PRODUCT DESIGN AND DEVELOPMENT

DIPLOMA WALLAH

MECHANICAL

Unit - III Industrial Design

JHARKHAND UNIVERSITY OF TECHNOLOGY (JUT)

◆ 3.1 Importance of Industrial Design & Industrial Design Process

Definition

Industrial design refers to the discipline of designing physical products (their form, function, usability and manufacturability) that will be mass-produced in industry. Stimulo+1 It combines aesthetics, user-experience, engineering and manufacturing considerations into one integrated process. The industrial design process is the structured sequence of steps—from research and ideation, through concept development, prototyping, to production planning—that ensures a product is desirable to the user, feasible to manufacture, cost-effective and aligned with brand/market objectives. Bk Engineering+1 In essence, industrial design bridges “what customers want” with “what industry can deliver”. inorigin.eu+1

Explanation

Industrial design is important because it helps differentiate products—appearance, ergonomics or user-experience help a product stand out in the market. China Daily+1

1. It ensures usability and user-comfort by focusing on ergonomic, intuitive features and interaction. inorigin.eu+1
2. The industrial design process incorporates manufacturability and production constraints early on—reducing cost and risk. IDC UK+1
3. It strengthens brand identity by aligning product appearance, user experience and functionality with brand values. inorigin.eu
4. Sustainable design is increasingly embedded in industrial design: choice of materials, manufacturing methods, lifecycle impact are considered. The Design Village+1
5. The process involves steps such as market & user research, ideation/sketching, prototyping, detail design, manufacturing planning, launch and feedback loops. Stimulo+1

6. Prototyping (physical or digital) enables early detection of issues, saving time and cost in later manufacturing. 积玉工作室
7. It promotes collaboration across disciplines—designers, engineers, manufacturing, marketing must work together for a product's success. IDC UK
8. Products designed well tend to command higher value, better user satisfaction, fewer defects, thus better market performance. China Daily
9. Because products and markets evolve quickly, the industrial design process must be iterative, adapting to changing user needs and technologies. The Design Village

⚙️ Applications :-

- Designing a consumer electronics product (e.g., a smartphone or smart-home device) where interface, shape, materials and manufacturing cost all matter.
- Designing household appliances (e.g., refrigerator, washing machine) where ergonomics, ease of use, maintenance and production efficiency are key.
- Automotive product components or interiors—industrial design defines how the product looks, feels, integrates into driving experience.
- Medical devices: requiring user-friendly design, ergonomics, safety, manufacturability under regulatory constraints.
- Industrial equipment/tools: where the product must be robust, manufacturable, safe for operators and cost-efficient in volume.

✅ Advantages :-

1. Better market acceptance and stronger competitive position due to differentiation and good user experience.
2. Cost savings by early integration of manufacturing/production constraints in design.
3. Improved product quality, durability and user satisfaction—leading to brand loyalty.
4. Shorter development cycle and fewer revisions because design is validated early via prototyping.

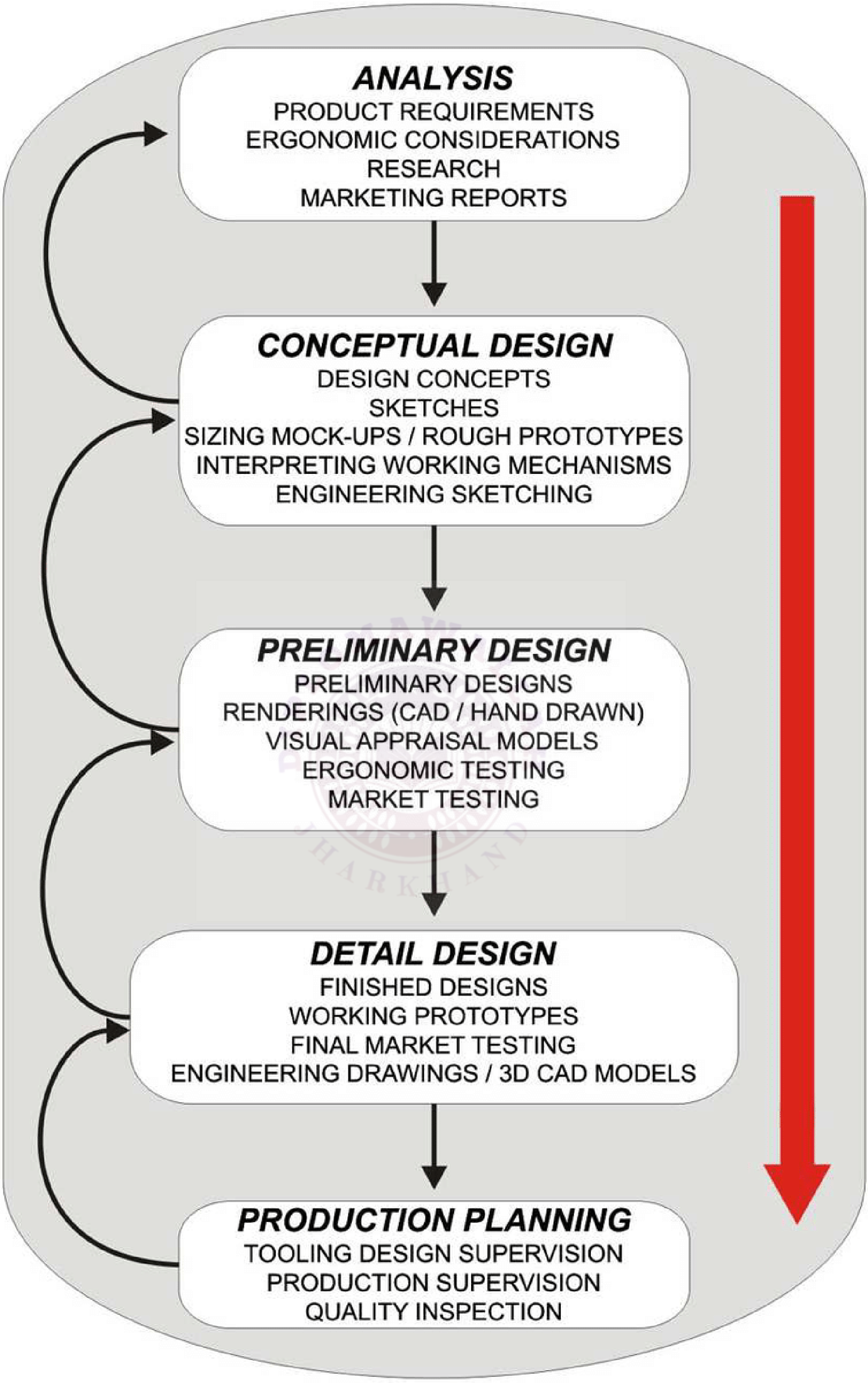
5. Greater sustainability and longer lifecycle value by design for durability, repairability, and minimal waste.

