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Value Stream Mapping Based Process Improvement Model for Waste Reduction of Specialized Metallic Parts

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***Abstract*—**Special Metallic Blank production is considered a critical process in manufacturing firearms and optimizing this process for efficiency and waste reduction is deemed crucial. Applying the Value Stream Mapping (VSM) technique to identify and eliminate waste and non-value-added activities in Special Metallic Blanks production is the subject of investigation in this Research Work. This thesis explores improving the indigenous development process for special metallic blanks, which are crucial components in various industries. It focuses on using Value Stream Mapping (VSM) to identify and eliminate waste while reducing non-value-added activities in production. The research emphasizes the importance of making this specialized manufacturing process more sustainable, cost-effective, and competitive globally. The methodology involves analyzing the current state of the process, using VSM symbols and metrics to highlight inefficiencies and opportunities for improvement. The study identifies non-value-added activities like overproduction and defects and creates a plan to reduce waste and increase efficiency. It also outlines a strategy for implementing these improvements and monitoring their long-term impact using key performance indicators and continuous improvement practices. The research aims to enhance the competitiveness and sustainability of industries. producing special metallic blanks by embracing VSM as a powerful tool for process improvement.

***Keywords*—** Value Stream Mapping, Special Metallic Blanks, Waste Reduction, Non-Value-Added Activities.

I. Introduction

The manufacturing sector continuously strives to augment operational efficiency, reduce wastage, and refine production procedures. This research aims to explore.

Applying the Value Stream Mapping (VSM) technique in the context of Special Metallic Blanks production. The primary objective is to eliminate waste reduction and non-value-added activities that do not contribute value to the process (Ohno, 1987). Through the application of VSM, this research seeks to identify areas requiring enhancement, optimize processes, and bolster the overall efficiency and quality of Special Metallic Blanks manufacturing. The results are original while the findings of this study have practical applications in similar manufacturing settings for optimizing processes and attaining higher productivity. This paper has been structured as follows; Section 2 describes the Research Context, Section 3 provides the Research Methodology, and Section 4 Presents the Data Collection and Analysis. Section 5 Explains the Results and Comparison of the Current and Future State. Finally, conclusions are provided in Section 6.

II. Research Background

In the agricultural sector, research has been improved in many ways to upgrade the quality and quantity of agricultural productivity. Researchers have worked on a wide range of projects to deal with characteristics and parameters of soil, and various climatic Conditions as well as exploring various crops. Farmers can evaluate this data for fertilizer necessities for the crop. It will help with smart climate solutions. We have tried to make this project fully automatic, ensure the healthy growth of the crops, and inform the farmer about the status/condition of the field through web pages so that we can check the status of the field anywhere, anytime.

III. Aim and Objectives

The production process of Special Metallic Blanks often involves several waste and non-value-added activities that can increase Production Costs, Reduce Efficiency, And Decrease the Overall Quality of the final product. Identifying and eliminating these activities can help improve the production process and create a more efficient and cost-effective manufacturing system.

The objective of this research includes:

a. To identify the current state of the production process for Special Metallic Blanks.
b. To map out the value stream for the current production process.
c. To identify waste and non-value-added activities in the production process.
d. To propose improvements to the production process that will eliminate waste and non-value-added activities.
e. To evaluate the effectiveness of the improvements in reducing waste in the production process.

IV. RESEARCH CONTEX

Lean manufacturing is an important philosophy developed for shop floors that aims to enhance value and reduce waste (Womack, 2003). The fundamental pillars of lean thinking comprise five principles: Identify value, identify value stream flow, pull, and perfection. In the realm of lean manufacturing, Just-In-Time (JIT), Kanban, Total Quality Management (TQM), Material Requirement Planning (MRP), 5S, Jidoka, and Poka-Yoke emerge as major tools.

Among these, VSM was initiated from the Toyota Production System, which is also known as material and information flow mapping [ii]. Initially conceived as a paper and pencil visualization technique, VSM traces the material and information flow from a customer's perspective to optimize throughput by minimizing manufacturing lead time.

The VSM process unfolds in four distinct phases. Phase 1 involves an evaluation of the organizational hierarchy, with establishing a specialized lean transformation team. This team, trained for the purpose, reviews the organization's competitive strategies, objectives, and operations through a lean lens.

Phase 2, termed the current state mapping phase, identifies all operations in the transformation from raw material to finished goods. A value stream map is then developed to assess and eliminate waste or non-value-added activities.

In Phase 3, the future state is designed using lean principles, incorporating techniques such as Kanban, inventory control for responsiveness to customer orders, and cellular production. The last phase is the development of an implementation plan, which needs procedural and policy alterations [iii, iv]. VSM in varieties of manufacturing industries such as pump manufacturing [v], automotive [vi], steel [vii], medium-scale manufacturing plant [viii, ix], and foundry[x]. As a superior tool for lean transformation, VSM precisely identifies where actual value is added to the product. It endorses the lean principle of waste removal by identifying and eliminating non-value-added activities [xi].

1. Context within the Manufacturing Industry: The manufacturing sector is marked by a perpetual pursuit of heightened operational efficiency, waste reduction, and optimizing production processes. This introductory statement recognizes the industry's continuous endeavor to enhance its practices and results.

2. Focus on Value Stream Mapping (VSM): This research focuses on using a special tool called Value Stream Mapping (VSM) to make processes better. VSM is the main technique we'll use in this study.

3. Special Metallic Blanks Production as the Target: This study focuses on a particular part of manufacturing: Making Special Metallic Blanks.

These are super important in industries like aerospace and automotive. So, in this study want to learn more about improving, or analyzing the production process of the specialized metal blanks. This might mean checking how they're created, the stuff used quality control, cost-effectiveness, and other things about making them. The reason for this focus is that special metallic blanks play a vital role in industries like aerospace and automotive. If we can make them better, it can make the final products in these industries better and cheaper. So, by targeting that area, the study wants to address specific challenges or opportunities in making special metallic blanks and potentially enhance the overall efficiency and effectiveness of the industries that rely on them.

4. Waste Reduction and Non-Value-Added Activity Elimination. The core aim of this research is clearly outlined: to reduce waste and eliminate non-value-added activities that don't add value to the production of Special Metallic Blanks. These aims are in sync with the overarching industry objective of enhancing operational efficiency and cost-effectiveness.

5. The Role of VSM: The introduction emphasizes that the primary methodology for achieving the research objectives is Value Stream Mapping (VSM). VSM is characterized as a technique capable of pinpointing areas requiring improvement, streamlining processes, and augmenting overall efficiency and product quality.

In essence, this introduction serves as a foundation for the research work. It provides the context within the manufacturing industry, specifies the focus area (Special Metallic Blanks production), outlines the research objectives (waste reduction and non-value-added activity elimination), and introduces the pivotal role of Value Stream Mapping (VSM) as the methodology for attaining these objectives. It establishes the reasoning behind the study and the potential advantages it could offer to the manufacturing field, particularly in the realm of Special Metallic Blanks production.

V. METHODOLOGY OF RESEARCH

Introduction:

This chapter elaborates on the methodology applied to execute the proposed research work, focusing on the utilization of Value Stream Mapping to analyze and enhance the production process of special metallic blanks. The core objective is to implement measures that reduce waste, consequently elevating the overall quality and efficiency of the production process. The chapter presents practical applications of Value Stream Mapping, shedding light on an approach that may not be commonly found in scientific literature. The methodology is underpinned by a comprehensive examination of the manufacturing process. It is our aspiration that the insights derived from this research can prove beneficial not only to the specific product under scrutiny but also to analogous businesses within the metal industry.

Production Process Current State:

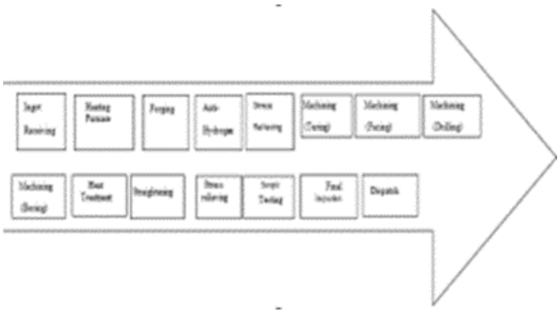

Fig 1. Production Current State Flow Diagram

Description:

Ingot Receiving: The production process commences with the acceptance and inspection of large metal ingots, typically formed through casting. These ingots serve as the primary raw material for subsequent manufacturing stages. In the case of Special Metallic Blanks production, a 4621 Kg ton ingot is received to fulfill the specified requirements.

Heating Furnace: Utilizing gas-fired heating furnaces, the aim is to convert a heat source into thermal energy, achieving elevated temperatures. This is achieved through the combustion of fuels and gases, enabling the heating of raw materials and products through direct or indirect contact. For Special Metallic Blanks, a heating furnace is employed at 1150 °C for 36 hours, utilizing 189.92 kg of material. Forging: The forging process involves shaping. The metal ingots by subjecting them to elevated temperatures. Compressive force is applied using tools like hammers or presses to manipulate the ingots, altering their shape to meet specific design requirements. Forging plays a crucial role in improving structural integrity and mechanical. Properties of the metal. Special Metallic Blanks are forged using a 3150-ton hydraulic press for 08 hours, resulting in the utilization of 231.05 kg of material, which may be in the form of cutting loss.

