 3D Mold Printing
- Artificial Intelligence and Machine Learning

18. Resources and future learning

Online Resources:
- Society of Plastics Engineers (SPE): The SPE offers a wealth of resources on injection molding, including technical papers, webinars, and courses https://www.4spe.org/.
- American Molders Association (AMA): The AMA provides information on best practices, troubleshooting guides, and industry events related to injection molding https://amba.org/.
- MoldMaking Technology Magazine: This online publication offers articles on the latest trends, technologies, and best practices in injection molding https://www.moldmakingtechnology.com/.

CAD Software:
- AutoCAD: Developed by Autodesk, AutoCAD is one of the most widely used CAD software for 2D and 3D design and drafting across various industries.
- SolidWorks: SolidWorks is a popular 3D CAD software known for its user-friendly interface and robust features, widely used in mechanical and product design.
- CATIA: Developed by Dassault Systèmes, CATIA is a powerful CAD software commonly used in aerospace, automotive, and industrial design for complex surface modeling and analysis.
- Creo Parametric (formerly Pro/ENGINEER): Creo Parametric, developed by PTC, offers parametric 3D modeling capabilities and is used in diverse industries for product design and engineering.
- NX (formerly Unigraphics NX): NX, developed by Siemens PLM Software, is a comprehensive CAD/CAM/CAE software known for its advanced capabilities in product design, simulation, and manufacturing.
- Inventor: Autodesk's Inventor is a 3D CAD software primarily used for mechanical design, simulation, and visualization, commonly integrated with other Autodesk products like AutoCAD and Fusion 360.
- Fusion 360: Fusion 360, also developed by Autodesk, is a cloud-based CAD/CAM/CAE platform suitable for product design, engineering, and collaboration, with features for both parametric and direct modeling.
- Solid Edge: Solid Edge, developed by Siemens Digital Industries Software, is a hybrid 2D/3D CAD software with synchronous technology for flexible modeling and assembly design.
- Rhino (Rhinoceros 3D): Rhino is a versatile 3D modeling software used in various design fields, including industrial design, architecture, and jewelry design, known for its flexibility and extensive plugin ecosystem.

- Tinkercad: Tinkercad is a free, web-based CAD software popular among beginners and educators for its intuitive interface and ease of use, suitable for basic 3D modeling and prototyping.
- Onshape: Onshape is a cloud-based CAD platform with collaborative features, enabling real-time design and engineering collaboration from any device with an internet connection.
- FreeCAD: FreeCAD is an open-source parametric 3D CAD software designed for mechanical engineering and product design, offering features for modeling, simulation, and rendering.
- AutoCAD LT: AutoCAD LT is a lighter version of AutoCAD, offering 2D drafting and documentation features at a lower cost, suitable for users who primarily need 2D design capabilities.
- MicroStation: MicroStation, developed by Bentley Systems, is a CAD software commonly used in architecture, engineering, and construction (AEC) industries for 2D/3D modeling, drafting, and visualization.
- Plasticity: This is software is powerfull for concept design but does not have all the engineering deliverables yet. I have been following them and they are committed to developing their software so maybe they follow the route that Fusion follow by constantly upgrading features on their software.

BP Nel Consulting Future Training Cources:
The following training cources are in development and will be available within the next 3-9 months.
1. Design for Manufacture: Blow Molding
2. Design for Manufacture: Rotational Molding
3. Design for Manufacture: Sheet metal Fabrication
4. Injection mold tool design basics
5. Fusion 360 Design for manufacture