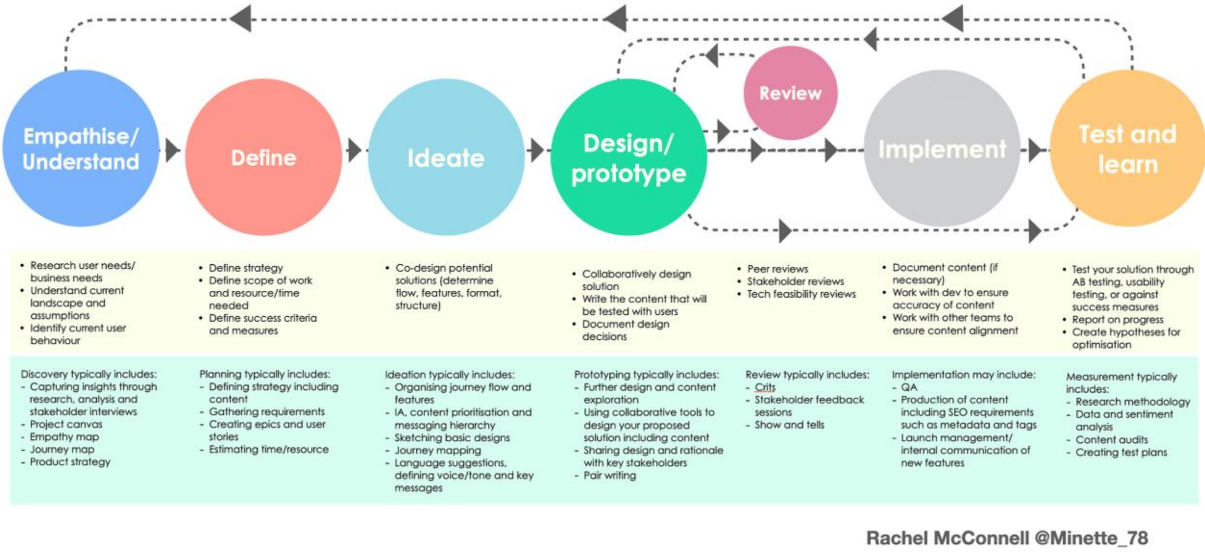
❌ Disadvantages

1. Up-front investment in design research, materials studies, prototyping and user testing can be significant.
2. If manufacturability is neglected in favour of aesthetics, the product may become costly or difficult to manufacture.
3. The industrial design process may slow down development if iteration and coordination are not managed well.
4. Over-focusing on design (form) may overshadow function or cost constraints, leading to unbalanced products.
5. Rapid changes in technology or user tastes mean a product may become outdated quickly if design process is rigid.

🗣 Summary :-

Industrial design ka matlab hai product ko "achha dikhe, use karne me aasan ho, banane me feasible ho" banana. Agar design process sahi ho — user needs aur manufacturing dono ka dhyan rakha jaye — tab product market me chalne ke chance badh jate hain.