Anti-Hydrogen Process: The term Anti-Hydrogen refers to a set of procedures designed to prevent the development or presence of hydrogen within the metal. The presence of hydrogen can lead to structural vulnerabilities and other undesirable consequences. These procedures typically involve preventive measures to eliminate or minimize hydrogen absorption, mitigating potential issues such as metal embrittlement. Although the setup or manufacturing the process is not advanced enough to eliminate the hydrogen treatment process, which is performed to meet quality standards, even though it is considered expensive and time-consuming. In the manufacturing of Special Metallic Blanks, a heating furnace is used for 80 hours at temperatures ranging from 850-900 °C for the anti-hydrogen process. Stress Relieving: Stress relieving is a specific heat treatment technique utilized in metallurgy to alleviate internal stresses within the metal. This process aims to enhance the stability and mechanical attributes of the metal. It entails heating the metal to a predetermined temperature and then meticulously cooling it at a controlled rate to achieve stress reduction, thereby promoting improved material properties. For the Stress Relieving Process of Special Metallic Blanks, a Heat Treatment Furnace is employed for 06 hours, maintaining a temperature of 400 °C, followed by a controlled slow cooling process. Machining (Turning): Turning is a machining process in which a cutting tool is used to remove material from the outer diameter of a workpiece, transforming it into a cylindrical shape. This operation is frequently performed on lathes. For Machining (Turning) Special Metallic Blanks, lathe machines are used for 204 hours. Machining (Facing): Facing is a type of machining operation that focuses on refining the surface of the metal by precisely cutting or shaping it to achieve a flat and smooth finish. This operation is typically carried out using tools such as lathes or milling machines. In the context of Special Metallic Blanks manufacturing, a lathe-facing machine is used for almost 72 hours. Machining (Drilling): Drilling is a specific operation aimed at creating holes in the metal. It involves using a rotating cutting tool to make holes in metal parts. This process is typically carried out using Numeric Control Drilling machines for almost 504 hours. Drilling with a diameter of 65mm is performed from both sides of the ingot, extending 3.5 meters on each side, as the machine size is limited. Machining (Boring): Boring is another machining. larger-diameter holes with a high degree of precision. This operation often requires specialized boring machines. In the case of Special Metallic Blanks, Numeric Control boring machines are used for almost. 168 hours. Boring with diameters of 80, 88, 95, and 100mm respectively is performed from both sides of the ingot, extending 3.5 meters on each side, as the machine size is limited. Heat Treatment: Heat treatment encompasses a rangeof processes, such as annealing, quenching, tempering, and others, which are employed to modify the mechanical properties of metal by subjecting it to controlled heating and cooling. To produce Special

Metallic Blanks, a PIT-type furnace is used for 64 hours. During this process, the special metallic blanks are subjected to temperatures of 800 °C, with gradual increases over time and specific temperature holding periods. After the process, the job is left hanging in the open air for natural cooling. Straightening: Following various machining and heat treatment operations, metal parts may require straightening to ensure they conform to specify dimensional and alignment criteria. A Straightening the press is used for straightening Special Metallic Blanks, involving a 10-hour process. This is a crucial step in the manufacturing process and requires highly skilled operators. Stress Relieving (again): This step may involve additional stress- relieving procedure to guarantee the metal's continuedstability and desired mechanical characteristics. In this case, a Pit-type furnace is used for approximately 08 hours, maintaining a temperature of 400 °C.

Sample Testing: This process involves extracting samples from the metal products and conducting tests to ensure they meet predefined quality and performance standards. These tests may encompass aspects such as hardness, tensile strength, or other material properties. Circular saws are employed to cut pieces for sample testing. Final Inspection: A comprehensive assessment of the completed metal products is performed to confirm that they conform to all specified requirements and are devoid of defects. Dispatch: The final step involves the preparation of the products for shipment and their distribution to customers or designated distribution points. Special Metallic Blanks' final products, with a weight of 3 tons, will be delivered to the customer.

Production Future State:

Fig 2. Production Future State Flow Diagram

Ingot Receiving: The first step in the Special Metallic Blanks production process involves receiving and inspecting the raw material, which typically consists of metal ingots. These ingots serve as the initial material for various metallurgical processes. In this case, a 3870 .15 Kg ton ingot is received to fulfill the production requirements. Heating Furnace: A gas-fired heating furnace is used to convert a heat source into thermal energy to achieve higher temperatures.

Through the combustion of fuels and gases, the raw materials and products are heated through direct or indirect contact. For Special Metallic Blanks production, a heating furnace is employed at 1150 °C for 36 hours, utilizing 116.1 kg of material. Forging: Forging is a critical manufacturing process where the ingot or metal billet is heated and shaped using compressive force, often with the aid of hammers or presses. This process not only alters the shape of the metal but also enhances its mechanical properties. In this context, a 3150-ton hydraulic press is utilized for forging Special Metallic Blanks for 6 hours, involving a material utilization of 154.02 kg due to cutting loss.

Anti-Hydrogen: In the future state of Special Metallic Blanks manufacturing, the Anti-Hydrogen process is eliminated as it is considered a non-value-added activity. Stress Relieving: Stress relieving is a heat treatment process employed to alleviate internal stresses in metal parts. These stresses may result from processes like forging or other mechanical operations. Stress relieving entails heating the metal to a specific temperature and maintaining it at that level for a predetermined duration to reduce these internal stresses and enhance the part's stability. For Special Metallic Blanks, the Stress Relieving process takes place in a Heat Treatment Furnace for 6 hours at a temperature of 400 °C, followed by a slow cooling process.

Machining (Turning): Turning is a machining operation that involves the use of cutting tools on a rotating workpiece to remove material and create cylindrical or conical shapes. Typically, it is used to produce components like shafts and rods with varying outer dimensions. In Special Metallic Blank manufacturing, lathe machines are employed for 204 hours.

Machining (Facing): Facing is another machining operation where metal surfaces are cut or milled to create flat, smooth, and perpendicular faces. This is often done to prepare surfaces for subsequent machining or welding processes. In the context of Special Metallic Blanks, a lathe-facing machine is used for approximately 72 hours.

CNC Machining (Drilling-Boring): This process utilizes computer numerical control (CNC) technology to control drilling and boring operations. For Special Metallic Blanks, drilling and boring are performed, with drilling of an 88mm diameter taking 48 hours, boring of a 99.5mm diameter, and the final boring or reaming process completed within 36 hours. The total machining time now amounts to 360 hours.

Deep Hole Drilling and Boring Machine: Specialized deep hole drilling and boring machines are used for these operations, enabling the creation of holes deeper than their diameter. Workpiece Setup: The workpiece is securely set up on the machine's worktable, whether it is a solid metal bar or a pre-machined component.NC Programming: A CNC program is generated to control the movements of the drilling and boring tools, specifying parameters like hole depth, diameter, and feed rate. Drilling: The drilling operation creates holes in the workpiece using long and slender drill bits designed for efficient material removal. Boring: Boring is conducted after drilling to refine the hole's dimensions and surface finish, utilizing specialized boring tools. Coolant and Chip Management: The machining process generates heat and chips, which are managed through coolant application and chip removal systems. Monitoring and Quality Control: The CNC machine may incorporate sensors and monitoring systems to ensure precision and detect deviations from programmed parameters in real time.

Final Inspection: After machining, a final inspection is conducted to verify that the finished workpiece meets specified requirements, including dimensions and surface finish. Sample Testing: A sample is taken from the product for various tests, such as tensile strength, hardness, or chemical composition. Band Saw: A band saw is employed to cut a piece for sample testing.

Dispatch: Dispatch is the final step where the finished metal product is prepared for shipment or delivery to customers or the next stage of the supply chain.

VI. Data Collection and Analysis

These processes are essential in metallurgy for transforming raw materials into finished metal products with the desired properties and quality. The specific steps and techniques can vary depending on the type of metal and the intended use of the final product. This research methodology is divided into five different phases, each of which is explained in detail. The research methodology flow diagram is shown in the following Fig:

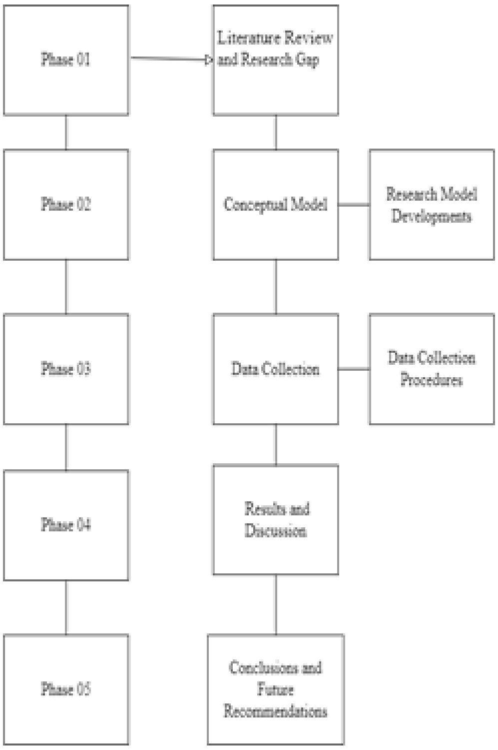

Fig.3 Research Methodology Flow Diagram

Phase 01

Literature Review & Research Gap

In the first phase, an extensive literature review was conducted to investigate existing research and developments in the Indigenous Development of Special Metallic Blanks. This comprehensive review encompassed global research on Special Metallic Blanks, with a particular focus on identifying opportunities for new developments in Pakistan.

