Automation and Advanced Manufacturing

Department of Mechanical and Industrial Engineering

Automation

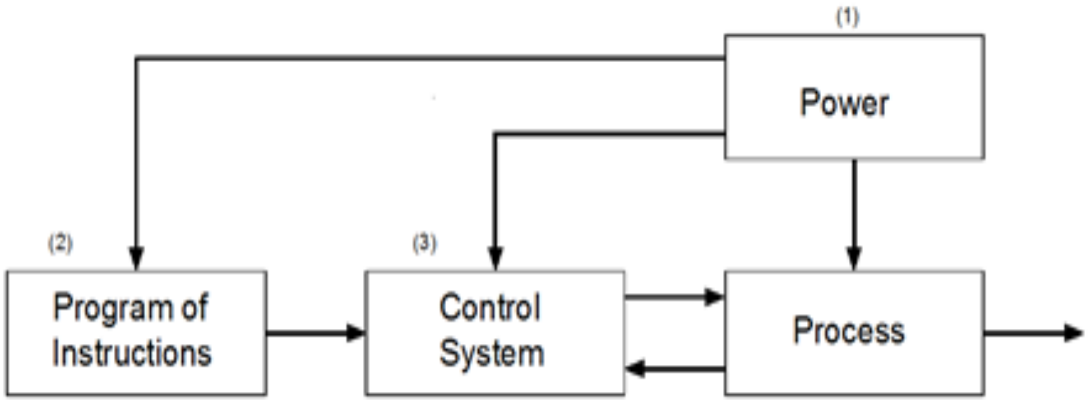
- Automation can be defined as a technology concerned with the application of mechanical, electronic, and computer based systems to operate and control production.

Automation

This technology includes

- Automatic machine tools to process parts
- Automatic assembly machines
- Industrial robots
- Automatic material handling and storage systems
- Automatic inspection systems for quality control
- Feedback control and computer process control
- Computer systems for planning, data collection, and decision making to support manufacturing activities

Automation - Components



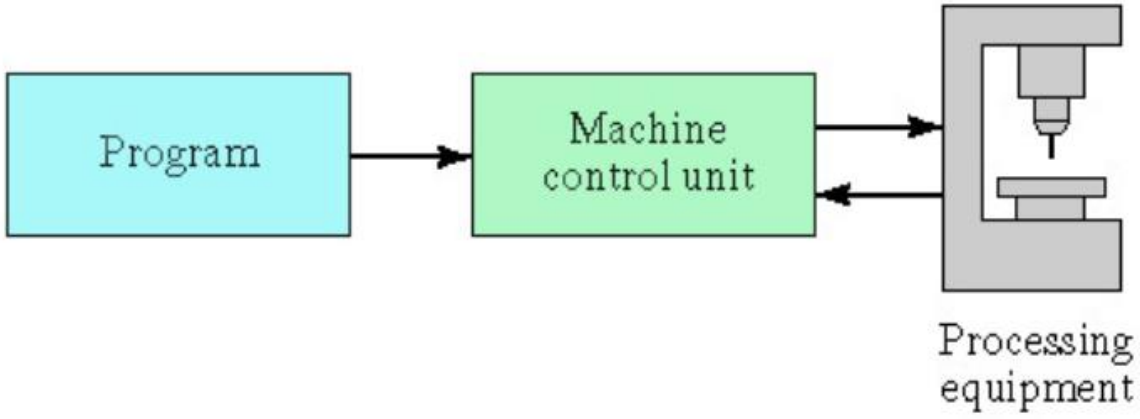
Elements of an Automated System

Automation - Reasons

- To increase labour productivity.
- To reduce labour cost.
- To mitigate the effects of labour shortages.
- To reduce or eliminate routine manual and clerical tasks.
- To improve worker safety.
- To improve product quality.
- To reduce manufacturing lead time.
- To accomplish processes that cannot be done manually.

Numerical Control

- It is a form of programmable automation, in which the process is controlled by numbers, letters and symbols.
- Components of NC machines



Numerical Control

Program:

- Detailed step-by-step commands that directs the processing equipment.
- Commands refer to positions of a machine tool spindle with respect to the worktable on which part is fixture.
- Instructions include spindle speeds, cutting tools, feed rate, etc.
- The program is coded on a suitable medium for submission to the machine control unit.

Numerical Control

Machine Control Unit:

Consists of the electronics and control hardware that read and interpret the program of instruction and convert it into mechanical actions of the machine tool or other processing equipment

Numerical Control

Processing equipment

- Is a component that performs useful work (NC Machine).
- The processing equipment consists of the work-table and spindle as well as motors and controls needed to drive them.

Problems associated with conventional NC

1. Part Programming Mistakes

- Mistakes can be either syntax or numerical errors, and needs three or more passes before the NC tape is correct.
- Achieving optimum sequence of processing steps is another problem especially with manual part programming

Problems associated with conventional NC

2. Punched Tape

- Paper tape is fragile and is susceptibility to wear and tear making it an unreliable NC component for repeated use on the shop floor.
- Durable tape materials like Mylar and aluminium help overcome this problem but are expensive.

Problems associated with conventional NC

3. Tape Reader

- Tape reader is known to be the least reliable hardware components of the machine.
- When a breakdown occurs on a NC machine, the maintenance personnel usually begin their search for the problem with tape reader.

Problems associated with conventional NC

4. Controller

- The conventional NC controller unit is hard-wired.
- This means that its control features cannot be easily altered to incorporate improvements into the unit.

Problems associated with conventional NC

5. Management information

- The conventional NC system cannot provide timely information on operational performance to management.
- Information may include piece counts, machine breakdowns and tool changes

Problems associated with conventional NC

6. Non-optimal speeds and feeds

- The function of conventional NC is to control the position of the tool relative to the work.
- There is no attempt to optimize the speeds and feeds during machining process.
- The part programmer must plan the cutting conditions conservatively which reduces productivity.

CNC Machine

CNC Machine

- Computer Numerical Control machine (CNC machine) is an NC system using a dedicated microcomputer as the machine control unit.
- The large hard-wired MCUs of conventional NC have been replaced by control units based on digital computer.

Features of CNC Control System

1. Programming and operating features

- More than one program can be stored
- Multiple program entry options
- Program editing at machine site
- Offset adjustment for tool radius and length is easy
- Adaptive control
- Re-computation of axis position

Features of CNC Control System

- Use of canned cycle – built in routines which move the tool in predefined way, thereby reducing the length of the program.