ANALYSIS
PRODUCT REQUIREMENTS
ERGONOMIC CONSIDERATIONS
RESEARCH
MARKETING REPORTS
CONCEPTUAL DESIGN
DESIGN CONCEPTS
SKETCHES
SIZING MOCK-UPS / ROUGH PROTOTYPES
INTERPRETING WORKING MECHANISMS
ENGINEERING SKETCHING
PRELIMINARY DESIGN
PRELIMINARY DESIGNS
RENDERINGS (CAD / HAND DRAWN)
VISUAL APPRAISAL MODELS
ERGONOMIC TESTING
MARKET TESTING
DETAIL DESIGN
FINISHED DESIGNS
WORKING PROTOTYPES
FINAL MARKET TESTING
ENGINEERING DRAWINGS / 3D CAD MODELS
PRODUCTION PLANNING
TOOLING DESIGN SUPERVISION
PRODUCTION SUPERVISION
QUALITY INSPECTION


Empathise/ Understand
Define
Ideate
Design/ prototype
Review
Implement
Test and learn
• Research user needs/ business needs
• Understand current landscape and assumptions
• Identify current user behaviour
• Define strategy
• Define scope of work and resource/time needed
• Define success criteria and measures
• Co-design potential solutions (determine flow, features, format, structure)
• Collaboratively design solution
• Write the content that will be tested with users
• Document design decisions
• Peer reviews
• Stakeholder reviews
• Tech feasibility reviews
• Document content (if necessary)
• Work with dev to ensure accuracy of content
• Work with other teams to ensure content alignment
• Test your solution through AB testing, usability testing, or against success measures
• Report on progress
• Create hypotheses for optimisation
Discovery typically includes:
- Capturing insights through research, analysis and stakeholder interviews
- Project canvas
- Empathy map
- Journey map
- Product strategy
Planning typically includes:
- Defining strategy including content
- Gathering requirements
- Creating epics and user stories
- Estimating time/resource
Ideation typically includes:
- Organising journey flow and features
- IA, content prioritisation and messaging hierarchy
- Sketching basic designs
- Journey mapping
- Language suggestions, defining voice/tone and key messages
Prototyping typically includes:
- Further design and content exploration
- Using collaborative tools to design your proposed solution including content
- Sharing design and rationale with key stakeholders
- Pair writing
Review typically includes:
- Crits
- Stakeholder feedback sessions
- Show and tells
Implementation may include:
- QA
- Production of content including SEO requirements such as metadata and tags
- Launch management/ internal communication of new features
Measurement typically includes:
- Research methodology
- Data and sentiment analysis
- Content audits
- Creating test plans
Rachel McConnell @Minette_78


CORRECT SITTING POSTURE
Shoulders relaxed
Straight back
Circulation in legs
Healthy hip and knee joints
Feet flat on the floor
18-24"
90°
130°
135°
25-28"

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3.2 Design for Manufacturability (DFM)

Definition :-

Design for Manufacturability (DFM) is the practice of designing products so that they are easy, cost-effective and high quality to manufacture. It means considering manufacturing processes, materials, tolerances, assembly and production constraints early in the design phase, rather than treating manufacturing as an afterthought. Protolabs Network+1 DFM aims to optimise factors like number of parts, complexity, standardisation, process alignment and tooling to minimise production time, cost and variability while maximising quality. Herold Precision Metals+1

Explanation :-

1. Designing with manufacturability in mind means reducing unnecessary complexity in part geometry, avoiding features that complicate tooling, assembly or inspection. modusadvanced.com+1
2. Choosing materials and manufacturing processes early—matching material, process and product requirements ensures smoother production. modusadvanced.com+1
3. Minimising number of parts (and interfaces) reduces assembly steps, inventory, logistics and defect sources. Protolabs Network+1
4. Standardising components, using off-the-shelf parts where possible, helps reduce cost, lead time and complexity. Herold Precision Metals+1
5. Specifying tolerances, draft, wall-thickness, parting lines, etc aligned with manufacturing capabilities helps in consistency and quality. design4manufacturability.com+1
6. Factoring in manufacturing equipment limitations (tooling, fixtures, process repeatability) prevents design changes later and cost overruns. Herold Precision Metals
7. DFM helps shorten time-to-market because manufacturability issues are addressed early, reducing iterations and rework. kingstarmold.com
8. The impact on cost: design choices locked early often determine ~80% of product cost. design4manufacturability.com
9. DFM improves quality, reliability and production consistency by anticipating defect sources and aligning design with manufacturing. Corbett Engineering

10. Factors affecting DFM include: volume of production, product complexity, material & component availability, aesthetics vs production tradeoffs, tooling cost, process capability. Protolabs Network

Steps for DFM

Here's a typical sequence of steps for DFM:

1. Review product concept with manufacturing team to identify manufacturability constraints.
2. Simplify design: reduce part count, unify features, avoid undercuts/complex geometry.
3. Choose materials/process aligned with production capabilities.
4. Standardise parts and components where feasible.
5. Specify tolerances, finishes, assembly interfaces in line with manufacturing process.
6. Prototype or simulate manufacturing to verify design.
7. Review supply chain and tooling implications.
8. Finalise design and hand off to manufacturing with manufacturability audit.