The review revealed that significant progress has been made in the field of Waste Reduction and Non-Value-

Added Activities through the utilization of the Value Stream Mapping technique. However, it became evident that the efficiency in this area has plateaued. Upon further investigation, it was discovered that very few studies have addressed the Development of Special Metallic Blanks on a global scale, and even fewer in underdeveloped countries like Pakistan. This dearth of research provides a clear opportunity to explore and address the existing Research Gaps in this field.

Phase 02 Conceptual Model:
Fishbone Diagram

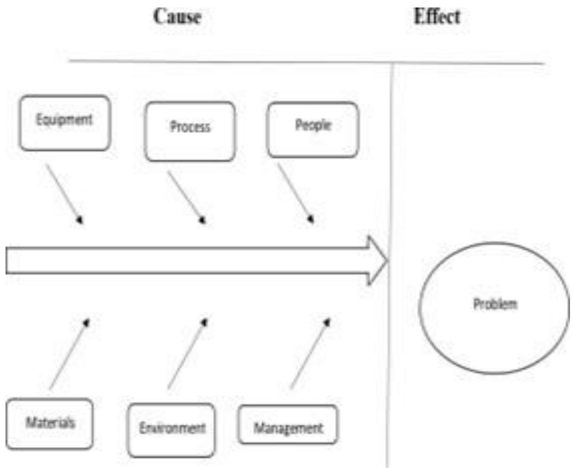

Fig 4 . Conceptual Model

Value Stream Mapping:

Value Stream Mapping (VSM) is a foundational lean tool used to analyze and optimize processes by creating a flowchart that documents every step in the process. Introduced at a Toyota assembly plant in 1980, VSM was developed as a response to the need for continuous improvement in enterprises to ensure their survival and competitiveness. It originated as a tool for identifying and reducing waste in manufacturing but has since been applied across various industries to streamline workflows and eliminate inefficiencies.

VSM was created to visually represent areas of waste within a company and aid in developing improvements to reduce and eliminate that waste. In its essence, the core concept of VSM aligns with the principles of lean manufacturing, which prioritize minimizing waste to maintain a streamlined production system. Creating value stream maps is essential for identifying opportunities to remove wasteful steps and optimize work processes.

Value stream mapping extends beyond manufacturing and has been adopted by various industries. It has proven to be an effective method for uncovering waste in any process. Each significant process step is meticulously detailed, and its contribution to value, as perceived by the customer, is evaluated. This customer-centric approach ensures that the analysis remains focused on what truly matters and enables companies to compete effectively in the market.

Value stream mapping is not a one-time endeavor but an ongoing process for continuous improvement. It helps practitioners deliver maximum value to customers in the most efficient manner. VSM identifies not only waste but also its source or root cause, enabling organizations to target areas for improvement effectively.

Beyond its analytical power, VSM is also a valuable tool for communication, collaboration, and cultural transformation within an organization. Decision-makers can gain a clear visual representation of the current state of a process, helping them pinpoint areas of waste, process delays, constraints, and inventory problems.

Additionally, with the Future State and Ideal State VSM, they can visualize the path to improvement.

Research Model Developments:

Special Metallic Blanks Current State Value Stream Map:
Current State Design:
Create a value stream map for the Special Metallic Blanks production process, emphasizing the current state, lead times, cycle times, and waste that has been identified. Classify activities into either value-adding or non-value-adding categories, with a focus on reducing and eliminating waste.

Current State Map

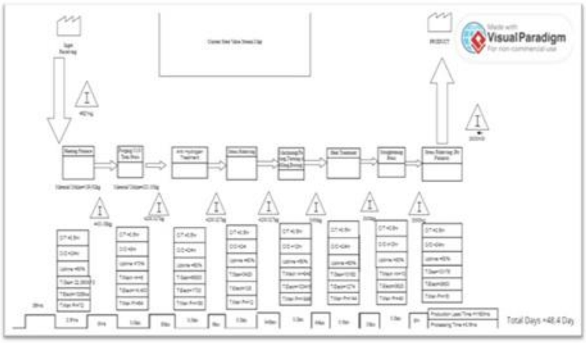

Fig 5. Research Model Current State

Special Metallic Blanks Future State Value Stream Map:
Future State Design:
Generate and put into action strategies aimed.at enhancing the value stream, optimizing processes, and minimizing waste. Incorporate lean manufacturing principles and methodologies. To construct an ideal future state map for Special Metallic blank production. As a result of applying the Value Stream Mapping Technique to the existing process, The anti-hydrogen step has been eliminated due to its classification as a non-value-added Activity.

Future State Map

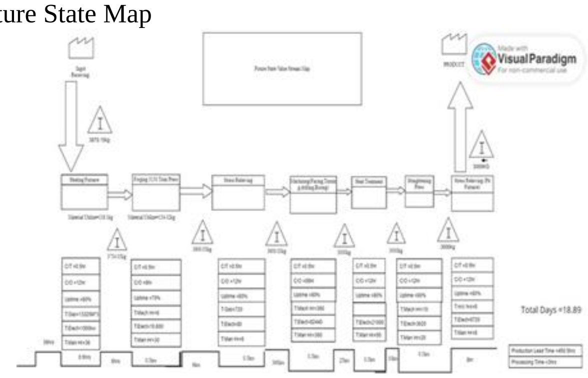

Fig 6. Research Model Future State

Phase 03
Current State Data Collection:

Gather information on the current state of Special Metallic Blanks production, including process steps, personnel, equipment, and metrics.
Observations to understand the existing workflow and identify areas of waste and Non-Value-Added Activity.

Flow Chart Current State Data Collection:

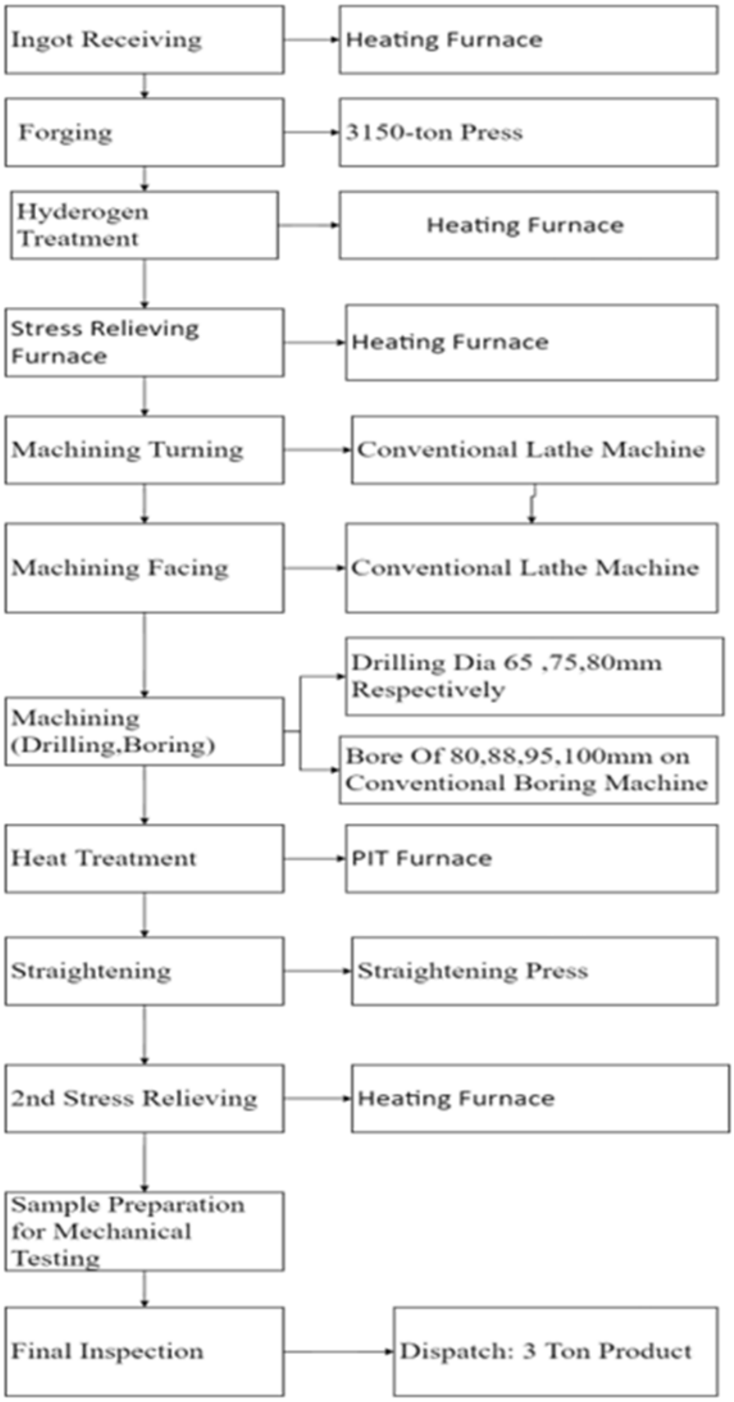

Fig 7. Flow chart Current State of Special Metallic Blanks

Detailed Flow Chart Current State Data Collection:

Fig 8. Flow chart Current State Data Collection

Data Collection Procedure:
Explanation:
Ingot Receiving: A low alloy steel blank, which originally started as an ingot and underwent remelting through the ESR (electro-slag remelting) process before forging. The weight of the required ingot is 4621 kg.

