

ME 338: Manufacturing Processes II

Course Project End-Term Review

Topic: Manufacturing Process of a Clock

Sidharth Mundhra (190110091)
Om Prabhu (19D170018)
Gopalan Iyengar (19D170009)

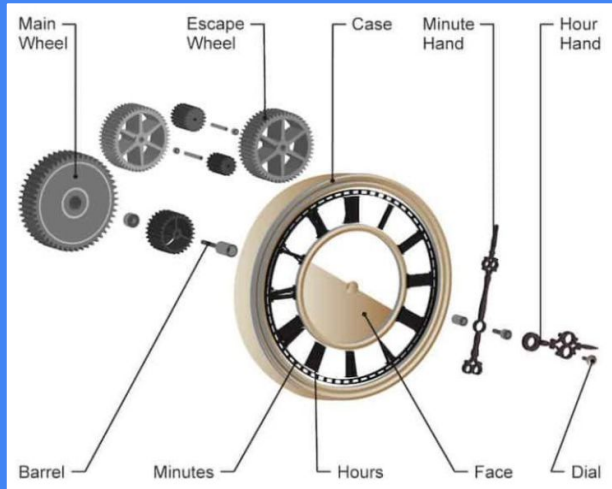


Description & Applications



- Used for measuring time, which is integral for day-to-day time management, alarms, timers, etc
- Historically used as sundials, based on the movement of the sun which results in movement of the casted shadow
- Analog clocks often seen in households, digital clocks used mainly in computers, mobile phones, alarm clocks, etc
- Analog clocks use a gear mechanism to rotate the hands of the clock periodically
- Digital clocks are based on the resonance of a carefully manufactured quartz crystal to alternate direction of current in an AC circuit

Design & Components

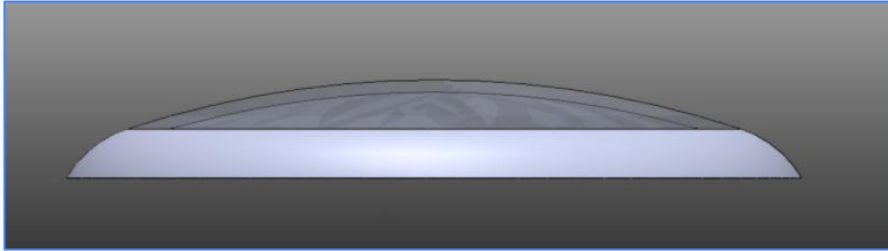


- Analog clock uses hours, minutes and seconds hands to convey information about time (see diagram alongside)
- Digital clocks use 7-segment LED displays to display time
- Nature of components depends on type of clock:
 - Outer casing: all types of clocks
 - Face: wall clocks, wristwatches
 - Arms: wall clocks, wristwatches
 - Gears: wall clocks, wristwatches
 - Mainspring: wall clocks, wristwatches
 - Pendulum: pendulum-based wall clocks
 - LED display: digital alarm clocks, smartphones, smartwatches, etc
 - Quartz crystal: electronic quartz clocks

Design & Components



Design & Components

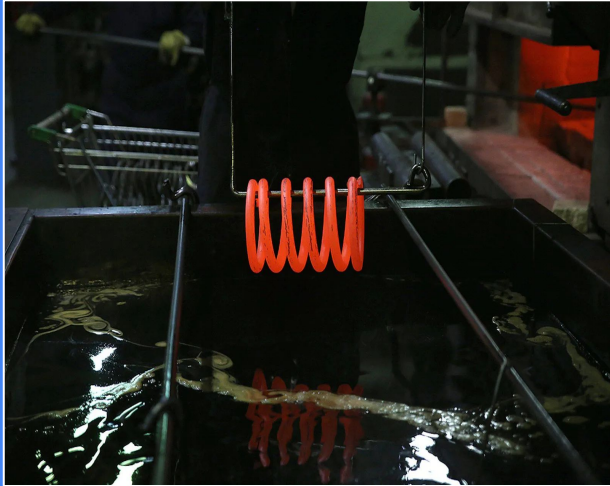


Manufacturing

- Clocks are usually made of four major classes of materials.
- Each has a different style of manufacturing, with varying processes used for separate components.
- Electronic parts like ICs and PCBs are custom-built to commercial standards.

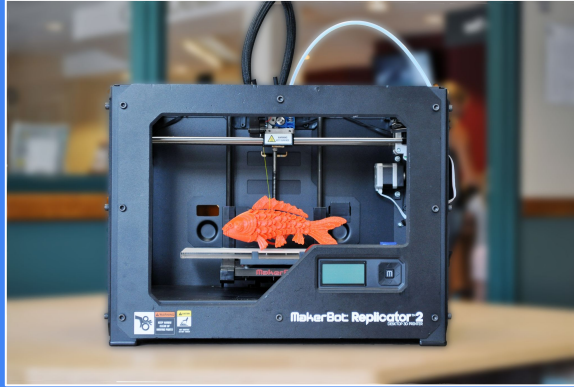
<u>MATERIAL</u>	<u>GENERAL CASES</u>		<u>SPECIAL CASES</u>	
	<u>Components</u>	<u>Processes</u>	<u>Components</u>	<u>Processes</u>
<u>Metal</u>	Frame, face, gears	Casting, then machining	Spring, clock arms	Winding, pressing
<u>Wood</u>	Frame, face and pendulum	Precision cutting, engraving	Smaller parts, clock arms	Manual carving
<u>Plastic</u>	Most parts	Casting (thermosetting polymers)	-	-
<u>Glass</u>	Face cover	Precision cutting	Full glass-body clock	Hot glass blowing