Design Principles for Manufacturability (some key ones)

- Design simplification: fewer parts, simpler features. modusadvanced.com
- Material & process alignment: choose materials/processes compatible with production. Tesla Mechanical Designs
- Standardisation: Use common components, hardware, dimensions. modusadvanced.com
- Tolerance optimization: only specify tight tolerances where absolutely necessary, else production cost rises. Tesla Mechanical Designs
- Designing for assembly: features should allow easy jigs/fixtures, minimal orientation/handling operations. design4manufacturability.com

Factors Affecting DFM

- Production volume: High volume justifies more tooling investment; low volume may need different approach. Protolabs Network

- Product complexity: More complex geometry, more features = higher cost and manufacturing challenge. Protolabs Network
- Material and component availability & cost: Rare or expensive materials increase risk/time. kingstarmold.com
- Aesthetics vs manufacturability: High finish/appearance may conflict with simple manufacturing. Protolabs Network
- Manufacturing process capabilities: Tooling, equipment, automation level, workforce skills affect what is feasible. Herold Precision Metals

⚙️ Impact of DFM on Cost, Quality and Time

- Cost: DFM enables design choices that minimise material waste, tooling cost, re-work and assembly cost—direct cost reduction. kingstarmold.com+1
- Quality: By aligning design with process capabilities, fewer defects, better repeatability and lower variability result. Corbett Engineering+1
- Time (Time-to-Market): With manufacturability considered early, fewer design iterations and manufacturing delays, enabling faster ramp-up. Herold Precision Metals

✅ Advantages :-

1. Lower manufacturing cost, less waste, fewer tooling changes and simpler production.
2. Higher quality and reliability of the final product, less scrap and rework.
3. Shorter product launch time, faster time-to-market (competitive advantage).
4. Better coordination between design and manufacturing teams, fewer surprises.
5. Capacity to scale production efficiently as design is optimised for manufacturing from start.