Heating Furnace: Gas-fired heating furnaces are designed to convert a heat source into thermal energy to achieve elevated temperatures. This is achieved through the combustion of fuels and gases, which heat raw materials and products by direct or indirect contact. For the heating of Special Metallic Blanks, a furnace is used at temperatures of 1150-1200 °C for 36 hours. The weight of the required ingot for heating in the furnace is 4621 kg, from which 189.92 kg of
material is utilized during the heating process. The consumption of Gas, Electricity, and Manpower is as follows:

- Total Gas consumption: 22,360 m³
- Total Electricity: 1,326 kW
- Total Man Hours: 72 hours

Forging on 3150-ton press:
Forging is a manufacturing process that involves shaping metal by hammering, pressing, or rolling it into the desired form. Through forging, parts with excellent mechanical properties can be produced while minimizing waste.
In the forging process, a 4431.08 kg ingot is used, with 231.05 kg of material being utilized during the forging process that lasts for 8 hours. The consumption of Gas, Electricity, and Manpower is as follows:

- Total Electricity: 14,400 kW
- Total Man Hours: 64 hours

Hydrogen Treatment Furnace: Enhanced product quality from forgings through the complete elimination of hydrogen.
For the heating process in the furnace, a 4200.027 kg ingot is necessary, and the furnace operates for 80 hours. The consumption of Gas, Electricity, and Manpower is as follows:

- Total Gas consumption: 45,800 m³
- Total Electricity: 1,733 kW
- Total Man Hours: 160 hours

Stress Relieving Furnace
Stress relieving in forging typically involves heating a metal below the lower critical temperature and then uniformly cooling it.
For the heating process in the furnace, a 4200.027 kg ingot is needed, and the furnace operates for 6 hours. The consumption of Gas, Electricity, and Manpower is as follows:

- Total Gas consumption: 3420 m³
- Total Electricity: 128 kW
- Total Man Hours: 12 hours

Machining Turning: Turning is a machining process that involves utilizing a lathe to rotate the metal while a cutting tool moves linearly to remove metal along the diameter, forming a cylindrical shape. This operation is typically executed using a Turning machine and takes approximately 204hrs hours to complete.
Machining (Facing):
Facing constitutes a machining operation that involves cutting or milling the metal surface to produce a flat, smooth, and perpendicular face. This operation is typically executed using a Turning machine and takes approximately 72 hours to complete.

Machining Drilling and Boring:
Machining employs various mechanisms, all aimed at enlarging an existing hole within a workpiece.
For machining, a 4200.027 kg ingot is required, and the process lasts for 672 hours. The consumption of Electricity and Manpower is as follows:

- Total Electricity: 103,416 kW
- Total Man Hours: 1896 hours

Machining (Drilling):
Drilling is conducted to create an initial hole in a workpiece and serves as the initial step in hole machining. This operation is typically executed using a Numeric Control Drilling machine and takes approximately 504 hours to complete. Drilling with a diameter of 65mm is performed from both sides of the ingot, with each side measuring 3.5 meters, considering the machine's size limitation.
Machining (Boring):
Boring is the process conducted to enlarge an existing hole within a workpiece. This operation is typically executed using a numerical control boring machine and takes nearly 168 hours to complete. Boring is performed with diameters of 80, 88, 95, and 100mm, respectively, from both sides of the ingot, with each side measuring 3.5 meters due to the machine's size limitation.
Heat Treatment (Pit Furnace):
Heat treating is the controlled process of heating and subsequently cooling materials to modify their physical and, at times, chemical properties. In the heat treatment process for special metallic blanks, the temperature gradually increases to 800 °C and includes specific temperature holds at different intervals.
Following the process, the job is left in the open air for natural air cooling. The maximum temperature achieved in this process is 900°C. The weight of the ingot after machining is 3000 kg, and the furnace operates for 64 hours. The consumption of Gas, Electricity, and Manpower is as follows:

- Total Gas consumption: 10152 m³
- Total Electricity: 1274 kW,
- Total Man Hours: 144 hours

Straightening (Straightening Press):
A hydraulic straightening press is applicable for straightening special metallic blanks after the Heat Treatment Process.
Following the Heat Treatment, the ingot weighs 3000 kg, and the straightening process, lasting 10 hours, consumes the following Gas, Electricity, and Manpower:

- Total Electricity: 3620 Kw
- Total Man Hours: 40 hours

2nd Stress Relieving (Pit Furnace):
Stress relieving is a method that involves heating and cooling steel to eliminate internal stresses. The maximum temperature reached in this process is 900°C. For heating in the furnace, a 3000 kg ingot is required, and the furnace operates for 8 hours. The consumption of Gas, Electricity, and Manpower is as follows:

- Total Gas consumption: 10176 m³
- Total Electricity: 3600 kW
- Total Man Hours: 16 hours

End Cutting for Sample:
The end Cutting for the Sample and sent to the laboratory for inspection purposes.
Final Inspection:
Following the finalization of the sample inspection reports, a site visit is organized for all the stakeholders, and the final inspection is performed in their presence.
Dispatch: 3 3-ton product is dispatched upon the completion of all manufacturing processes for Special Metallic Blanks.
Production Lead Time =1160hrs Processing Time =3.5hrs
Total Days =48.4 Days

Future State Data Collection:
Gather information on the future state of Special Metallic Blanks production, including process steps personnel, equipment, and metrics.

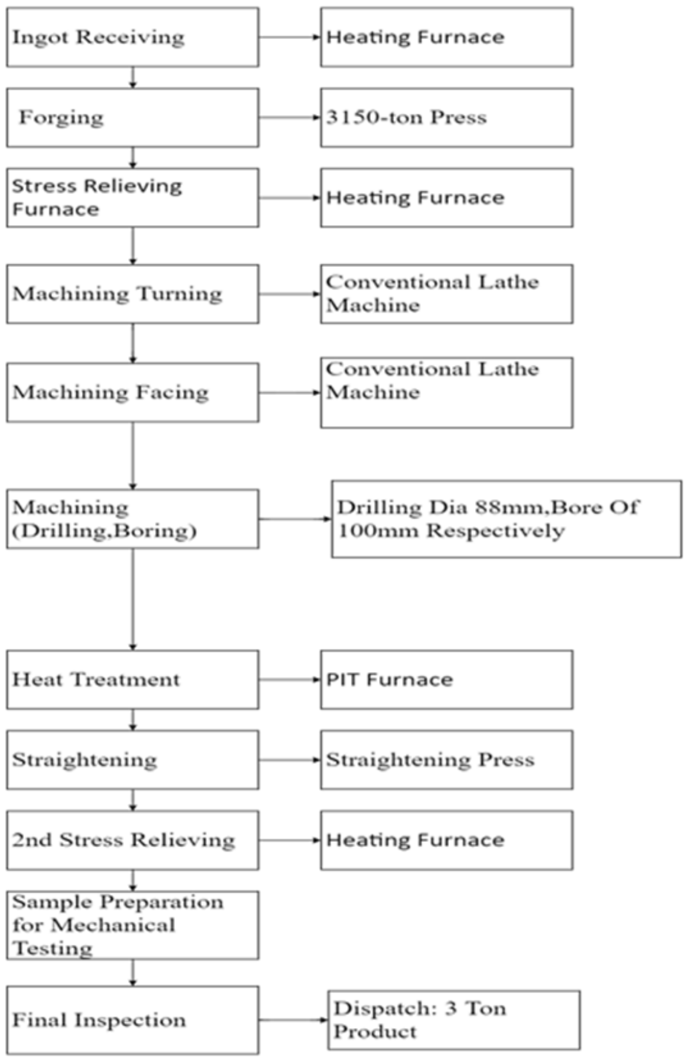

Fig 9. Flow chart Future State Data Collection

Detailed Flow Chart Future State Data Collection:

