Internship Report

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Under The Guidance Of

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Research And Development (R&D)

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This Is to Certify That **Viswa M, Infant Jevin S**, Students of **Sri Krishna College of Technology**, Coimbatore Studying in IIIrd Year B. E Mechanical Engineering Has Undergone Internship in **Super Auto Forge Pvt.Ltd, Kolapakkam Plant,** Chennai from (15.05.2025-31.05.2025).

Mr. N. Narayanan

Manager-(R&D)

Acknowledgement

We would like to thank The **Chairman and Vice-Chairman of Super Auto Forge Pvt.Ltd** for giving us the golden opportunity to do the internship in the esteemed institution.

We sincerely express our gratitude to **Mr. Karthik Narayanan, Deputy General Manager and Head of R&d** at super auto forge ltd., for providing us with the opportunity to undertake our internship within the organization. This experience offered valuable industry exposure and greatly enhanced our technical learning.

We express our thanks and gratitude to our guide **Mr. N. Narayanan – Manager** at super auto forge for their guidance and support throughout the internship.

We owe our sincere thanks to the research and development team members who guided us and helped us in through the internship, and let us have access to their resources for the study.

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Abstract

This report presents a comprehensive account of the internship undertaken at **super auto forge Pvt.Ltd., Chennai**, within the **research and development (R&D) department**. The primary objective was to gain in-depth exposure to the full spectrum of forging operations—spanning from **raw material conversion** to **cold and warm forging**, **tool design and manufacturing**, **robotic automation**, and **precision machining**—with a focus on optimizing process planning and product quality.

Key processes studied include **cold forging**, **multi-stage warm forging** (preform, enclose, forward, backward extrusion), **phosphating and polymer coating**, **CNC and gantry machining**, and **post-forging finishing**. Each stage was supported by automated handling systems and real-time quality monitoring using advanced metrology tools like **CMM, SEM, and Spectrometers**.

The R&d department played a vital role across all operations, conducting **feasibility studies, simulation using deform and Simufact, tool and die design in Siemens NX**, and **machining strategy validation**. Emphasis was placed on **automation integration, cycle-time reduction, material flow optimization,** and **die life extension**

The outcome of this internship is a fully mapped process flow integrated with R&D touchpoints—forming a blueprint for consistent, high-quality, and efficient manufacturing of forged automotive components to meet global OEM standards.

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1.Introduction

Super Auto Forge Pvt. Ltd. (SAF) is a pioneer and one of the most respected names in the Indian automotive components industry, specializing in the production of **cold and warm forged parts**. Founded in **1975** and headquartered in **Chennai, Tamil Nadu**, saf has built a strong global reputation for its high-quality, precision-engineered components that cater to some of the most demanding applications in the automotive sector.

Over the decades, saf has evolved into a **world-class manufacturer**, with a strong emphasis on **technological innovation, product reliability, and customer satisfaction**. The company manufactures a wide range of forged components such as:

- **Transmission and drive-line components** (**cv-joints**)
- **Steering and suspension system parts**
- **Universal joint yokes**
- Other **high-precision forged parts** for passenger and commercial vehicles (**links**)

Saf's clientele includes many top-tier **OEM'S (original equipment manufacturers)** and **tier-1 suppliers** across **North America, Europe, and Asia**, demonstrating its strong international presence. The company exports a significant portion of its production and is recognized as a trusted supplier in the global automotive supply chain.

To meet growing demands and high standards, SAF has developed **state-of-the-art manufacturing infrastructure**, equipped with:

- **High-tonnage forging presses**
- **Automated material handling systems**
- **Advanced CNC machining centres**
- **In-house tool rooms and die-making facilities**
- **Additive manufacturing technologies (3d metal printing)**
- **Comprehensive testing and quality control labs**

Saf also places a high priority on **research and development (R&D)**. Its dedicated R&D team continually works to develop innovative solutions in forging design, tooling, and process optimization. The company actively adopts technologies like **simulation-based forging**, **robotic automation**, **shrink-fit tooling**, and **net-shape forging** to enhance efficiency and precision.

A standout capability at saf is its expertise in **net-shape and near-net-shape forging**, which reduces the need for secondary machining, saves material, and improves dimensional accuracy — all of which contribute to cost-effectiveness and environmental sustainability.

Furthermore, saf practices **lean manufacturing**, continuous process improvement, and quality management systems such as **IATF 16949** to ensure product reliability, process stability, and customer satisfaction.