Materials & Process Selection



- Case: Largest part, bulk manufacture using shaping/milling. Finishing in the form of electroplating or painting required
- Face: Due to brittle nature of materials used, low speed machining (shaping/milling) is done
- Arms: Smaller and thin, so can be bent easily. To avoid this, pressing is used, followed by punching
- Digital Display: Integrated circuit is manufactured by squeezing semiconductor wafers under high pressure
- Mainspring: 5-step process involving winding, quenching, strengthening, setting and coating
- Gears: Hobbing is used to produce external gear teeth. Quenching is also done to relieve stresses
- Quartz Crystal: Artificially grown, then subjected to laser cutting to make extremely thin plates, followed by chemical treatment.

Machines & Equipment



- 3D Printer: Used to obtain a prototype of the clock to get a sense of the tactile qualities and proportions of the watch
- Vacuum Chamber: Needed during growth of Quartz Crystal
- Press Machine: Used to place the hands quickly and accurately. Specific and expensive, but precise

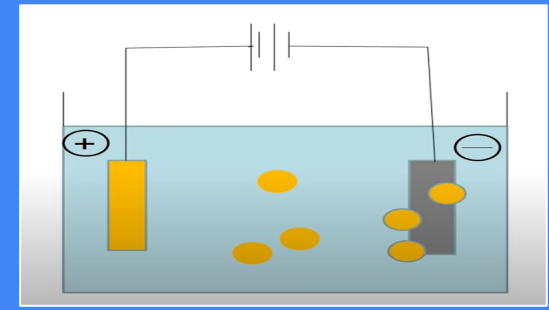
Machines & Equipment



- CNC Machine: Workpiece head moves to given set of coordinates. Used widely for cutting of shapes from sheets
- Spring Vibration Tool: Used to determine active length
- Polishing Wheel: Used for polishing lever, which is the only point of contact between balance and rest of the watch
- Polishing sticks: Sticks made from the woody stem of the yellow gentian are used for polishing flanks and bevels



Finishing & Coating



<u>WOOD</u>	Sanding	Surface grinding for smooth finish
	Varnishing	Aesthetic coating of glossy liquid material after sanding
<u>METAL</u>	Electroplating	Wear & corrosion resistance, and adds visual appeal
	Filling	Cavities left in base metal are filled by secondary metal, increasing strength
	Physical Vapour Deposition	Great surface finish
	Diamond Like Coating	Surface attains diamond-like properties

Assembly and Inspection

- **Part Inspection:**
 - Pre-assembly quality check to filter out potentially faulty components
 - Usually manually conducted, since mechanized quality checks can often lead to false positives
 - Random X-Ray/ultrasound checks to determine internal defects
- **Assembly:**
 - The central dial is fitted manually
 - The clock hands are fitted on the dial on a Lecureux line (assembly line containing specialized workstations)
 - Assembly line is manually monitored at each workstation through infrared/ultrasound displays to check for assembly errors
 - The casing and glass are cleaned under compressed air and vacuum, and then fastened to the casing
 - In case of wrist watches, the body of the watch is sent over for strap assembly
- **Finished Product Inspection:**
 - Finished product is put aside for about 24-48 hours to verify proper functioning
 - Multiple test models are used to check for impact resistance, water resistance, material strength.

Cost Analysis

(for Electronic Quartz Analog Clocks)

- Despite largely different processes as well as machines/equipment, the basic manufacturing pipeline remains the same
- Fairly reasonable to assume that other types of clocks also have a similar costing pattern
- Manufacturing processes are standardized
- Previously labour-intensive tasks have now been almost completely replaced by machines
- Initial assumption: capital cost will be much larger compared to labour & fixed costs

Details	Quantity	Approx. Cost (₹)
Fixed costs (pre-operation, mechanical & office equipment, etc)		52,400
Standard testing equipment (digital multimeter + quartz clock tester)	4 + 3	74,000
Total Fixed Capital Costs		1,26,400
Staff wages	~8 - 10	25,300
Raw material & manufacturing (quartz, case, dials, etc)	~750	4,50,000
Utilities (power, water, etc)		2,200
Contingent expenses (telephone, taxes transport, advertisement, etc)		22,000
Monthly Labour + Capital Cost		4,99,500
Annual Depreciation + Interest		2,75,000
Total Annual Production Cost		62,69,000

Work Distribution

Stage 1

Product Proposal - All

Stage 2

Description - Gopalan

Applications - Sidharth

Approximate Cost - Om

Stage 3

Design - Gopalan

Components - Om

Engineering Drawing - Sidharth

Stage 4

Materials - Om

Process Selection - Om, Sidharth

Stage 5

Manufacturing - Gopalan

Finishing & Coating - Om

Machines & Equipment - Sidharth

Assembly & Inspection - Om, Gopalan

Final Submission

Cost Analysis - Om

Thank You!