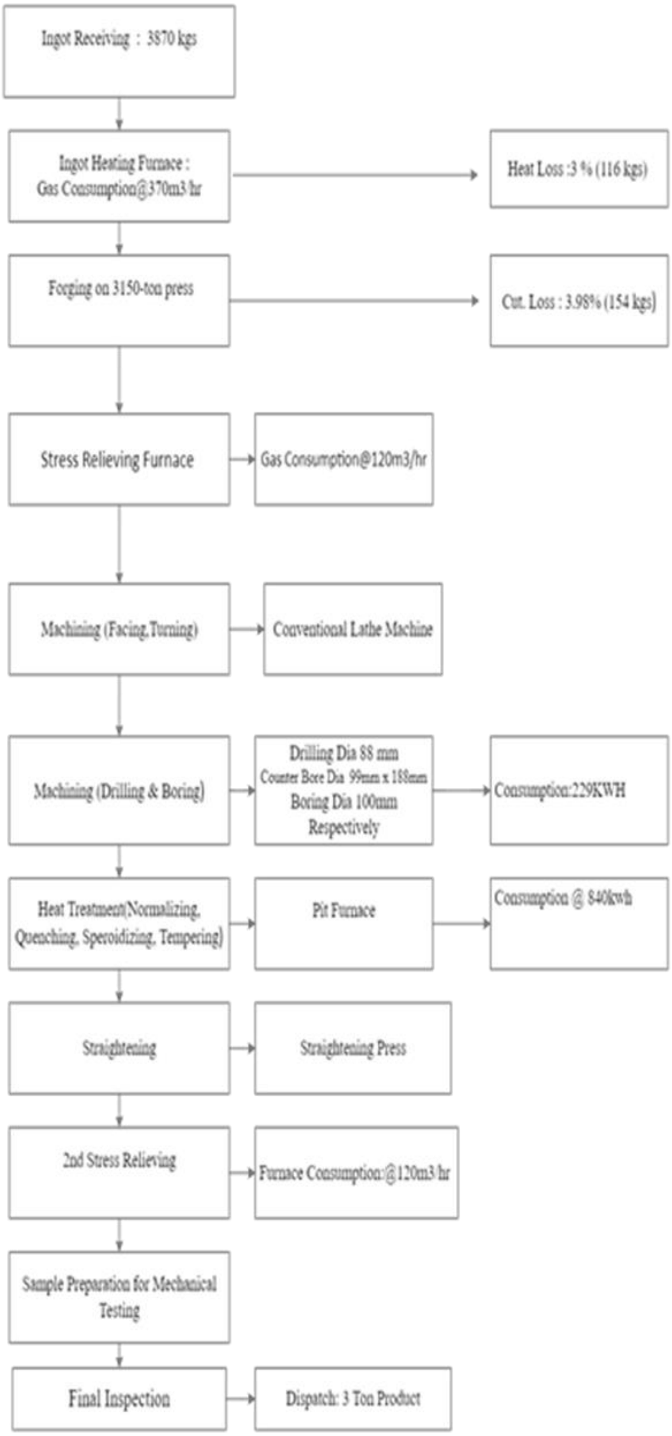

Fig 10. Detailed Flow Chart Future State Data Collection

Explanation:

Ingot Receiving

A low alloy steel blank, initially in the form of an ingot, undergoes remelting in the ESR (electro-slag remelting) process before forging.

The weight of the required ingot is 3870.15 kg.

Heating Furnace:

A heating furnace is a structure that generates useful heat through combustion or other means.

Forging furnaces are employed for preheating billets and ingots, with the maintained temperature inside these furnaces ranging from approximately 1200 to 1250 °C. These furnaces utilize an open fireplace system, primarily transmitting heat via radiation.

For heating in the furnace, a 3870.15 kg ingot is required, of which 116.1 kg of material is utilized during the 36-hour heating process. The consumption of Gas, Electricity, and Manpower is as follows:

Total Gas consumption: 13320 m³ Total Electricity: 1000 kW

Total Man Hours: 36 hours

In Future State The heating furnace's bricks refractory has been substituted with Ceramic Fiber Blocks, maintaining a temperature range between 1260-1600 °C.

Forging on 3150-ton press:

Press forging can be described as the method of shaping a metal by exerting mechanical or hydraulic pressure while it is positioned between two dies.

For the forging process, a 3754.05 kg ingot is used, from which 154.02 kg of material is utilized during the 6-hour forging operation. The consumption of Gas, Electricity, and Manpower is as follows:

Total Electricity: 10,800 kW Total Man Hours: 30 hours

Stress Relieving Furnace:

Stress relieving in forging typically involves heating a metal below its lower critical temperature and subsequently uniformly cooling it.

In the Stress Relieving Furnace, bricks refractory has been replaced with Ceramic Fiber Blocks, maintaining a temperature range between 1260- 1600 °C. For heating in the furnace, a 3600.03 kg ingot is required, and the furnace operation lasts for 6 hours. The consumption of Gas, Electricity, and Manpower is as follows:

Total Gas consumption: 720 m³ Total Electricity: 80 kW

Total Man Hours: 6 hours

Machining Turning:

Finish turning, a process following rough turning on a lathe result in a smooth surface finish and accurately sizes the workpiece. This operation is typically executed using a Turning machine and takes approximately 204hrs hours to complete.

Machining (Facing):

Facing is an operation in machining where the metal surface is cut or milled to produce a flat, smooth, and perpendicular face. This operation is typically executed using a Facing machine and takes approximately 72hrs hours to complete.

Machining (Drilling &Boring)

A CNC drilling and boring machine, designed for drilling and boring large workpieces with a substantial diameter, functions as follows: the workpiece rotates slowly while the cutting tool rotates at high speed and feeds. During drilling, BTA chip removal is utilized, and for boring, metal chips are removed forward inside the boring rod using cutting liquid.

The drilling diameter range accommodates sizes from Φ40 to Φ120mm, with a maximum boring diameter of Φ800mm. In the Special Metallic Blanks Process of drilling, It takes approximately 48 hours to complete drilling and for the Boring Process, it takes 36 hrs.

For machining, a 3600.03 kg ingot is required, and the machine operates for 360 hours. The consumption of Electricity and Manpower is as follows:

Total Electricity: 82440 kW Total Man Hours: 360 hours

Heat Treatment (Pit Furnace):

The heat treatment process involves a controlled temperature increase, a specified soak period to maintain the material's temperature, and controlled cooling, which can be rapid in the case of quenching operations.

The maximum temperature reached in this process is 900°C. Following machining, the weight of the ingot is 3000 kg, and the furnace operation lasts for 25 hours. The consumption of Gas, Electricity, and Manpower is as follows:

Total Gas consumption: 10152 m³ Total Electricity: 21000 kW Total Man Hours: 50 hours

Straightening Press:

After the Heat Treatment Process, a hydraulic straightening press is employed to straighten special metallic blanks. The weight of the ingot post-heat treatment is 3000 kg, and the straightening process lasts for 10 hours. The consumption of Gas, Electricity, and Manpower is as follows:

Total Electricity: 3620 kW Total Man Hours: 20 hours

2nd Stress Relieving (Pit Furnace)

A pit furnace is employed for metallurgical processes that necessitate low temperatures, primarily for hardening alloys such as steel and ensuring uniform heating.

The pit furnace, when used for heat treating steel components, can reach a maximum temperature of 900°C. In this process, a 3000 kg ingot is required for heating in the furnace, which operates for 8 hours. The consumption of Gas, Electricity, and Manpower is as follows:

Total Electricity: 6720 kW Total Man Hours: 8 hours

End Cutting for Sample Band saw:

The end Cutting for the Sample and sent to a laboratory for inspection purposes.

Final Inspection:

When sample inspection reports are finalized, all the stack holders visit the site, and a final inspection is carried out in front of them.

Dispatch: 3 Ton Product When all the process of manufacturing Special Metallic Blanks is completed the Product will be dispatched.

Production Lead Time =450.5hrs Processing Time =3hrs

Total Days =18.89

Phase 04

Results and Discussion

In this phase, the results are meticulously examined with the aid of graphs. The results derived from the research work conducted to assess the application of the Value Stream Mapping (VSM) technique for reducing waste and eliminating non-value-added activities in the production process of Special Metallic Blanks will be presented and deliberated upon.

Following the comprehensive discussion and analysis of the data, the outcomes and the conclusion of the research study will be articulated.

A detailed comparison of the Gas, Manpower, and Electricity consumption results obtained from the current and future states of the manufacturing process of Special Metallic Blanks will be carried out.

All phases will be explored in-depth to provide a comprehensive and detailed overview of the overall results of the study.

Phase 05

Conclusions and Future Recommendations

In this phase, the outcomes of the research study, along with its conclusion, are discussed after a thorough analysis of the data. Future recommendations and suggestions are formulated based on the insights gained from the research study. The conclusion and future recommendations of this research work are drawn according to the results obtained and are briefly discussed at the end.

VII. Results and Comparison

In this paper, the results obtained from the research work conducted to analyze the application of the Value Stream Mapping (VSM) technique for waste reduction and elimination of non-value-added activities in the production process of Special Metallic Blanks will be presented and discussed. The Research Studies will involve actual manufacturing processes in relevant industries and will highlight the effectiveness of VSM in improving process efficiency and reducing waste.

Overview of the Research Studies:

The focus will be on understanding the existing process flows, identifying areas of waste and non-value-added activities, and implementing process improvement strategies using VSM. The key performance indicators (KPIs) such as cycle time & and lead time, Total Gas Consumption, Electricity Consumption, and Cost of Total manpower utilized will be measured before and after the implementation of Process Improvements.

Special Metallic Blanks Current State Value Stream Map:

The results of consumption of Gas, Manpower, and Electricity obtained from the current state of the manufacturing process of Special Metallic Blanks will be discussed and compared here as follows:

Special Metallic Blanks Total Gas Consumption Current State:

Table 1. Special Metallic Blanks Total Gas Consumption Current State:

	Gas Consumption (M^3)/ Hr	Total Time Hr	Gas Consumption Per Hr		Total Time Per Hr	Total Gas Consumption In Process
Heating Furnace	621.11	36	621.11	*	36	22359.96
Anti-Hydrogen Treatment	572.5	80	572.5	*	80	45800
Stress Relieving	570	6	570	*	6	3420
Heat Treatment	158.6	64	158.6	*	64	10150.4
Stress Relieving	1272	8	1272	*	8	10176

						Total Gas Consumption in Process	**91906.36**

Special Metallic Blanks Total Manpower Current State:

Table 2. Special Metallic Blanks Total Manpower Current State

	Man Hours		**Rate**	**Total Cost Current State**
Heating Furnace	72	*	156	11232
Forging 3150 Tonn Press	64	*	156	9984
Anti-Hydrogen Treatment	160	*	156	24960
Stress Relieving	12	*	156	1872
Machining (Facing, Turning)	1896	*	156	295776
Heat Treatment	144	*	156	22464
Straightening Press	40	*	156	6240
Stress Relieving	16	*	156	2496
				375024

Explanation: Table 2 shows a calculation of the total cost of manpower for the current state of manufacturing special metallic blanks, and the outcome is a sum of 375,024 Rupees. Here's a breakdown:

Calculation of Manpower Cost: The focus is on determining the total cost associated with the workforce involved in the manufacturing process. This includes wages, salaries, benefits, and any other expenses related to human resources.