2. Machine Tool Control

- Linear Interpolation
- Circular Interpolation
- Helical Interpolation

Features of CNC Control System

3. Diagnostic feature

- Control start up diagnostics
- Malfunction and failure analysis
- Tool life monitoring
- Preventive maintenance notice
- Programming diagnostics

Advantages of CNC machines

- Reduced non-productive time
- Simplified fixture
- Reduced manufacturing lead time
- Greater manufacturing flexibility
- CNC adapts better to changes in jobs and production schedules.
- Improved quality control – due to less rejections and lesser inspection

Advantages of CNC machines

- Complex geometries are possible
- Engineering changes can be easily accommodated
- Less floor space requirement

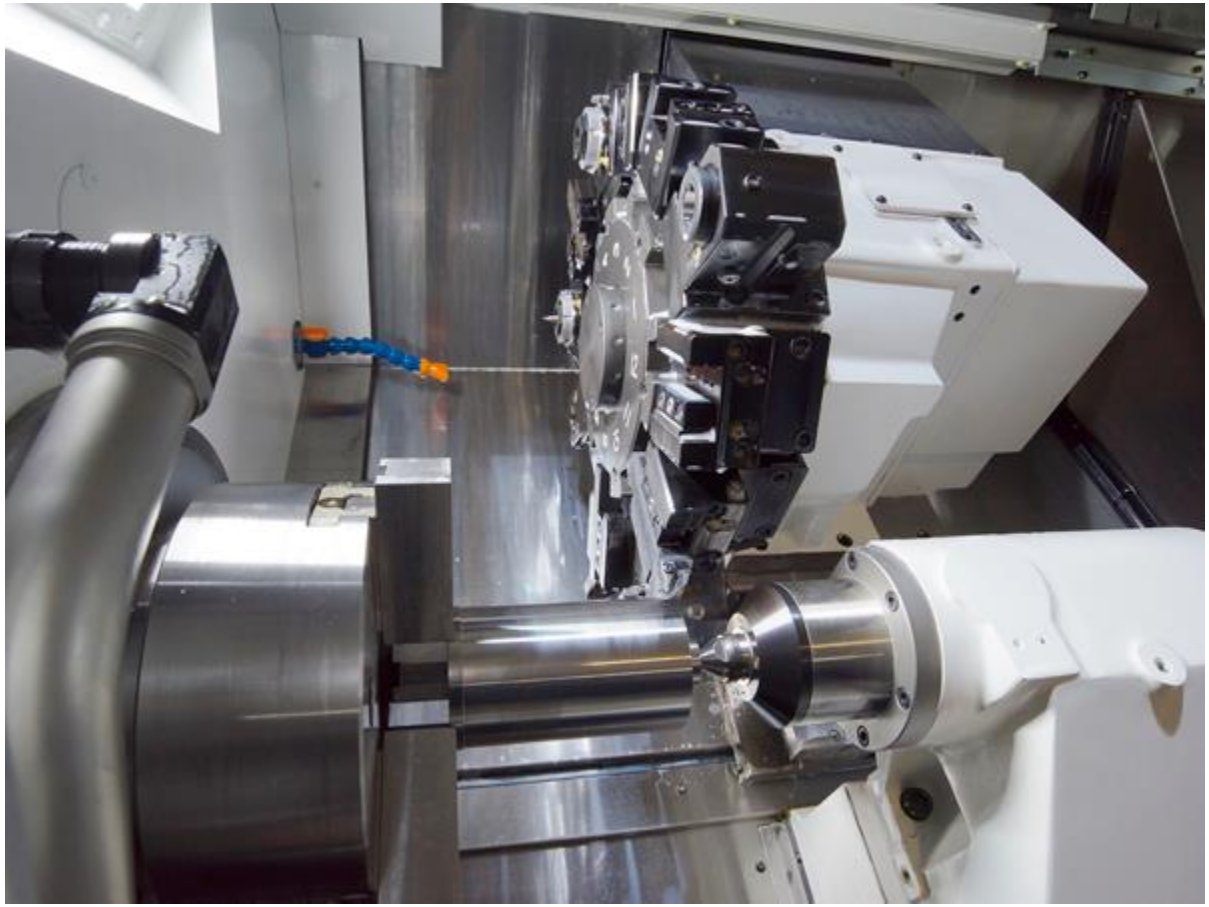
Disadvantages of CNC machines

- Higher initial investment
- Higher maintenance cost
- Skilled programmers are needed