With over four decades of legacy, Super Auto Forge Pvt. Ltd. Continues to grow as a symbol of **engineering excellence**, setting benchmarks in **precision forging technology**, and contributing significantly to the **Indian and global automotive industry**.

2.Process design at super auto forge (SAF)

At super auto forge, **process design** is a foundational function led by the **r&d department**, ensuring every forged component is manufacturable, repeatable, cost-effective, and aligned with customer requirements. It encompasses everything from simulation and die design to cycle time optimization and press/tool manufacturing.

Key stages of process design

Initial feasibility study

- Analyze part drawings, tolerances, and material.
- Determine whether cold or warm forging is suitable.
- Validate process chain: forging → trimming → machining → inspection.

Cad modelling & stage design

- Use **siemens nx** and **solidworks** to design:
    - Final part geometry
    - Intermediate stages (preform, enclose, extrusion steps)
    - Flash, draft angles, fillet radii
- Simulate each stage to prevent cracks, underfill, or defects.

Simulation & validation

- Simulate material flow, temperature gradients, and stress zones using:
    - **Deform**
    - **Simu fact forming**
- Predict load paths, flash formation, and die wear and stress concentration.
- Identify and eliminate failure risks before physical trials.

Tooling and equipment selection

- Match press capacity to part shape and material (400t, 600t, 1000t presses).
- Design tooling for each forging stage:
    - Dies (open, closed, cavity based on press selection)
    - Punches (flat, cylindrical, male/female)
    - Ejectors and knockout pins

Cycle time and process flow planning

- Plan forging cycle time, process flow time for shifts and robotic handling delays.
- Layout the operation:
    - Material flow → heating → lubrication → forging → cooling → inspection
- Optimize for takt time and minimal tool changeover.

Robotic integration

- Coordinate robotic arms for pick-and-place, alignment, and transfer.
- Program orientation logic for backward/forward extrusion.
- Industry confirms safety zones and cycle sync.

Toolpath and machining design

- For post-forging machining stages:
    - Plan toolpaths in gantry and CNC machines.
    - Simulate probe paths and verify fixture clearances.

3.Cold forging

Cold forging at SAF is a high-precision, high-speed metal forming process performed at room temperature using fully automated lines, progressive multi-stage presses, and precision tooling to produce complex automotive components with excellent dimensional accuracy and surface finish.

Temperature range:

• cold forging is performed at room temperature (20°c – 100°c) without any external heating.

Raw material conversion:

Step	Description	Time	Temperature	Equipment	Remarks
Wire straightening	Steel wire coils straightened	10-15 min	Room temperature	Wire straightener	Ensures uniform blank length & shape
Cutting to slugs	Wire cut into precise lengths (slugs)	5-10 min	Room temperature	Automatic cut-off machine	Length depends on final forging size

Shot blasting and moly coating:

- A **drum roller shot blasting machine** (also called **tumbling blast machine**) consists of a **rotating drum** where forged parts are loaded to enhance cleaning, surface preparation, descaling of slugs.
- **Molybdenum coating** is applied using electrostatic spray coaters to reduce friction between die and workpiece, extend die life, and improve flow during forging.

Annealing process:

- Used to relieve internal stresses caused by cold forging. **(hardness: 85–95 HRB / 200-220 HV)**
- **Furnaces used:**
  - Electric bell furnace

- Micro furnace
- Temperature-controlled batch furnace (up to 1200°c)

- **Temperature and time:** 300°c–400°c for 30–60 minutes.
- Improves ductility for subsequent machining or forging steps

Phosphating process (surface treatment):

A **13-tank zinc phosphate coating line** is used for corrosion resistance and improved lubricant adhesion.

Tank no.	**Process stage**	**Temperature (°c)**	**Time (min)**	**Description**
1	Load station	Ambient	-	Manual or robotic loading
2	Hot rinse	60-70	1-2	Removes oil and grease residues
3	De-rusting	Ambient	5-10	Acid solution (15% hcl) removes rust
4	Rinse 1	Ambient	1-2	Water rinse
5	Rinse 2	Ambient	1-2	Water rinse
6	Empty station	Ambient	-	Buffer zone
7 to 10	Phosphating tanks 1–4	70-85	10-15 (each)	Nitride and iron bath with accelerators
11	Rinse 3	60-75	1-2	Water rinse
12	Rinse 4	70-80	1-2	Final water rinse
13	Lube coating	70-80	4-5	Sodium stearate/polymeric lubricant coating
14	Drier tank	Up to 120	10–15	Air drying to fix the coating

Forging operations:

Forging presses:

- The prepared slugs are forged using **mechanical presses** (e.g., 400t, 600t, 1000t) into intermediate or final shapes.
- Typical operations include:

- **Forward extrusion**: to elongate the part
- **Backward extrusion**: to form cup sections
- **Heading**: to create bolt heads or flanges
- **Final forge**: for fine details and final dimensions
- **Trimming**: excess material (flash) is removed using **trimming presses** to ensure a clean and accurate profile.