Current State of Manufacturing: The calculation specifically pertains to the current state of manufacturing special metallic blanks. It reflects the expenses related to the workforce in the current scenario.

Resultant Total Cost: After conducting the calculation for manpower cost, the total cost for the current state of manufacturing is revealed. In this case, the total cost is specified as 375,024 Rupees.

In summary, the statement conveys that, after evaluating all the costs related to the workforce in the current manufacturing state of special metallic blanks, the total expenditure is determined to be 375,024 Rupees. This information is vital for financial analysis, budgeting, and understanding the economic aspects of the manufacturing process.

Special Metallic Blanks Total Electricity Consumption Current State:

Table 3. Special Metallic Blanks Total Electricity Consumption Current State

	Electricity Consumption kw/Hr	**Total Time hrs**	**Electricity Consumption /Hr**	*****	**Total Time Per Hr**	**Total Electricity consumption in Process**	**Rate**	**Total Consumption In Process**	*****	**Rate**	**Total Cost**
Heating Furnace	36.89	36	36.89	*	36	1328.04	50	1328.04	*	50	66402
Forging 3150 Tonn Press	1800	8	1800	*	8	14400	50	14400	*	50	720000
Anti Hydrogen Treatment	21.66	80	21.66	*	80	1732.8	50	1732.8	*	50	86640
Stress Relieving	21.33	6	21.33	*	6	127.98	50	127.92	*	50	6399
Machining	109.08	948	109.08	*	948	103407.84	50	103408	*	50	5170392
Heat Treatment	19.9	64	19.9	*	64	1273.6	50	1273.6	*	50	63680
Straightening Press	362	10	362	*	10	3620	50	3620	*	50	181000

Explanation:

Table 3 shows the computation of the total electricity consumption for all Processes involved in the current phase of manufacturing special metallic blanks. The result of this calculation is a total electricity cost of 6,474,513 Rupees.

Here's a breakdown of the information:

Electricity Consumption Calculation:

The primary focus is on determining the overall electricity consumption of all Processes engaged in the current manufacturing process of special metallic blanks. This involves measuring the amount of electricity used by these Processes during their operation.

Current State of Manufacturing:

The calculation specifically pertains to the current state of manufacturing special metallic blanks. It reflects the electricity requirements and usage in the present scenario.

Resultant Electricity Cost:

After computing the total electricity consumption, the table reveals the associated cost. In this case, the cost is specified as 6,474,513 Rupees. This amount represents the financial expenditure incurred for the electricity used in the manufacturing process.

In summary, the table indicates that, in the current state of manufacturing special metallic blanks, all Processes collectively consume a certain amount of electricity, resulting in an associated cost of 6,474,513 Rupees. This information is crucial for financial analysis, budgeting, and understanding the resource requirements and expenses associated with electricity usage in the manufacturing process.

Special Metallic Blanks Total Gas Consumption Future State:

The total gas consumption of all furnaces in the Future state manufacturing of special metallic blanks is calculated here.

Result: 14040 M^3 gas is consumed in the process.

Table 4. Special Metallic Blanks Total Gas Consumption Future State

	Gas Consumption (M^3)/ Hr	Total Time hrs	Gas Consumption Per Hour	*	Total Time Per Hour	Total Gas Consumption in Process
Heating Furnace	370	36	370	*	36	13320
Anti-Hydrogen Treatment	0	0	0	*	0	0
Stress Relieving	120	6	120	*	6	720
Heat Treatment	0	25	0	*	25	0
Stress Relieving	0	8	0	*	8	0
					Total Gas Consumption	**14040**

Explanation:

Table 4 shows the total gas consumption in the manufacturing process of special metallic blanks in the Future state. The result indicates that the total gas consumption for this process is 14,040 cubic meters (M^3).

Gas Consumption: This refers to the amount of gas used in the manufacturing process. Gas is often used as a heat source in furnaces to melt and shape metallic materials.

Furnaces: Furnaces are devices used in industrial processes for heating materials to high temperatures. In the context of manufacturing special metallic blanks, furnaces are likely used for melting and shaping the metal.

Special Metallic Blanks: These are likely intermediate products in the manufacturing process, possibly raw metal materials that are shaped or processed further to create final products.

Result: - 14,040 M^3 indicates the specific quantity of gas consumed in the process. The unit of measurement is cubic meters (M^3). It's important to note that the amount of gas consumed can be influenced by various factors such as the size and efficiency of the furnaces, the type of metal being processed, and the overall manufacturing process.

In summary, the provided information suggests that in the Future state manufacturing process of special metallic blanks, the total gas consumption is 14,040 cubic meters. This data is crucial for assessing the energy and resource requirements of the manufacturing operation, as well as for evaluating the environmental impact associated with gas consumption.

Special Metallic Blanks Total Manpower Future State: Explanation

	Man Hours	*	Rate	Total Cost Future State
Heating Furnace	36	*	156	5616
Forging 3150 Tonn Press	0	*	0	0
Anti-Hydrogen Treatment	80	*	156	12480
Stress Relieving	6	*	156	936
Machining (Facing, Turning)	360	*	156	56160
Heat Treatment	50	*	156	7800
Straightening Press	20	*	156	3120
Stress Relieving	8	*	156	1248
			Total Cost Future State	**87360**

Table 5 conveys that the total cost associated with manpower in the future state of manufacturing special metallic blanks has been calculated, and as a result, the total cost for the future state is specified as 87,360.

Let's break down the key points:

Manpower Cost Calculation: The focus is on determining the overall cost linked to the workforce involved in the future state of manufacturing special metallic blanks. This includes various expenses such as salaries, wages, benefits, and any other costs associated with the workforce.

Future State of Manufacturing: The calculation specifically pertains to a future scenario of manufacturing special metallic blanks. It anticipates the expenses related to the workforce in the Future manufacturing state.

Resultant Total Cost for Future State: The statement indicates that, based on the calculation of the manpower cost in the future manufacturing state, the total cost projection is 87,360. This total cost likely encompasses all relevant expenditures related to the workforce in the anticipated future state.

In summary, the Table suggests that the comprehensive cost associated with the workforce in the future manufacturing state of special metallic blanks has been calculated, and the total projected cost is 87,360. This information is valuable for financial planning, budgeting, and understanding the anticipated expenses in the future state of the manufacturing process.

In summary, the provided information suggests that in the Future state manufacturing process of special metallic blanks, the total gas consumption is 14,040 cubic meters. This data is crucial for assessing the energy and resource requirements of the manufacturing operation, as well as for evaluating the environmental impact associated with gas consumption.

Table 5. Special Metallic Blanks Total Manpower Future State: Explanation:

	Man Hours	*	**Rate**	**Total Cost Future State**
Heating Furnace	36	*	156	5616
Forging 3150 Tonn Press	0	*	0	0
Anti-Hydrogen Treatment	80	*	156	12480
Stress Relieving	6	*	156	936
Machining (Facing, Turning)	360	*	156	56160
Heat Treatment	50	*	156	7800
Straightening Press	20	*	156	3120
Stress Relieving	8	*	156	1248
			Total Cost Future State	**87360**

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Manpower Cost Calculation: The focus is on determining the overall cost linked to the workforce involved in the future state of manufacturing special metallic blanks. This includes various expenses such as salaries, wages, benefits, and any other costs associated with the workforce.

Future State of Manufacturing: The calculation specifically pertains to a future scenario of manufacturing special metallic blanks. It anticipates the expenses related to the workforce in the Future manufacturing state.

Resultant Total Cost for Future State: The statement indicates that, based on the calculation of the manpower cost in the future manufacturing state, the total cost projection is 87,360. This total cost likely encompasses all relevant expenditures related to the workforce in the anticipated future state.

In summary, the Table suggests that the comprehensive cost associated with the workforce in the future manufacturing state of special metallic blanks has been calculated, and the total projected cost is 87,360. This information is valuable for financial planning, budgeting, and understanding the anticipated expenses in the future state of the manufacturing process.

Special Metallic Blanks Total Electricity Consumption Future State:

The total electricity consumption of all Processes in the Future state manufacturing of special metallic blanks is calculated here. The electricity cost of 6282985 Rupees is consumed in the process.