CNC Machines

CNC Turning Centre

CNC Machines



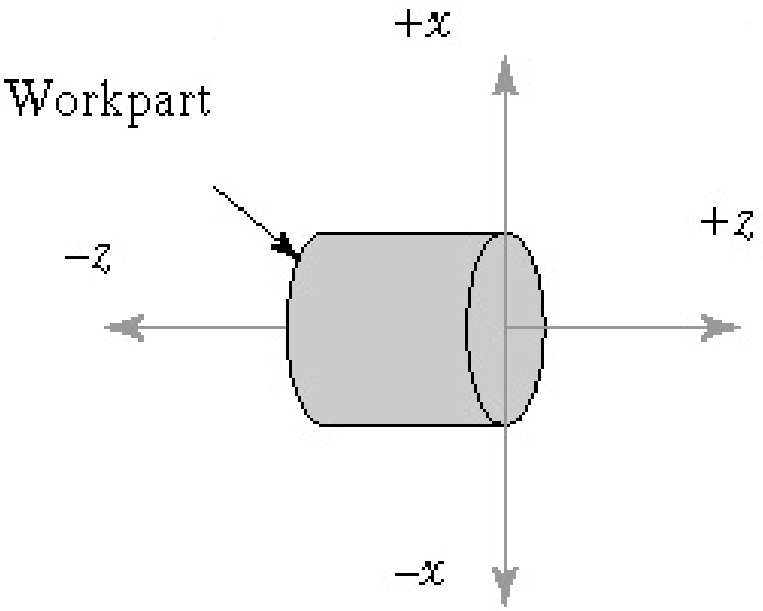
CNC Turning Centre

CNC Machines

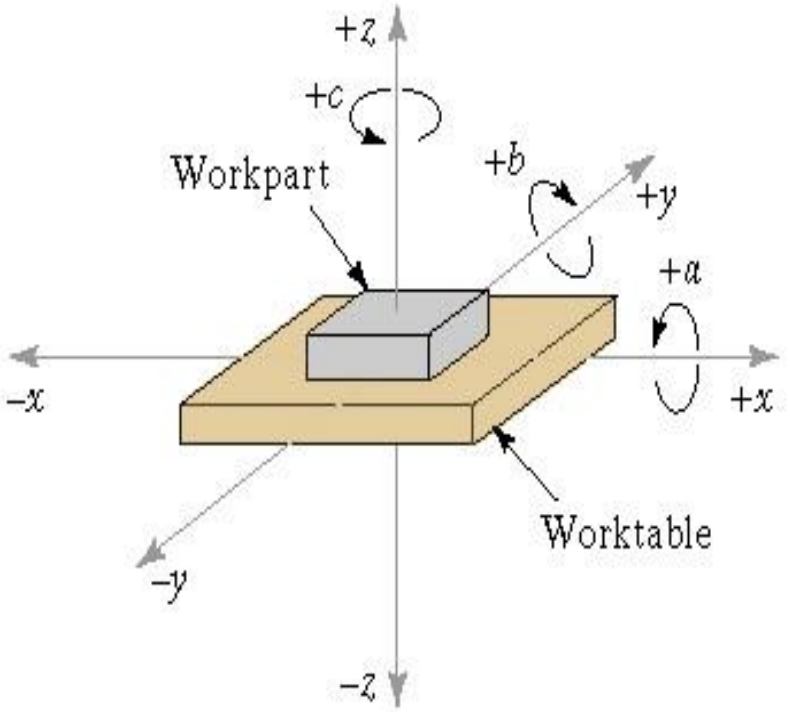
CNC Machining Centre

CNC Machines

Coordinate system



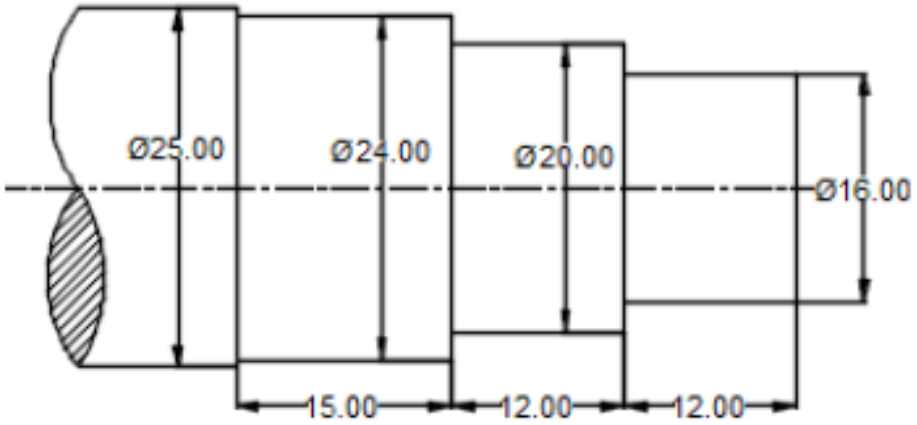
CNC Turning Centre



CNC Machining Centre

Sample Program – Turning centre

```
O0001
G95 G28 U0 W0
T0101
M3 S1500
G0 M7 X27 Z2
G79 X-2 Z0.5 F0.1
Z0
G0 X25 Z2
G77 X24.2 Z-39 F0.1
X23 Z-24
X22
X21
X20.2
X19 Z-12
X18
X17
X16.2
G0 X16
```




```
G1 Z-12
X20
Z-24
X24
Z-39
X25
G28 U0 W0
M5 M9
```

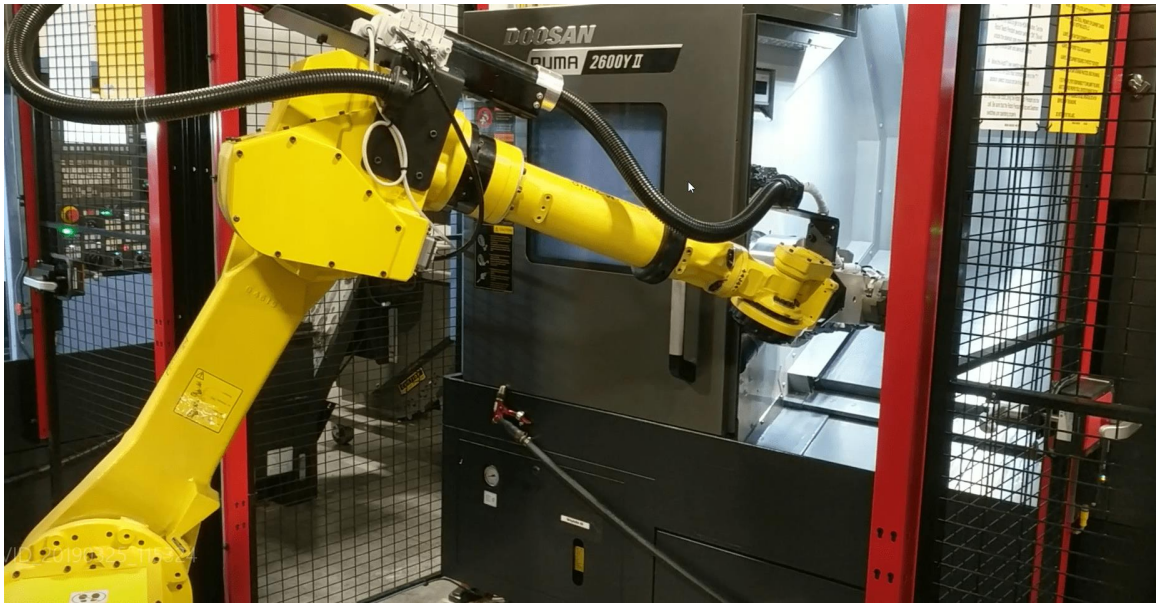
Robotics

- An industrial robot is a general purpose, programmable machine which processes certain anthropomorphic characteristics.
- The robot can be programmed to perform some useful task. It will repeat that motion pattern again and again until reprogrammed to perform some other task.
- Hence robot can be used for a variety of different industrial operations.

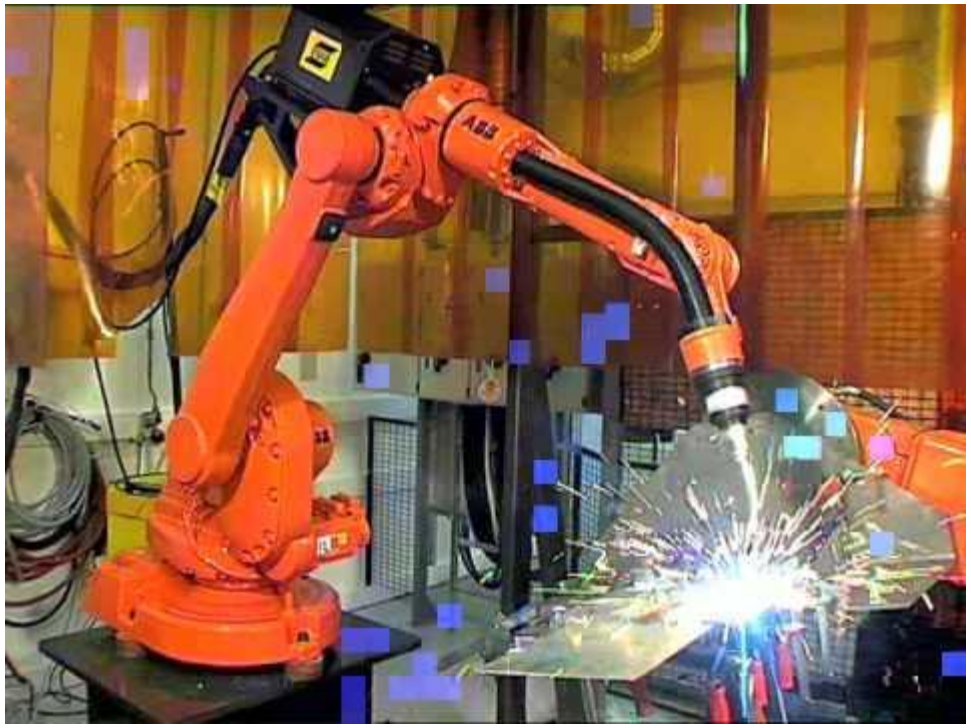
Application of Robots

- Material transfer and handling
- Machine loading and unloading
- Welding
- Spray coating
- Processing operations
- Assembly
- Inspection