Final forge:

The **final forge** (also known as **net-shape or near-net-shape forging**) is the forging process where the component achieves its **final geometry, surface finish, and dimensional tolerances**. It eliminates or minimizes the need for further machining.

Tooling in final forge:

Component	**Function**
Die	Has a precise cavity shaped to match the final component.
Punch	Applies force to form details like splines, shoulders, and heads.
Ejector	Removes part safely from the die cavity without distortion.

Post forging process:

Post-forging operations refer to set of manufacturing processes performed **after the forging stage** to refine the part's geometry, surface quality, and functionality. These operations are essential for removing excess material, achieving final dimensions, adding specific features, and preparing the forged component for inspection or assembly.

Operation	**Description**
Trimming	Removal of flash or excess material around the forged part using hydraulic presses.

Piercing	Creation of holes or slots using vertical presses or custom punch tools.
Broaching	Internal surface shaping (e.g., spline cutting) using broach machines.
Thread rolling	Rolling threads onto studs or bolt sections without material removal.
Deburring	Manual or mechanical removal of sharp edges and burrs.
Cooling	Controlled air or conveyor-based cooling to avoid warping or distortion.

Material commonly used in cold forging at SAF:

- 10b21
- 1010
- 1015
- 1bb25
- 41cr4

Components forged in cold forging:

- Inner race
- Spider
- Brake piston
- Ball sleeve
- Ball housing

Machines used in cold forging

Wilkins and mitchell forging machine:

400 ton forging press:

4.Warm forging

Warm forging at SAF is a semi-automated, high-efficiency forging method using robotic arms, precision dies, multi-stage presses, and induction heating for producing critical automotive parts.

Temperature range:

- Warm forging range: 850°c – 950°c (measured by non-contact pyrometers).

Raw material conversion

Materials like **SF3C**, **CF53**, AND **XC45** bars are first **cut into shorter pieces called slugs** before the forging process. These bars are long rods or billets of steel, which are not yet shaped for their final use.

Pre heating:

Preheating involves heating the metal billet to **250°c–300°c** (for steel) to:

- **Improve ductility**, making the metal easier to deform.
- **Reduce flow stress**, lowering the force needed during forging.

Billet coating

Billet coating refers to applying a protective or functional layer on a metal billet before hot, warm, or cold forming operations such as forging, extrusion, or rolling.

A **billet coating** helps in:

- Reducing **oxidation** during heating (especially in forging or extrusion)
- Improving **lubricity** (reducing friction during forging)
- Extending **tool life**
- Preventing **scaling** or **surface defect**

Lubrication for die

- Graphite + water (1:10 to 1:12) spray is used in forging to reduce friction and prevent the hot metal from sticking to the dies, ensuring smooth part ejection and better surface finish.
- it withstands high temperatures and protects the die surface, increasing die life and improving overall forging efficiency.

Stages of warm forging

Preform:

- Roughly shapes the heated metal to prepare for better forming in later steps.

Forward:

- Makes the metal flow in the punch's direction to create long, narrow parts

Enclose:

- Forms the final, detailed shape with tight tolerances

Backward:

- Forms hollow parts (like cups or sleeves) by pushing metal backward

Cooling and Coating in Warm Forging

Cooling Conveyor

- **Transfers Parts:** Moves the forged parts from the press to the next station.
- **Cooling Role:** Allows parts to cool slowly, avoiding cracks or damage due to sudden temperature changes.

Polymer Coating

- **How It's Applied:** A polymer is mixed with hot water (60°C–70°C) and applied before and after forging.

- **Why It's Used:** Helps in forming the shape better and protects the part during forging.

Function of Polymer

- **Reduces Friction:** Makes it easier for metal to flow and reduces stress on tools.
- **Improves Finish:** Gives a smoother and cleaner surface to the forged part.