Table 6. Special Metallic Blanks Total Electricity Consumption Future State

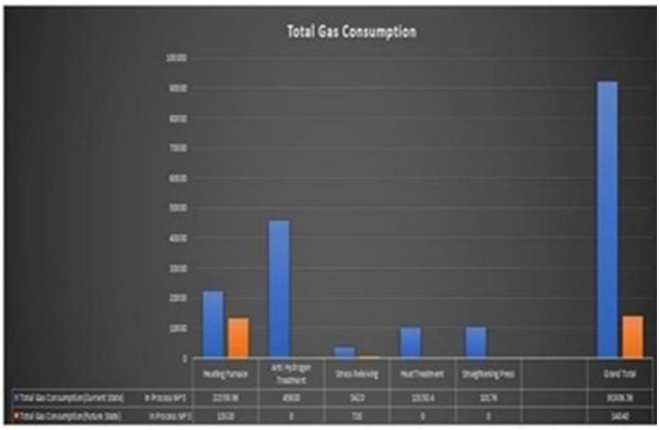
	Electricity Consumption kw/Hr	**Total Time hrs**	**Electricity Consumption**	*	**Total Time Per HR**	**Total Electricity Consumption in Process**	**Rate**	**Total Electricity Consumption In Process**		**Rate**	**Total Cost**
Heating Furnace	27.77	36	27.77	*	36	999.72	50	999.72	*	50	49986
Forging 3150 Tonn Press	1800	6	1800	*	6	10800	50	10800	*	50	540000
Stress Relieving	13.33	6	13.33	*	6	79.98	50	79.98	*	50	3999
Machining (Facing, Turning)	229	360	229	*	360	82440	50	82440	*	50	4122000
Heat Treatment	840	25	840	*	25	21000	50	21000	*	50	1050000
Straighteningng Press	362	10	362	*	10	3620	50	3620	*	50	181000
Stress	840	8	840	*	8	6720	50	6720	*	50	336000

Relieving											
										Grand Total	**6282985**

Explanation:
Table 6 conveys that the total electricity consumption for all processes in the future state of manufacturing special metallic blanks has been calculated. The outcome of this calculation is a total electricity cost of 6,282,985 Rupees.
Let's break down the key points:
Electricity Consumption Calculation: The primary focus is on determining the overall electricity consumption of all processes involved in the future state of manufacturing special metallic blanks. This involves estimating the amount of electricity needed for the various manufacturing processes.
Future State of Manufacturing: The calculation is specific to a future scenario of manufacturing special metallic blanks. It anticipates the electricity requirements and usage in the Future manufacturing state.
Resultant Electricity Cost: The Table indicates that, based on the computation of the electricity consumption for all processes in the future manufacturing state, the total electricity cost is 6,282,985 Rupees. This figure represents the financial expenditure associated with the electricity used in the anticipated future manufacturing processes.
In summary, the Table suggests that, in the future state of manufacturing special metallic blanks, all processes collectively are estimated to consume a certain amount of electricity, resulting in an associated cost of 6,282,985 Rupees. This information is crucial for financial planning, budgeting, and understanding the resource requirements and expenses associated with electricity usage in the future manufacturing process.
Comparative Analysis of Total Gas Consumption B/w Current& Future State:
The Total Gas Consumption in a Process Is 91,906 M^3 (Amount of 47, 99,309Rs) Before the Process Improvement through VSM While after Applying VSM Its value Down To 14040M^3 (Amount of 7, 33,180.04Rs) Which Is Almost Seven Times Less Consumption.

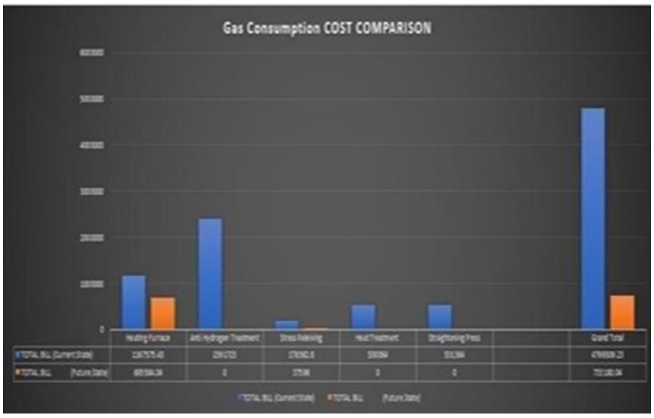
Table 7: Comparative Analysis of Total Gas Consumption B/w Current& Future State

	Total Gas Consumption (Current State) in Process M^3	Total Gas Consumption (Future State) in Process M^3	TOTAL BILL (Current State)	TOTAL BILL (Future State)
Heating Furnace	22359.96	13320	1167575.43	695584.04
Anti-Hydrogen Treatment	45800	0	2391723	0
Stress Relieving	3420	720	178582.8	37596
Heat Treatment	10150.4	0	530064	0
Straightening Press	10176	0	531364	0
Grand Total	**91906.36**	**14040**	**4799309.23**	**733180.04**



Graph 1- 1 Total Gas Consumption

Here graph below explains the comparison results of the Total Bill (Current State) and Total Bill (Future State).



Graph 1- 2 Total Cost Comparison

Comparative Analysis Total Electricity Consumption B/w Current & Future State:
Before the Process Improvement, the Total Electricity Consumption in the Process Was 129490.26 Kw (Amount of 64, 74,513Rs) While After Applying VSM Its value is 125659.7Kw (Amount of 62,82,985Rs).

Table 8. Comparative Analysis Total Electricity Consumption B/w Current & Future State

	Total Electricity Consumption (Current	Total Electricity Consumption	Total Cost Current State	Total Cost Future State

	State) In Process	(Future State) In Process		
Heating Furnace	1328.04	999.72	66402	49986
Forging 3150 Tonn Press	14400	10800	720000	540000
Anti Hydrogen Treatment	1732.8	0	86640	0
Stress Relieving	127.92	79.98	6399	3999
Machining (Facing, Turning, drilling, Boring)	103408	82440	5170392	4122000
Heat Treatment	1273.6	21000	63680	1050000
Straightening Press	3620	3620	181000	181000
Stress Relieving	3600	6720	180000	336000
Grand Total	**129490.36**	**125659.7**	**6474513**	**6282985**

Explanation:

Table 8 describes the impact of process improvement through Value Stream Mapping (VSM) on the total electricity consumption in a manufacturing process.

Here's a breakdown of the key points:

Initial Electricity Consumption: Before the implementation of process improvement using VSM, the total electricity consumption in the process was 129,490.26 kilowatts (Kw), incurring a cost of 64,74,513 Rupees.

Introduction of Value Stream Mapping (VSM): Value Stream Mapping is a methodology used for process improvement to identify and eliminate waste in manufacturing processes. In this case, VSM was applied to enhance the efficiency of the process.

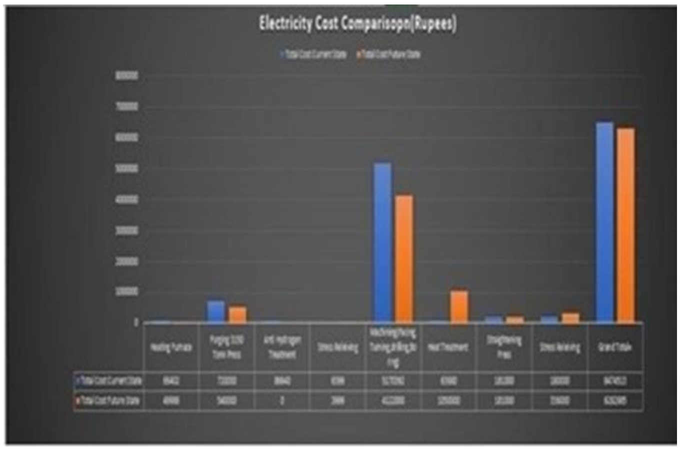
Reduced Electricity Consumption: As a result of applying VSM, the electricity consumption in the process decreased. The new total electricity consumption is reported as 125,659.7 kilowatts (Kw).

Reduced Cost: With the decrease in electricity consumption, there is a corresponding cost reduction. The new cost associated with reduced electricity consumption is reported as 62,82,985 Rupees, which is lower than the initial cost.

In summary, the application of Value Stream Mapping has led to an improvement in the efficiency of the process, resulting in a reduction in electricity consumption. This reduction in electricity consumption also translates to cost-saving, demonstrating the effectiveness of the process improvement initiative through VSM. The new values of 125,659.7 Kw and 62,82,985 Rs reflect the optimized and more resource-efficient state of the manufacturing process after the application of VSM.

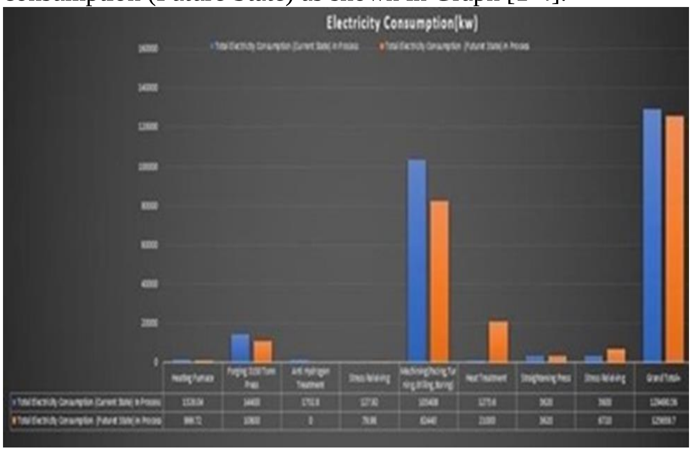
Graphical Analysis:

A graph is a visual representation of numerical data and provides a visual way to summarize complex data. Similarly, here graph explains the comparison results of Total Electricity Cost consumption (Current State) and Total Electricity Cost consumption (Future State) as shown in Graph [1-3].