Material transfer and handling



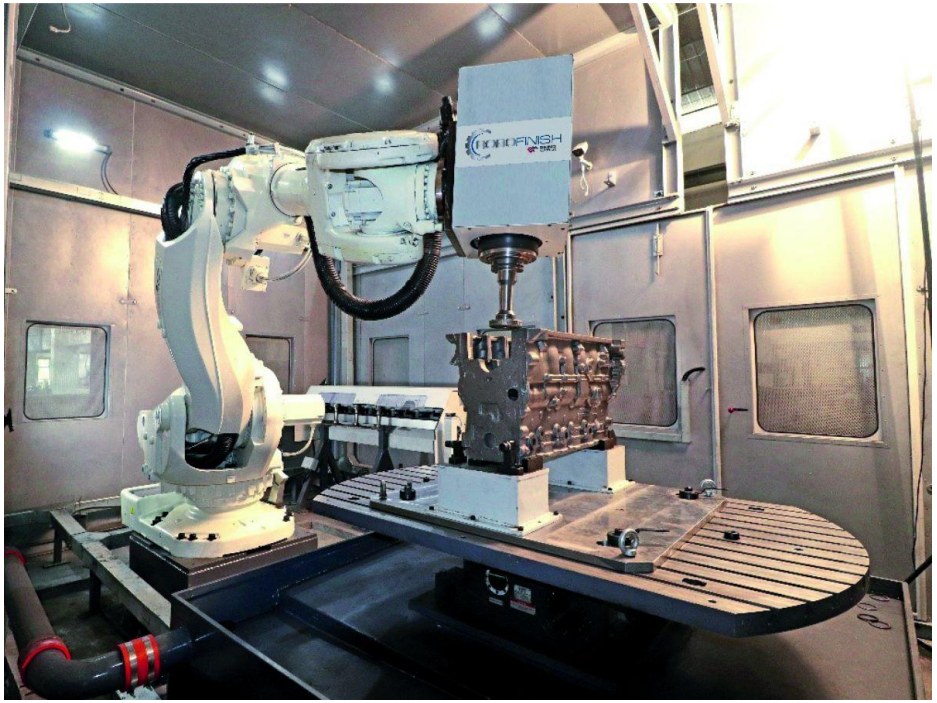
Machine loading and unloading



Robotic Welding

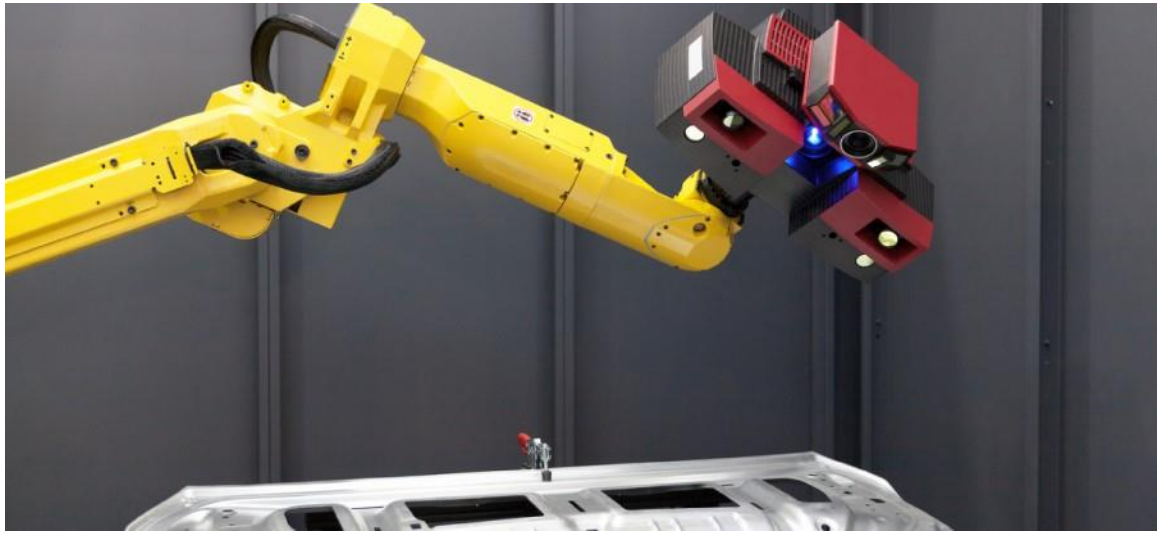
Spray painting

Robots for carrying out machining operations



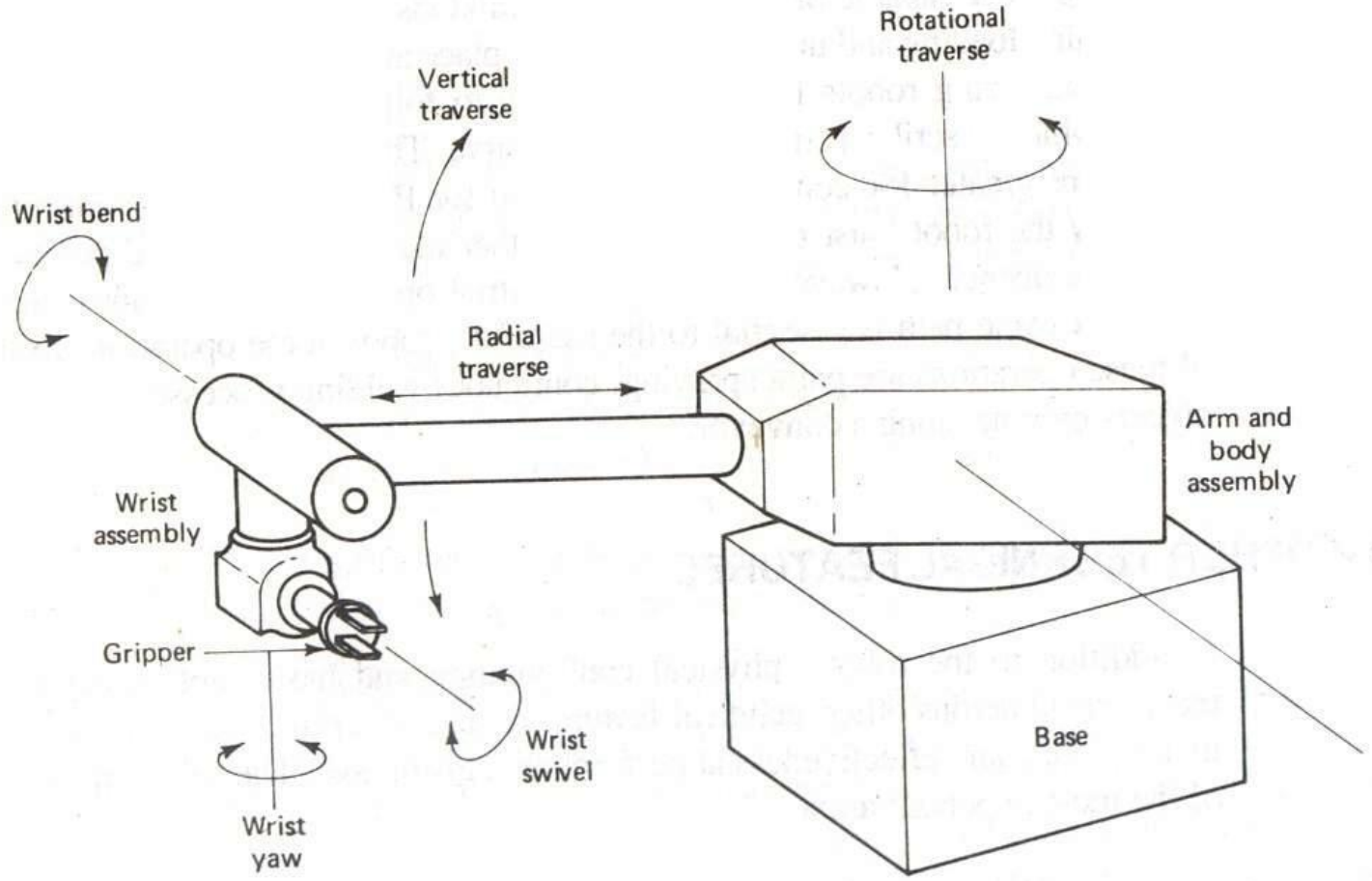
Robots for carrying out machining operations