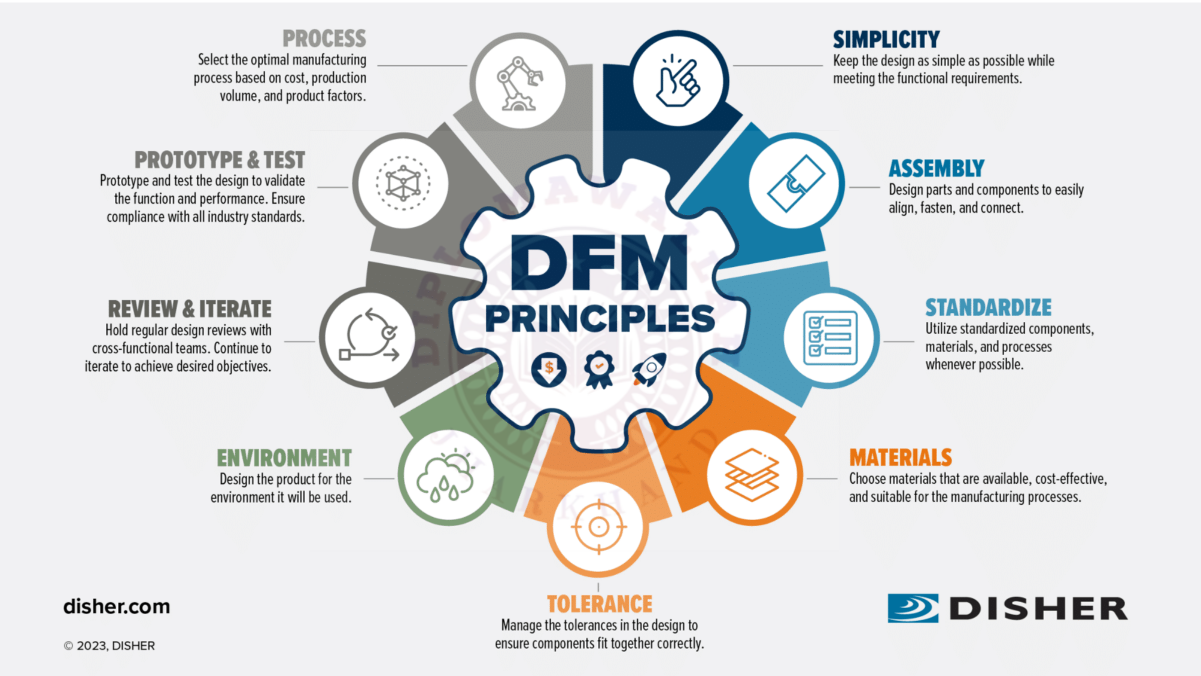
❌ Disadvantages :-

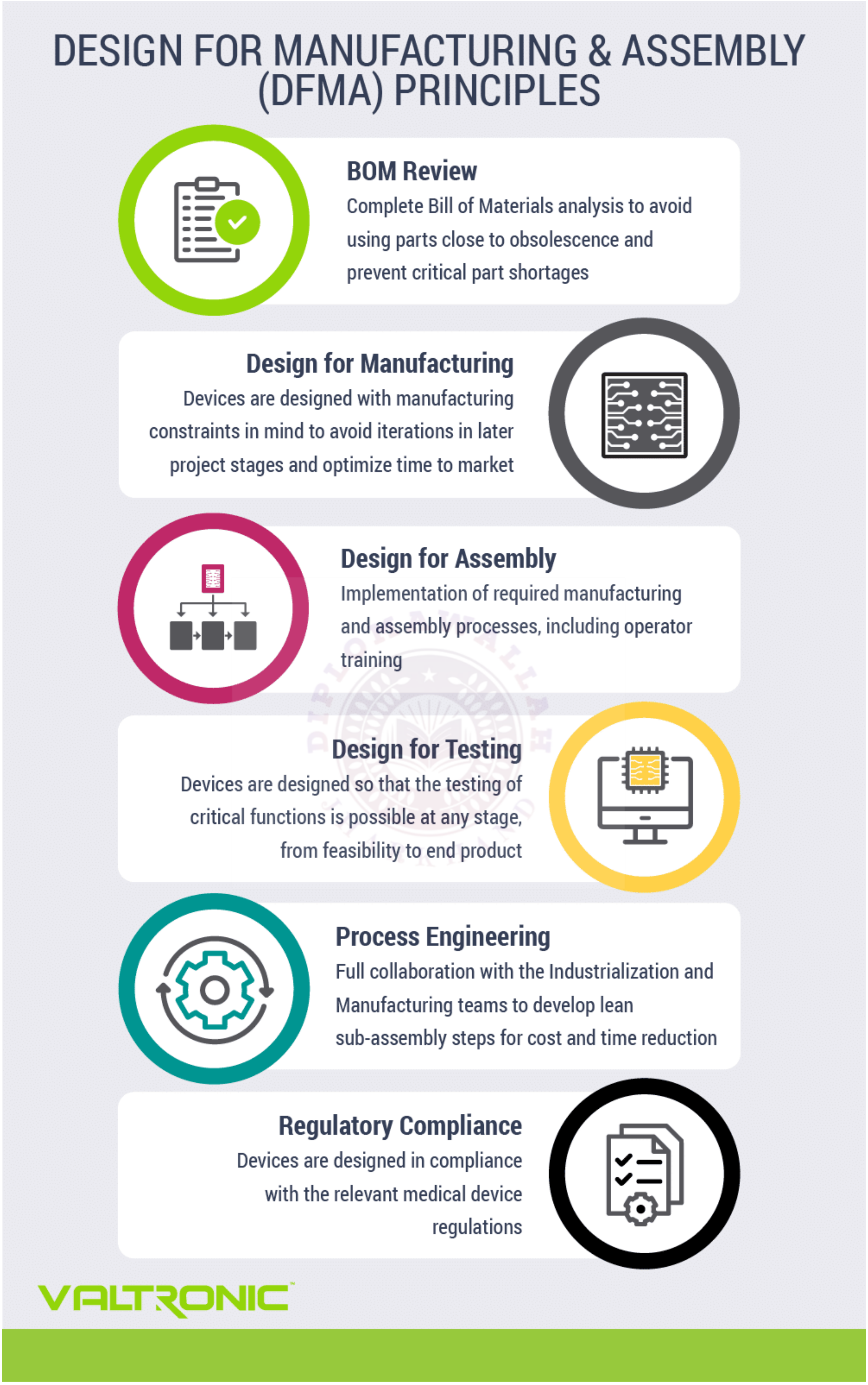
1. Emphasis on manufacturability may restrict design creativity or uniqueness.
2. Early detailed manufacturability work adds time and cost upfront in design phase.

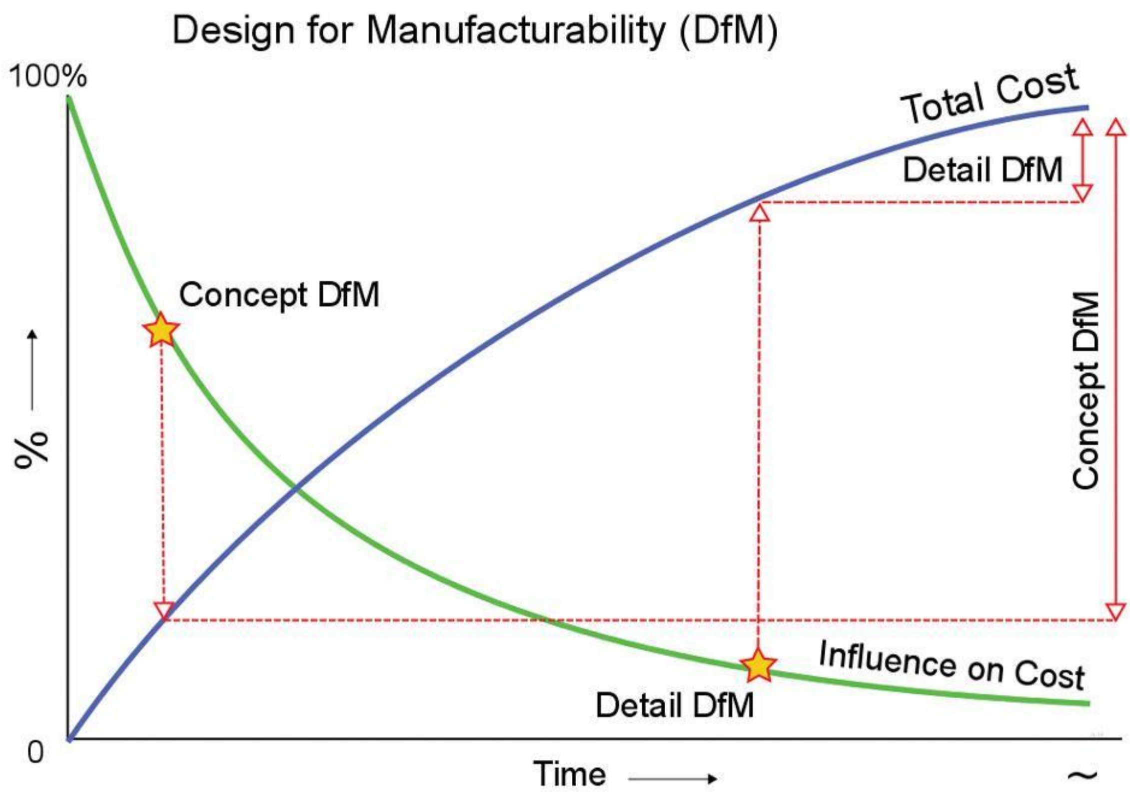
3. If assumptions about manufacturing capabilities change (tooling, process) design may become sub-optimal.
4. For very low volume or custom products, investing heavily in DFM may not give proportionate benefit.
5. If DFM focus is too rigid, product may lack differentiation or premium features, losing competitive edge.