Graph [1-3]. Total Electricity Cost consumption (Current State) and Total Electricity Cost Consumption (Future State)

Similarly, here graph explains the comparison results of Total Electricity consumption (Current State) and Total Electricity consumption (Future State) as shown in Graph [1-4].



Graph 1- 3 Comparison Results of Total Electricity Consumption (Current State) and Total Electricity consumption (Future State)

Comparative Analysis Total Manpower Consumption B/w Current & Future State:

Before the Process Improvement, the Total manpower cost In a Process was 3,75,024Rs while after Applying VSM Its value was 79,560Rs.

Table 9. Comparative Analysis Total Manpower Consumption B/w Current & Future State

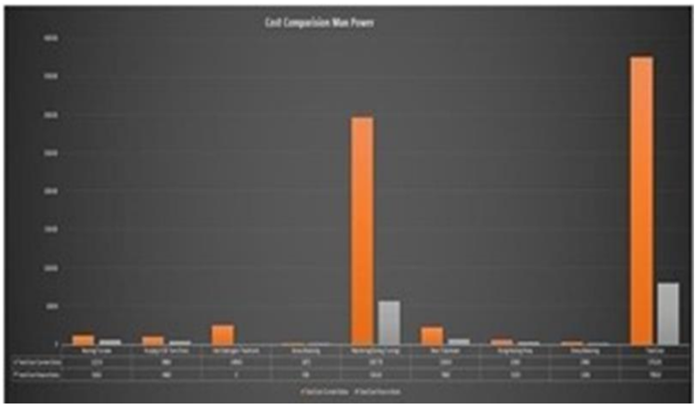
	Man Hour	*	Rate	Total Cost Current State	Man Hour	*	Rate	Total Cost Future State
Heating Furnace	72	*	156	11232	36	*	156	5616
Forging 3150 Tonn Press	64	*	156	9984	30	*	156	4680

Anti-Hydrogen Treatment	160	*	156	24960	0	*	0	0
Stress Relieving	12	*	156	1872	6	*	156	936
Machining (Facing, Turning)	1896	*	156	295776	360	*	156	56160
Heat Treatment	144	*	156	22464	50	*	156	7800
Straightening Press	40	*	156	6240	20	*	156	3120
Stress Relieving	16	*	156	2496	8	*	156	1248
Total Cost				**375024**				**79560**

Explanation:
Table 9 presents a comparative analysis of the total manpower consumption between the current state and future state, with and without process improvement through Value Stream Mapping (VSM).
Let's break down the key points:
Initial Manpower Cost (Current State): Before the implementation of process improvement using VSM, the total manpower cost in the process was 3,75,024 Rupees.
Introduction of Value Stream Mapping (VSM): Value Stream Mapping is applied as a process improvement methodology to enhance efficiency and identify waste in manufacturing processes.
Reduced Manpower Cost (Future State): After applying VSM, the total manpower cost in the future state decreased significantly. The new total manpower cost is reported as 79,560 Rupees.
In summary, the comparative analysis indicates a substantial reduction in manpower costs after the implementation of Value Stream Mapping. The initial manpower cost of 3,75,024 Rs in the current state is lowered to 79,560 Rs in the future state with process improvement through VSM. This reduction suggests increased efficiency, streamlined processes, and likely the elimination of unnecessary or redundant tasks in the manufacturing process. Lower manpower costs often indicate improved productivity and resource utilization, highlighting the positive impact of process improvement initiatives on both operational efficiency and cost savings.

Graphical Analysis:
A graph is a visual representation of numerical data and provides a visual way to summarize complex data. Similarly, the here graph explains the comparison results of Total Manpower Cost consumption (Current State) and Total Manpower Cost consumption (Future State).

Graph 1- 5. Comparative Analysis Total Manpower Consumption B/w Current & Future State:



Summary
As per the detailed Analytical and Graphical Analysis, the overall comparison will be shown as:

Table 10. Overall Comparison

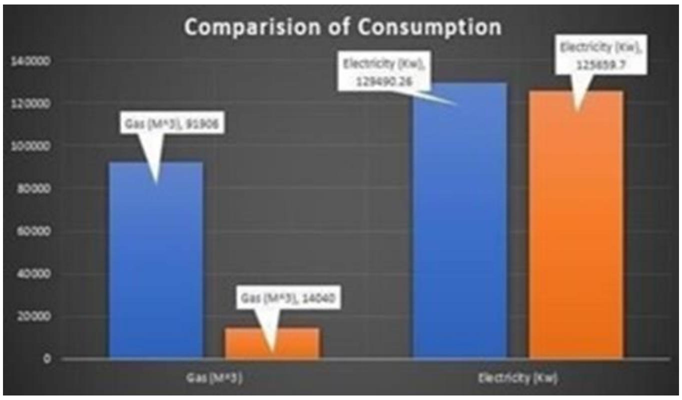
	Waste Reduction	Gas (M^3)	Electricity (Kw)	Manpower (Rs)	Time Reduction
Current Consumption	4621 Kg	91906	129490.26		48. 4 Days
Future Consumption	3870.15 Kg	14040	125659.7		18.89 Days
Current Cost		4799309	6474513 Rs	375024	
Future Cost		733180.04	6282985 Rs	79,560	
Target	**Achieve**	**Achieve**	**Achieve**	**Achieve**	**Achieve**

Explanation:
The provided table summarizes the detailed analytical and graphical analysis of three key factors—gas consumption (in cubic meters), electricity consumption (in kilowatts), and manpower cost (in Rupees)— for both the current and future states of the manufacturing process.
Here's a breakdown:
Gas Consumption (M^3):
Current Consumption: 91,906
Future Consumption: 14,040
Electricity Consumption (Kw):
Current Consumption: 129,490.26
Future Consumption: 125,659.7
Manpower Cost (Rs):
Current Cost: 4,799,309
Future Cost: 628,2985
Gas Consumption: A significant reduction is observed in future gas consumption compared to the current state, indicating an achievement of the target.
Electricity Consumption: The future state shows a slight reduction in electricity consumption, achieving the set target.
Manpower Cost: There is a substantial reduction in manpower costs in the future state, indicating an achievement of the target.

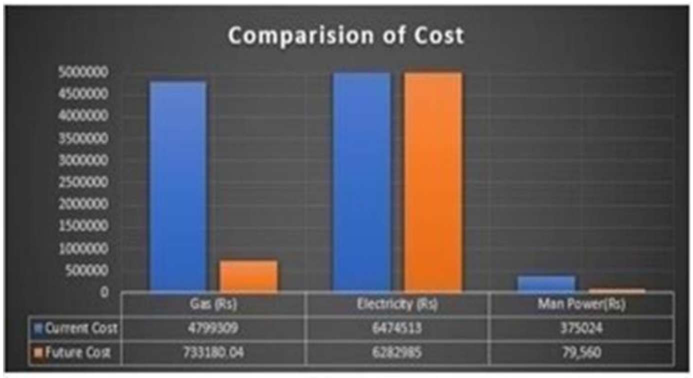
In summary, the detailed analysis and comparison reveal positive outcomes in terms of reduced resource consumption (gas and electricity) and lowered manpower costs after the implementation of process improvements. Achieving these targets suggests increased efficiency, cost-effectiveness, and improved overall performance in the manufacturing process. The graphical analysis likely supports these findings, illustrating the improvements visually.

Graphical Analysis:

A graph is a visual representation of numerical data and provides a visual way to summarize complex data. Similarly, here graph explains the Total comparison of consumption of Gas and Electricity.



Similarly, here graph explains the Total cost comparison of consumptions of Gas, Electricity, and Manpower as shown in figure [1-7].



CONCLUSION

The primary objective of this research endeavor was to devise a methodological framework aimed at enhancing the efficiency of a particular process, specifically within the domain of manufacturing Special Metallic Blanks. This improvement strategy relied heavily on the utilization of the Value Stream Mapping (VSM) technique, which serves as a powerful tool for pinpointing areas where waste is generated and eradicating elements of the production process that do not contribute value.

To accomplish this overarching goal, the study embarked on a multifaceted journey. Initially, it sought to gain an in-depth understanding of the current operational state of the production process, leaving no stone unturned in the quest for comprehensive insight. This entailed a thorough examination and analysis of every facet of the manufacturing process, with the intent of identifying inefficiencies and redundancies.

Subsequently, the research transitioned to the pivotal task of creating a visual representation of the entire production process, known as the value stream. This intricate mapping exercise served to graphically illustrate the flow of materials, information, and activities throughout the entire manufacturing process. By doing so, it enabled the identification of bottlenecks, delays, and instances of non-value-added activities with pinpoint precision.

Finally, armed with the knowledge derived from the preceding stages, the research study set out to proffer a series of recommendations and enhancements. These proposed improvements were meticulously designed to bolster operational efficiency while concurrently purging the production process of any elements that were deemed wasteful or non-value-adding. In essence, the study's goal was to streamline the manufacturing of Special Metallic Blanks, ensuring that resources were utilized optimally, and that the product was delivered with the highest degree of efficiency and value.

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