Robots for carrying out assembly



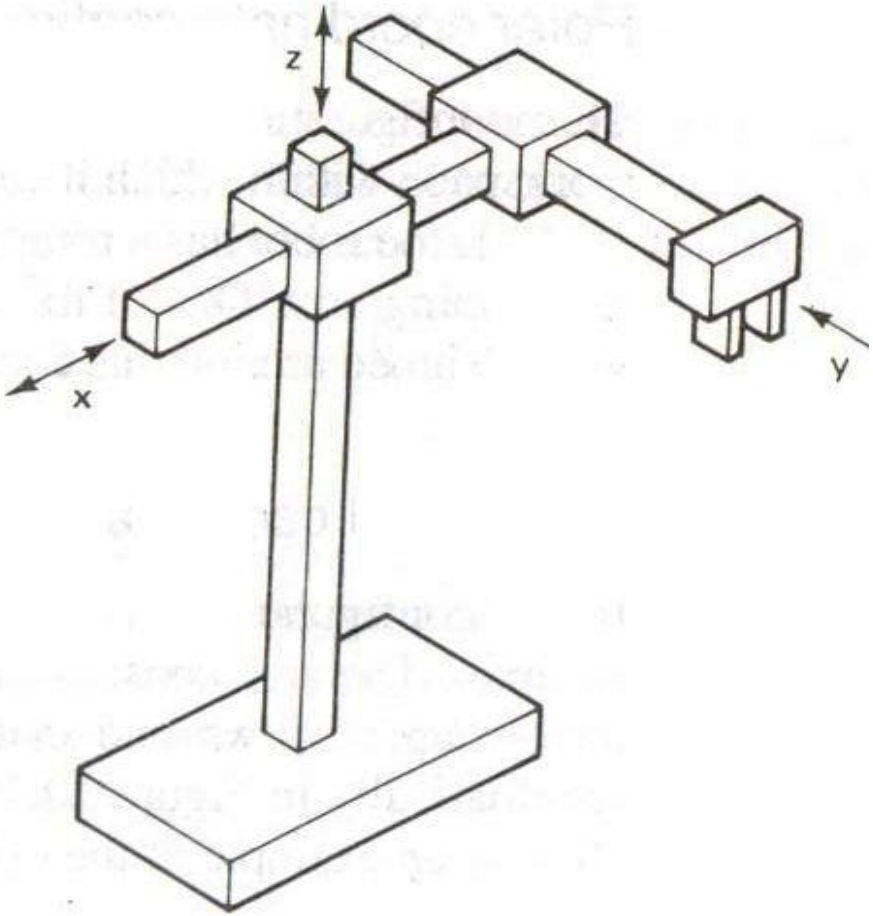
Robots for carrying out inspection

Degrees of freedom

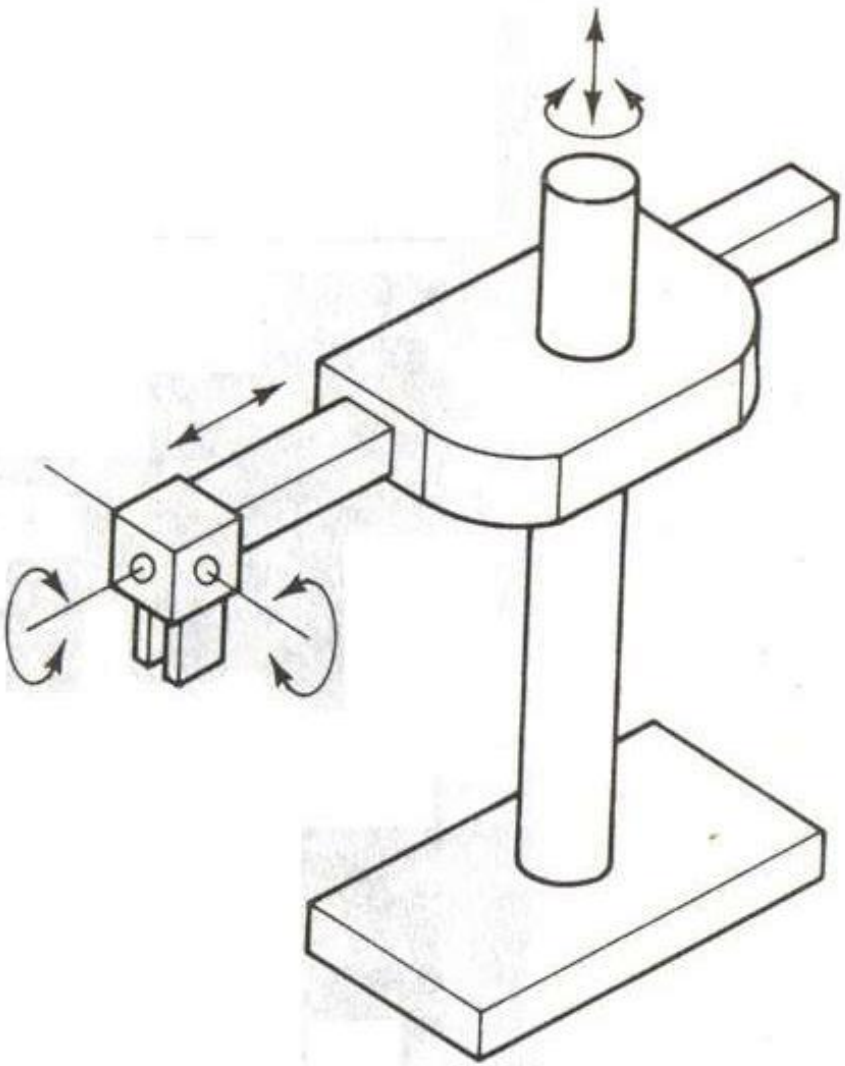


Typical six degrees of freedom in robot motion.

