Individual Research Document

Project Purpose — My Perspective

- Design a system that is capable of detecting miniscule forging defects and deformities on Ford Sun Gear blanks before final machining is complete.
- Avoid contact with the parts and design according to the environmental conditions. (Tooling and equipment that can withstand high forging temperatures and function at > 70 pcs/min)
- Have the system be integrated on the manufacturing line and adjustable to be utilized for different manufactured components.
- Eliminate the need for manual, visual inspection and increase the efficiency and accuracy of the inspection process.
- Create a sorting system that will guide and separate the good and bad parts from each other after inspection.
- Include feeding system that properly aligns and orients components in order to obtain the most accurate imaging and inspection.

Effect of Defects on Business

- Chasing problems in field
- Hiring outside sorting company
- Loss of business due to reputation
- Automotive industry's **back charges** for assembly line shutdowns
- Inefficiency and scrap financial loss [PBR01]

Hot Forging Process

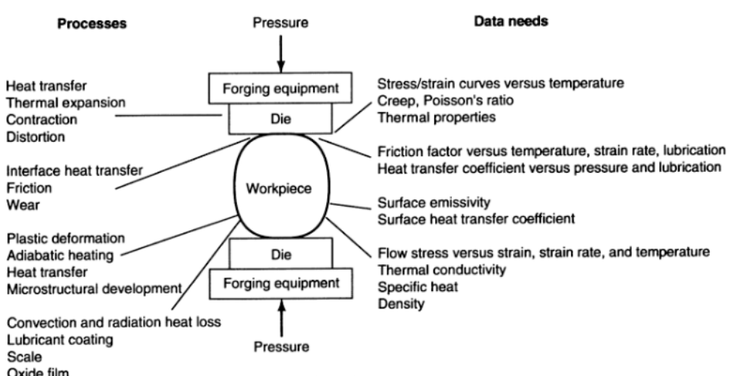


Figure 1. Hot forging process with corresponding steps and required engineering theory [PBR04].

Methods of Deformity Detection in Forging

- Used in high speed automotive component manufacturing lines for quality assurance:
- To occur during **Green Stage** (after the forged components are cooled):

1. Liquid Penetrant Test: Liquid seeps into various types of minute surface openings (as fine as 4 microns) by capillary action and highlights minute deformities with high sensitivity [PBR09]
2. Magnetic Particle Inspection: **ferromagnetic** part can be magnetized either directly by passing electric current through the test material or indirectly through imposing a magnetic field externally [PBR05]
   - Subject component to iron particles that cluster not only at the poles at the ends of the part, but at poles of cracks and openings causing magnetic flux leakage. [PBR08]

1. Ultra Sonic Inspection: Ultrasound transducer is connected to a diagnostic machine that passes over part
   - Transducer sends pulse waves through the part and diagnostic machine displays signals with amplitudes that detect the intensity/ amount of sound transmitted (deformities reduces the amount of sound) [PBR05]
   - Detects/matches patterns to types of deformities [PBR07]:
     - i. Discontinuity in defective sections
     - ii. One large defective section in either top or bottom section
     - iii. Single defect anywhere in the part

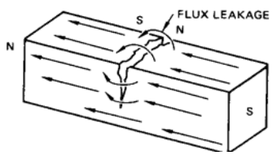


Figure 2. Magnetic flux leakage [PBR08].

Gear Material: 8620 Modified Steel

- Hardenable chromium, molybdenum, nickel low alloy steel used for carburizing to develop a case-hardened part with good wear characteristics [10]
- Melting point: 2600°F
- Density: 0.284 lb/in^3
- Tensile strength: 76900 psi
- Yield Strength: 55800 psi
- Thermal conductivity: 323 Btu*in/hr*ft^2°F [PBR11]

Imaging and Measurement

- Keyence Machine Vision Defect Inspection: detect defects above or below the surface [PBR06]
- General Inspections (Gi-720): Conveyor belt process with 8 frontlit cameras (to detect metallurgical defects) and 8 backlit cameras (to obtain dimensional measurement) [PBR12]
- **Multi-Laser Inspection** [PBR02]: provides cross sectional (360° imaging) measurements with a specified number of inspection points (ranging from 4-16) based on the number of lasers in use (4-8).
  - Number of lasers and size of part (diameter) determines the tolerances

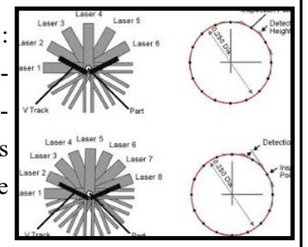


Figure 3. Multi-laser schematic with inspection points [PBR02].

- **Magnetic Imagery** for metallurgical defects: advanced eddy current technique [PBR02]
  - Coil along path develops a magnetic profile to create a part's signature
  - Displays percentage of deviation from ideal part
- **Shadow Gage Sorter** [PBR03]: system of side and top cameras measure features such as diameters/ lengths, etc.
  - Software recognizes the orientation of the parts that are loaded without regard to orientation
  - Programmed with relation between focus and measurement and compensates optical lenses accordingly

Mechanical Sorting Processes

- Vibratory feeders/hoppers
- Rail systems with obstructions to manipulate orientation of the parts
- Position sensors (lasers) with feedback [PBR02]
- Force bad parts off conveyor belt through force (air ejectors, slides, paddles) driven by imaging/measurement results [PBR02]