🗣 Summary :-

DFM ka matlab hai "banane me aasan, cost-kam, quality-achhi" design banana—jisse manufacturing stage me problems kam, cost kam aur time bhi kam lage. Agar DFM pe early dhyan na de, to badme badhe cost, zyada defects aur delay hone ke chances badh jate hain.




DESIGN FOR MANUFACTURING & ASSEMBLY (DFMA) PRINCIPLES
BOM Review
Complete Bill of Materials analysis to avoid using parts close to obsolescence and prevent critical part shortages
Design for Manufacturing
Devices are designed with manufacturing constraints in mind to avoid iterations in later project stages and optimize time to market
Design for Assembly
Implementation of required manufacturing and assembly processes, including operator training
Design for Testing
Devices are designed so that the testing of critical functions is possible at any stage, from feasibility to end product
Process Engineering
Full collaboration with the Industrialization and Manufacturing teams to develop lean sub-assembly steps for cost and time reduction
Regulatory Compliance
Devices are designed in compliance with the relevant medical device regulations
VALTRONIC



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◆ 3.3 Product Life Cycle – Definition, Importance, Stages, Examples (Motorcycle, Electric Vehicle)

Definition :-

The Product Life Cycle (PLC) is a concept in marketing and product management which describes the journey of a product from its introduction into the market, through growth, maturity, and eventual decline and discontinuation. Shopify+1 It acknowledges that products do not remain in one stage forever; their sales, market share, profitability and competitive environment change over time. The PLC helps organisations plan strategies, allocate resources, manage product-portfolio and take timely decisions on product updates, diversification or withdrawal. Inflibnet Ebooks

Explanation :-

1. Introduction stage: The product is launched into the market; sales are low, costs are high (due to R&D, marketing, launch), profits are minimal or negative. Shopify+1

2. Growth stage: Demand increases rapidly, sales rise, profits increase; competitors may enter; marketing is focused on differentiation and scaling. MasterClass+1
3. Maturity stage: Market becomes saturated, growth slows, competition is intense, prices may fall, profits start declining or stabilising at lower levels. Economics Discussion+1
4. Decline stage: Sales and profits decline due to changing consumer preferences, technology obsolescence or stronger substitutes; decision needs to be taken about discontinuation or refresh. Your Article Library+1
5. Some models include a Development stage before introduction (where product is being created) and sometimes a Saturation stage distinct from maturity. Salesforce
6. The duration of each stage varies widely with product type (durables may have long maturity periods, tech products may cycle quickly). rcet.org.in
7. The PLC concept is important because it helps firms anticipate changes in product demand, plan marketing, production, upgrades and phase-out strategies. gemanalyst.com
8. Firms can extend the life of a product (maturity stage) via modifications, new markets, cost reduction, repositioning. Economics Discussion
9. Understanding PLC helps in resource allocation: high investment in introduction/growth, maintenance in maturity, minimal in decline. Simplilearn.com
10. Example: A motorcycle model may go through introduction (launch new model), growth (rapid uptake), maturity (many similar models exist, competition), decline (EVs replace conventional bikes) – likewise an electric vehicle may currently be in growth stage, eventually moving to maturity as market saturates.

Applications :-

- Automotive & motorcycle industry: planning when to refresh models, introduce new technology, reduce cost in maturity.
- Consumer electronics: managing upgrade cycle, deciding when to discontinue older versions.

- Durable goods/appliances: managing replacement market, spare parts, after-sales as product moves into maturity/decline.
- Service offerings (e.g., software products) follow PLC – know when to pivot, update features.
- Portfolio management: balancing products at different PLC stages to maintain company growth and profitability.