Components forged in warm forging

- Outer race
- Tulip

Machines used in warm forging

Gw bliss 1500 ton press:

1200 ton press:

5.Machining & Post-Forging processes

At super auto forge Pvt. Ltd., a combination of conventional and advanced machining is employed to achieve precise geometry and functional features. The following processes complement the tool room and metrology capabilities, providing a complete **manufacture-to-inspect cycle**.

Piercing process

- **Purpose:** Forming precise holes and cutouts in forged components using **high-tonnage press tools**.
- **Tools used:** Carbide or hardened tool steel punches and dies.
- **Material:** Typically used on carbon steels and alloyed forgings.
- **Coolant/lubricant:** Synthetic or mineral stamping lubricants.
- **Inspection:** Dimensional check using plug gauges and optical comparators.

Gantry machining – i and ii

- **Machines:**
  - **Gantry i:** 3-Axis heavy-duty horizontal machining center for large forged blanks.
  - **Gantry ii:** Equipped with advanced probing systems and auto tool changers for batch processing.
- **Operation type:** Milling, facing, drilling, and tapping, thread rolling , splines rolling

Magnetic inspection through light

- **Technique:** Magnetic particle inspection (MPI) with **fluorescent light** for crack detection.
- **Application:** Detects surface/subsurface defects in ferromagnetic parts post-machining.
- **Process:**
  1. Magnetization of the component

2. Application of fluorescent magnetic particles
3. Viewing under UV/blue light

Resonance testing (natural frequency method)

- **Purpose:** Identify cracks or internal flaws via **vibration signature analysis**.
- **Method:** Tap component → measure frequency → compare to known healthy part frequency.
- **Instruments:** Accelerometers, impact hammers, FFT analyzers.

Final dimensional inspection

- **Tools used:**
  - Profile projectors, CMM's (coordinate measuring machines), air gauges, calipers, micrometers.
- **Checks performed:**
  - Tolerances (±10 µm)
  - Surface finish (ra ≤ 1.6 µm)
  - Runout and concentricity
- **Software:** Statistical process control (SPC) integrated inspection.

Laser engraving

- **Machine type:** Fiber laser engraving system.
- **Purpose:** Part marking (serial no., batch code, heat no., customer id).
- **Features:**
  - High precision
  - No physical wear on tool
  - Permanent, corrosion-resistant mark

- **Applications:** Identification in traceability systems, export compliance.

Broaching process

- **Machine type:** Vertical pull broaching machine.
- **Application:** Internal keyways, splines, and complex internal profiles.
- **Tools:** Carbide-tipped broach tools; progressive cutting teeth.
- **Coolant:** Heavy-duty cutting oil with chip evacuation systems.
- **Use case:** Often the final internal machining step for critical fit parts.

Machines used in machining process

GANTRY MACHINE:

BROACHING MACHINE:

MPI MACHINE:

LASER ENGRAVING MACHINE:

6.Tool room

Introduction:

As part of my internship in the research and development department at super auto forge pvt. Ltd., i had the opportunity to gain extensive exposure to a wide range of advanced machining and finishing equipment housed within the tool room. These machines play a critical role in the precision manufacturing of forging dies, tooling components, and prototypes, supporting the company's high-performance automotive component production. Below is a categorized overview and functional summary of the key machines in the tool room:

CNC Vertical Machining Centers (VMCS):

- **MAKINO D300 (5-AXIS VMC):**
  A high-speed, precision 5-axis machining center ideal for complex geometries and die components. Used extensively for intricate contour milling, Mold bases, and high-accuracy die components.
- **MAKINO F5 4-AXIS VMC:**
  It is known for its thermal stability and tight tolerances, used for precise Mold cavity machining and high-speed finishing.
- **S3 33-1 & S3 33-2 VMCS:**
  Twin VMS's used for die preparation and rapid material removal, aiding in the roughing and semi-finishing of tooling components.
- **F3 4-AXIS VMC:**
  Supports high-speed die cutting and 3d profiling tasks, especially in mold and die manufacturing.
- **MAKINO PS6 & PS155 VMCS:**
  Robust machining centres offering stable and consistent performance for mid-range production tasks. Used for die slots, contouring, and base machining.

EDM and High-precision Tooling Support:

- **EDGE 3 EDM (ELECTRICAL DISCHARGE MACHINE):**
  Utilized for machining hard materials and intricate internal geometries that cannot be milled conventionally, ensuring high-precision cavities in hardened dies.

- **Shrink fit machine:**
  Employed to mount high-precision cutting tools with minimal runout using thermal expansion, improving tool holding stability during high-speed machining.