Configurations

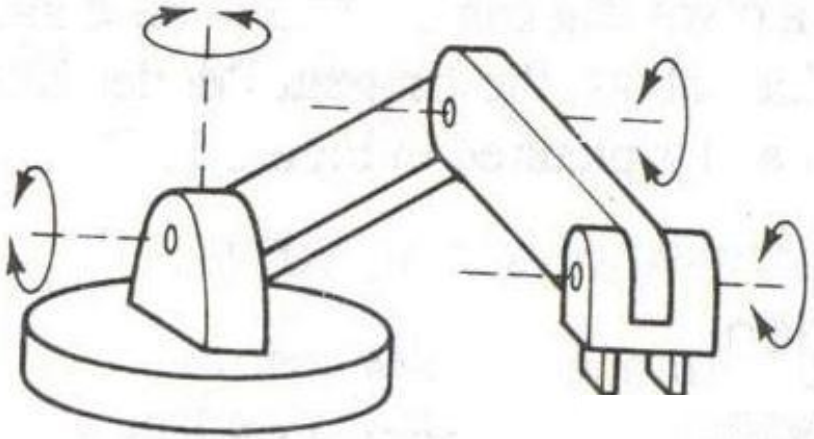


Cartesian

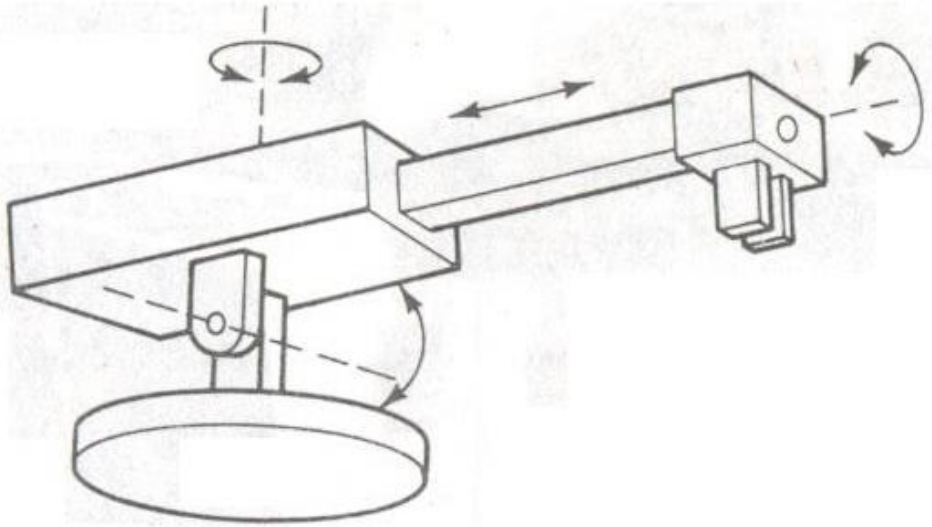


Cylindrical

Configurations



Jointed arm



Spherical/ Polar

Additive Manufacturing

- Additive manufacturing is the formalized term for what used to be called rapid prototyping and what is popularly called 3D Printing.
- Referred to in short as AM, the basic principle of this technology is that a model, initially generated using a three-dimensional Computer-Aided Design (3D CAD) system, can be fabricated directly without the need for process planning.

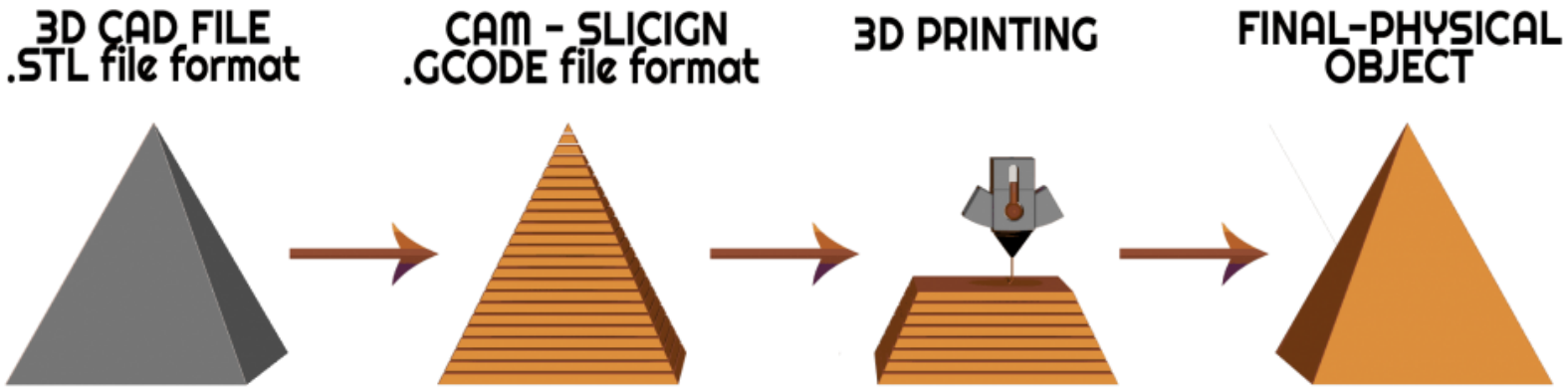
Additive Manufacturing

- Other manufacturing processes require a careful and detailed analysis of the part geometry to determine things like the order in which different features can be fabricated, what tools and processes must be used, and what additional fixtures may be required to complete the part.
- In contrast, AM needs only some basic dimensional details and a small amount of understanding as to how the AM machine works and the materials that are used to build the part.