✅ Advantages :-

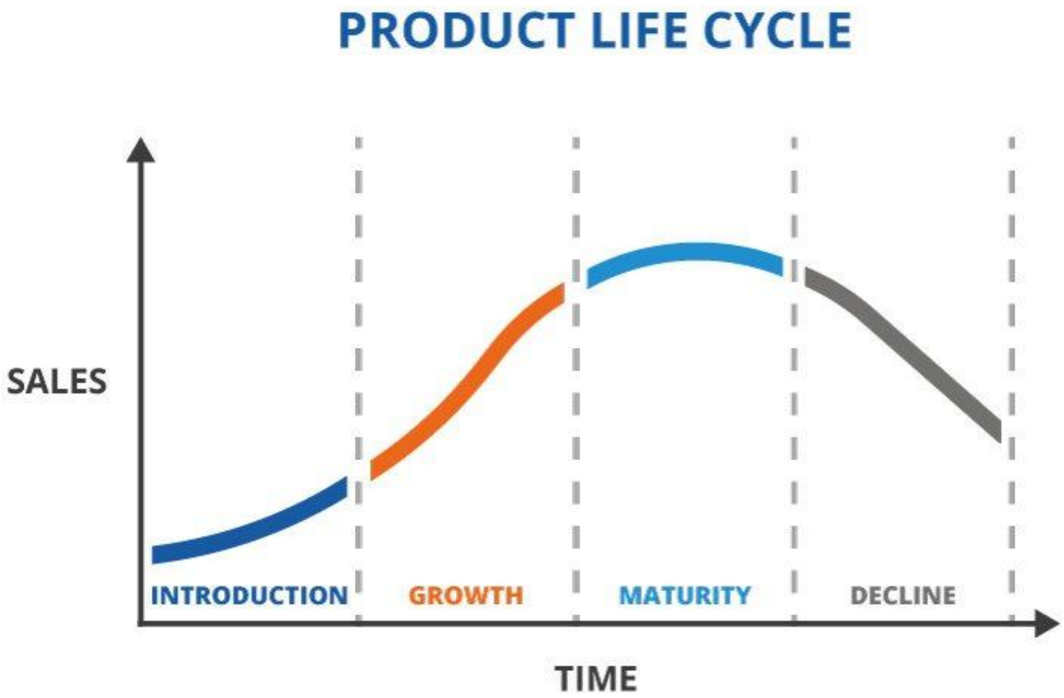
1. Helps companies predict and prepare for changes in sales volume, profitability and competition across the product's life.
2. Enables strategic planning for product updates, cost control, investment timing, marketing emphasis.
3. Supports market-strategy decisions like when to reduce price, when to improve features, when to withdraw.
4. Helps in allocation of resources – e.g., more marketing investment in growth, less in decline.
5. A useful framework to manage product portfolio for sustainable business growth.