CNC Turning and Lathe Machines:

- **LT 25-1 CNC & LT 25-2 CNC:**
  CNC turning centers used for producing die inserts and custom round components with consistent dimensional accuracy.
- **MAZAK LT-20C CNC LATHE:**
  A sophisticated turning machine used for both prototyping and production of high-precision cylindrical die components.
- **TM50 MANUAL LATHE & TURNER LATHE:**
  Traditional lathes used for secondary operations, maintenance, and small-batch prototyping.

Grinding and surface finishing:

- **Micromatic cylindrical grinding:**
  Used for high-precision external and internal cylindrical grinding, essential for finishing die components and ensuring tight tolerances.
- **Victotec cylindrical grinding machine:**
  Another high-precision grinder used for finishing forged dies and round tooling with superior surface quality.
- **Hmt surface grinding:**
  Employed for achieving flat and parallel surfaces on die bases and tool holders.
- **Lapping machines (lapping area - machine iii):**
  Used for ultra-fine finishing and improving surface flatness, especially in critical sealing and contact.

Machines used in tool room

MAKINO F5 4 AXIS VMC:

MAKINO D300 VMC:

MAKINO 3 EDGE EDM

TM50 MANUAL LATHE

7.Advanced metrology & materials analysis lab

At **Super Auto Forge**, our advanced materials and metrology lab delivers cutting-edge precision inspection and raw material analysis. This critical support ensures superior quality and reliability for both traditional forging and state-of-the-art additive manufacturing processes.

Equipment & capabilities:

Equipment	Description	Purpose	Software / output
Sem evo 18 (carl Zeiss)	Scanning electron microscope	Microstructure observation (up to 50,000x), surface morphology	Paired with smart sem software for imaging & analysis
Oxford eds	Energy-dispersive x-ray spectroscopy	Elemental composition analysis	Integrated with SEM for point/line/area eds
Zeiss Axiocam 705 POC	5 MP CMOS digital microscope camera	High-res microstructure imaging	Used for metallography sample documentation
Micro Vickers hardness tester	10g to 1kg load range	Hardness mapping on small features, HAZ, powder particles	Hv0.1, hv0.5 reporting
Ametek Spectro machine	Optical emission spectrometer (OES)	Spectral analysis of metal alloys for Fe, Al, Ti, Ni, etc.	Printable spectrum report, alloy conformity
Particle size analyzer	Laser diffraction-based analyzer	Measures size distribution of metal powder (d10, d50, d90)	Used for metal 3d printing powder qc
Smart Sem	Sem operation and digital analysis suite	Captures surface topography and defect analysis	Exports in image+.XLS data format

Raw material & powder testing protocol (for additive manufacturing)

Purpose: To qualify metal powder/slug raw materials for use in metal 3d printing and ensure dimensional and compositional integrity.

Test sequence:

Test name	Equipment	Standard followed	Output
Particle morphology	Sem evo 18	ASTM f1877	Shape (spherical/irregular), satellite detection
Elemental composition	Oxford eds +Ametek Spectro	ASTM e415 / ISO 15350	Weight % of Fe, Cr, Ni, Mo, C, etc.
Particle size distribution	Particle size analyzer	ISO 13320	D10, d50, d90, PSD curve
Hardness analysis	Micro vickers	ASTM e384	Hv0.1 for sintered and pre-sintered particles
Surface cleanliness	Sem imaging	Internal standards	Surface contamination / oxide layer thickness
Documentation	Zeiss Axiocam + Smart SEM	Digital record keeping	Pdf/jpeg report with captions and scale bars

Additive manufacturing 3d metal printer

Stlr 400 amaze:

During my internship at Super Auto Forge Pvt.Ltd., i gained hands on experience with the STLR 400 amaze, a selective laser melting (SLM) metal 3d printer. It builds complex metal parts layer-by-layer using metal powders like stainless steel and titanium alloys.

With a build volume of 400x400x450 mm and high precision, it is ideal for rapid prototyping and manufacturing intricate tooling components with minimal waste. This technology supports innovative die designs, including internal cooling channels, improving tool performance and reducing lead times.

The STLR 400 amaze enhances the R&D process by enabling quick production of complex parts that are difficult to make with traditional methods, helping super auto forge stay at the forefront of advanced tooling solutions.

Tools used:

- **Materialize magics-** used for preparing the 3d model for printing
- **Siemens NX:** primarily used for advanced cad modeling and design of the components (like punches and tools).

Machines Used in Additive Manufacturing:

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