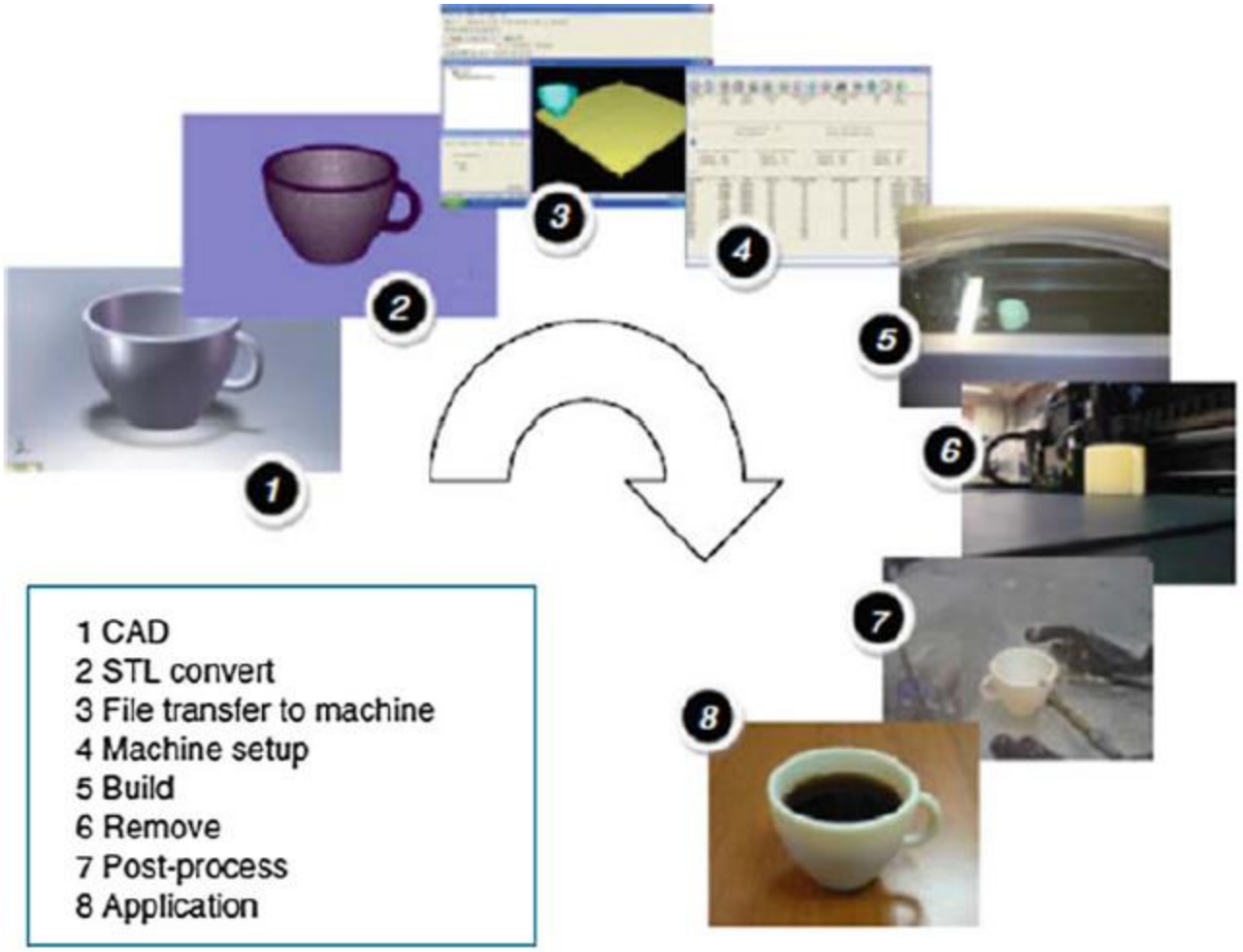
Additive Manufacturing

- The key to how AM works is that parts are made by adding material in layers; each layer is a thin cross-section of the part derived from the original CAD data.
- All commercialized AM machines to date use a layer-based approach, and the major ways that they differ are in the materials that can be used, how the layers are created, and how the layers are bonded to each other.
- Such differences will determine factors like the accuracy of the final part plus its material properties and mechanical properties.

