

## Digital Twin

Definition: A digital twin is a virtual representation of a real world asset.

→ created using real time data from IOT and sensors

Key functions:

1) real time monitoring: continuous monitoring, helps in detecting failures → optimize production

2) predictive maintenance → predict failures by using real time data and help schedule maintenance to prevent any down time

3) simulation: digital twins can help simulate different manufacturing scenarios without having to physically alterate.

4) Remote assistance: experts can use digital twins to analyse and visualise ~~and~~ for troubleshooting and offer remote training

5) continuous improvement → can be used to continuously improve the product keeping the customer reviews and real time data in check.



## Virtual Factory

Definition: A virtual factory is a computer generated simulated of a real world manufacturing facility  
↳ includes machines, work flows and human interactions in a digital environment

Key features:

- 1) Simulation and modelling: Allows manufacturers to visualise and ~~dig~~ analyse processes digitally in order to find bottlenecks and optimise workflows without physical prototypes.
- 2) process optimization.
- 2) Training: Operators can practice using machinery and upskilling without risking equipment
- 3) Virtual Commissioning: Simulates the integration of new machinery into the production line without disrupting the workflow
- 4) predictive analysis: virtual factories can analyse real time data and anticipate potential issues.
- 5) collaboration: Stakeholders can interact with virtual models to make data-driven decisions collaboratively.



## Virtual Factory Software

- Anylogic → versatile simulation used in industries such as manufacturing, healthcare etc.  
It supports multiple modelling methods.
- Arena → A discrete-event simulation tool  
commonly used in manufacturing and supply chain analysis
- FlexSim → A 3D simulation software in visualizing manufacturing and logistic processes.

etc

## Limitations of Virtual Factory Software

- Customization: Virtual Factory models must be highly customised to ~~factory~~ reflect real factory conditions.
- Cost: Developing and implementing virtual factories can be expensive.
- Real time data: Accurate simulations require real time data collection
- Data Analytics Integration: most softwares can model process  
↓  
A few have advanced analytics  
↓  
need additional tools like  
'Artificial Neural Networks'



## Total Productive Maintenance (TPM)

Definition → TPM is a maintenance strategy that maximises the efficiency and the effectiveness of the machinery by involving all employees in proactive and preventative maintenance.

### Key Benefits:

- increased Reliability → Reduces equipment breakdowns through preventative maintenance
- Enhanced product quality → minimises defects → more consistent quality
- improved efficiency → optimises machine performance → Reduces downtime
- Cultural transformation → TPM fosters a sense of ~~ownership~~ ownership among employees.  
↳ promotes continuous improvement

### challenges:

- High initial Effort → requires significant commitment, training etc.  
↳ resource intensive
- Resistance to change → Employees may be against to adopting new processes./practices.



Applications → used in industries :

- automotive
- electronics
- food / beverage
- pharmaceuticals

### Understanding Industry 4.0 in MSME's

↳ micro, small, medium enterprises.

- **Technology Adoption** : MSME might face challenges in adopting industry 4.0 technologies due to financial problems.
- **Enhanced connectivity** : will help MSME establish interconnectivity between machines and processes → allows real-time data collection
- **Data-Driven Decisions** : MSME's can analyse the data collected and identify areas for improving, cost cutting, predictive maintenance and customer satisfaction etc leading to better decision making helping the future.
- **Customization and flexibility** : advanced technologies will help MSME's to respond quickly to changing market demands  
↳ flexibility.



## Industry 5.0

Definition: • builds on industry 4.0

- emphasising on ~~data~~ human collaboration  
↳ with advanced technologies  
↳ human centered manufacturing  
↳ workers collaborate with machines to enhance creativity and problem solving.

key features:

- Human centered manufacturing: workers + automation → augment their skills
- Collaborative Robotics (robots) →
  - ↳ work alongside humans
  - share tasks, increase efficiency and accuracy.
- Customization and personalisation → human creativity + technology → highly customised products
- Sustainability → aims to promote
  - ↳ sustainable manufacturing + social responsibility.