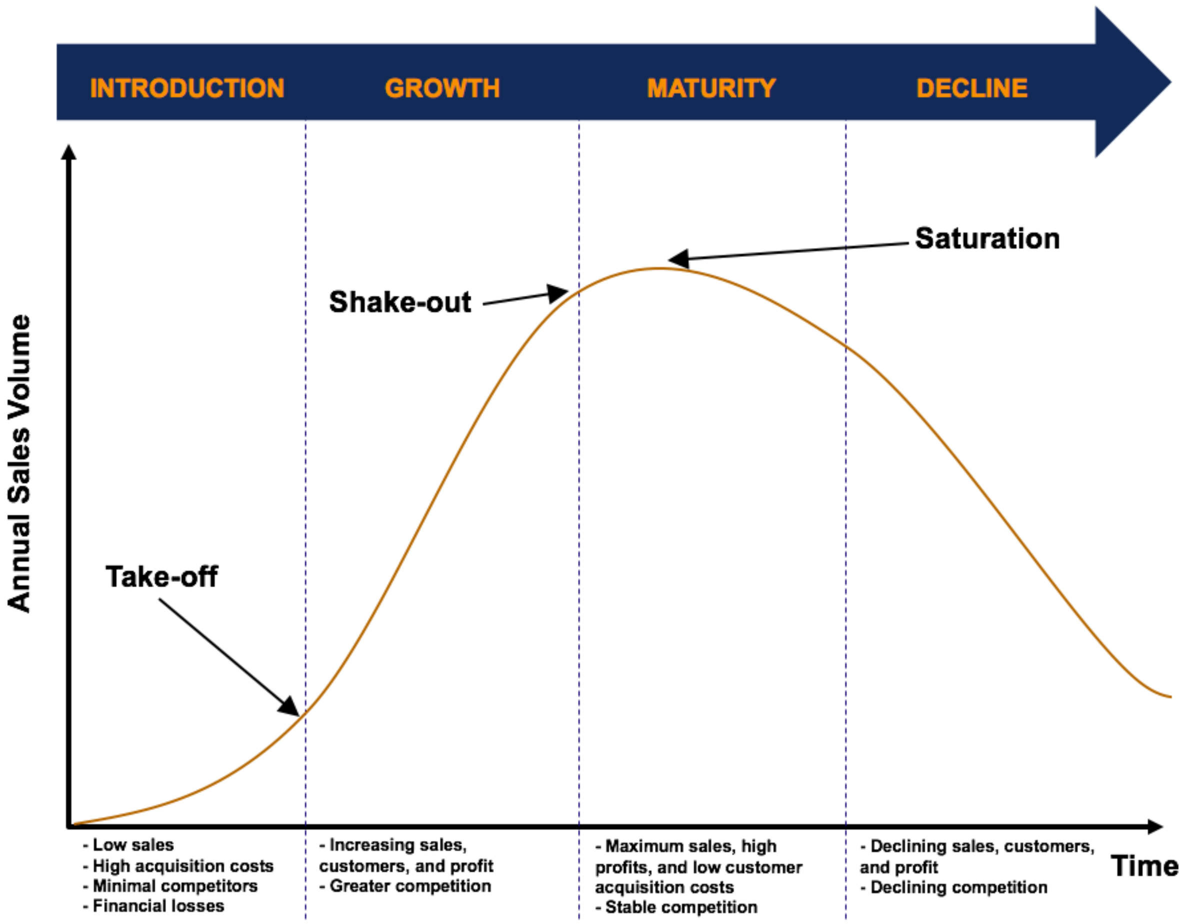
❌ Disadvantages :-

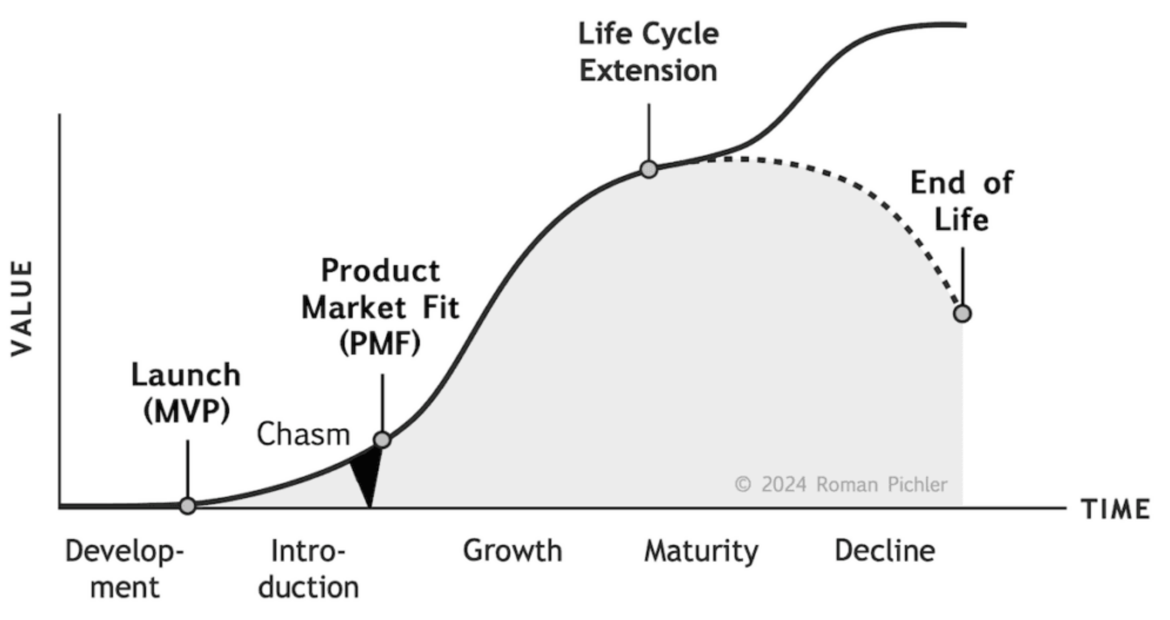
1. The PLC model is a generic template—actual products may not follow the ideal curve or may skip stages. Your Article Library+1
2. It can be difficult to precisely determine which stage a product is in.
3. Over-reliance may lead to wrong decisions (e.g., prematurely withdrawing a product still with potential).
4. Doesn't always account for external disruptions (technology jump, market shocks) which may radically change the lifecycle.
5. Emphasis on stage may cause firms to ignore innovation or emerging opportunities, thinking just of defence in maturity/decline.

🗣️ Summary

Har product ka ek life cycle hota hai — pehle market me aata hai (introduction), phir grow karta hai (growth), fir ek point pe settle ho jata hai (maturity), aur akhir me demand kam hone lagti hai (decline). Agar hum is lifecycle ko samajh lein to product strategy, cost management, production planning aur marketing sab time pe kar sakte hain.


PRODUCT LIFE CYCLE
SALES
INTRODUCTION
GROWTH
MATURITY
DECLINE
TIME


INTRODUCTION
GROWTH
MATURITY
DECLINE
Saturation
Shake-out
Annual Sales Volume
Take-off
- Low sales
- High acquisition costs
- Minimal competitors
- Financial losses
- Increasing sales, customers, and profit
- Greater competition
- Maximum sales, high profits, and low customer acquisition costs
- Stable competition
- Declining sales, customers, and profit
- Declining competition
Time


Life Cycle Extension
End of Life
VALUE
Product Market Fit (PMF)
Launch (MVP)
Chasm
© 2024 Roman Pichler
TIME
Develop- ment
Intro- duction
Growth
Maturity
Decline

6

📌 Examples for Product Life Cycle

- For a motorcycle model: When a new model is launched (introduction), it gains traction (growth), then many competitors and similar models appear (maturity), eventually demand falls as newer models or EVs come in (decline).
- For an electric vehicle (EV): Many EV models are currently in growth stage—sales increasing rapidly, many new entrants. Eventually when adoption saturates and competition is high, maturity will follow and then eventual decline as new mobility solutions may replace EVs.

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