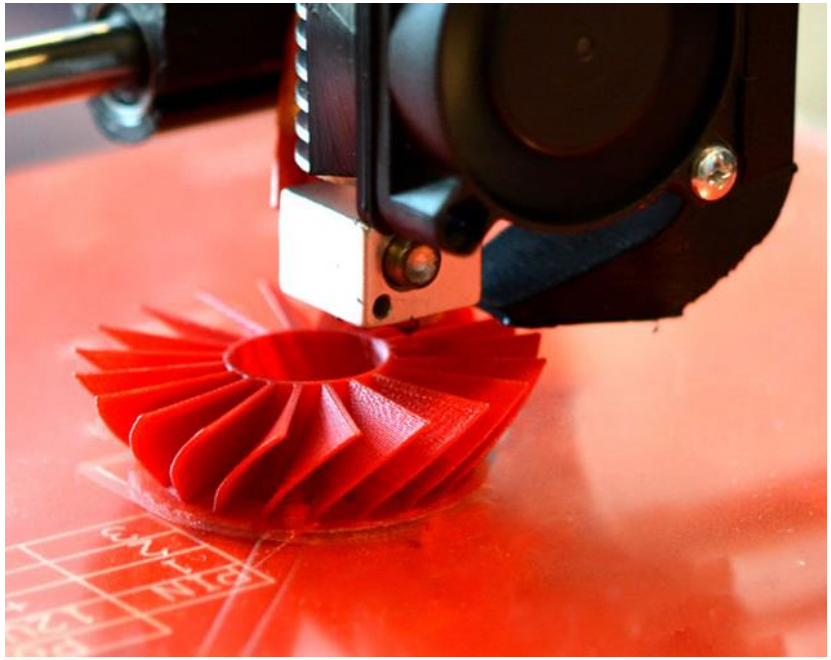
Principle of AM

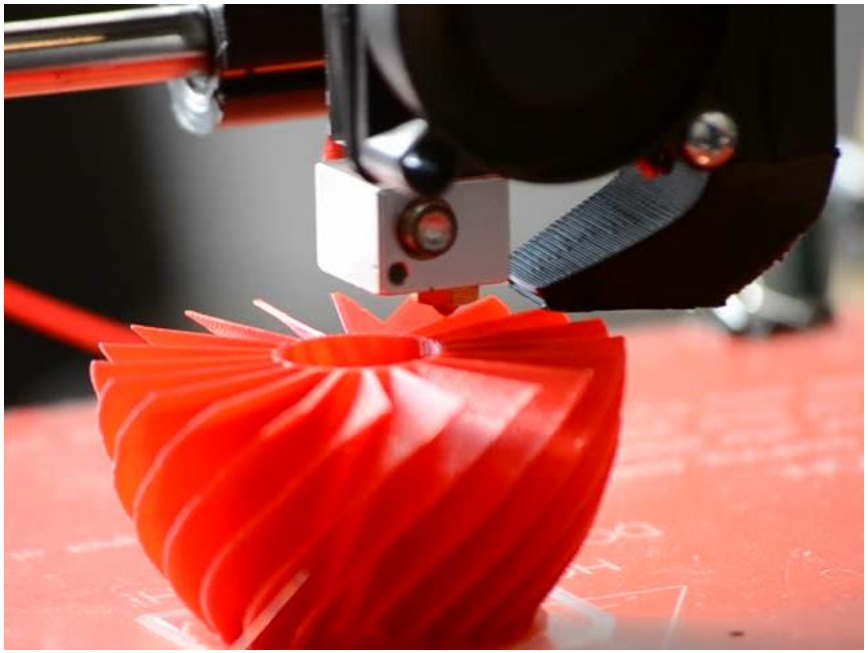


Steps involved in AM

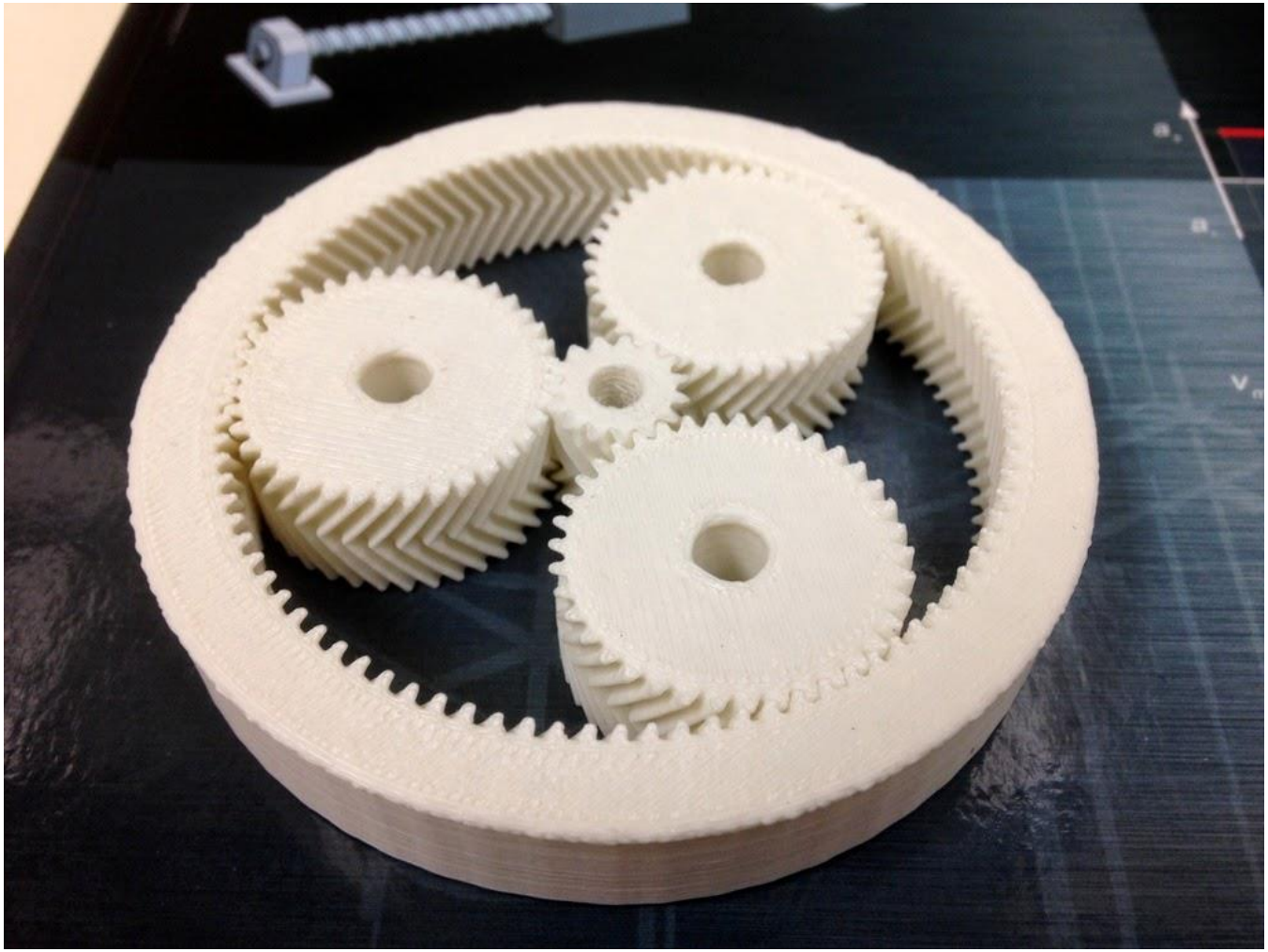


Additive manufacturing

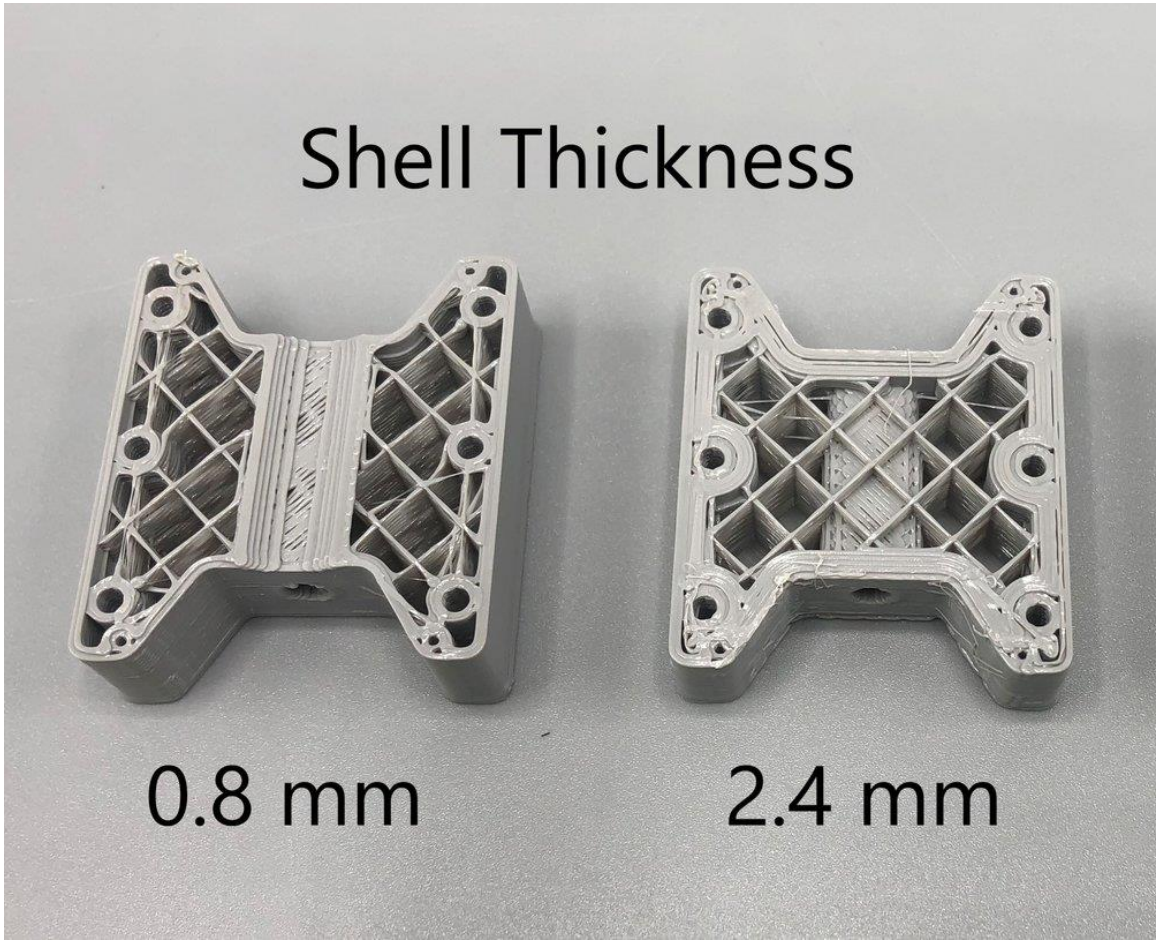




Additive manufacturing



Additive manufacturing



Additive manufacturing