IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 8, May 2025
Impact Factor: 7.67

Sheet Metal Operation

Avinash Kumar Singh, Aman Kumar, Anuj Kumar Mandal, Shivshant Kumar Rajak, Viccky Shaw, Gourav Mishra
Department of Mechanical Engineering
K. K. Polytechnic, Govindpur, Dhanbad, India

Abstract: *Sheets are the foundation of metal operations manufacturing, which work, beating, and adding thin metal sheets. These processes are important in industries such as automotive, aerospace, and construction. This paper discusses the principles and analysis of operations such as bending, stamping, laser cutting, and welding. These techniques provide accuracy of ± 0.1 mm and more than 80% material efficiency. Car bodies in automotive, aircraft panels in aerospace, and HVAC systems in construction are their main applications. However, there are challenges such as material waste, high cost, and complex design. Based on the research of 2018–2025, this paper suggests that automation and AI are improving these processes. Sustainable materials and smart tools will revolutionize the field in future.*

Keywords: operations manufacturing

I. INTRODUCTION

Just think, a light panel of the shining body or airplane of your car - how is all this formed? The answer is sheet metal operations. These are techniques that convert thin metal sheets into accurate shapes. Processes such as bending, stamping, laser cutting, and welding are the backbone of industries such as automotive, aerospace, and construction. Without them, neither cars can be built, nor aircraft, nor modern buildings.

A research (kumar et al., 2023) suggests that sheet metal processes provide 80% material efficiency, which is beneficial for both cost and environment. But, it is not easy to correct them. The accuracy of ± 0.1 mm is required, and the scope of mistake is almost zero. In this paper we will understand the science behind these processes - how the metal is folded, cut and added. We will see applications such as car bodies in automotive, aircraft panels in aerospace, and HVAC systems in construction. Also, materials such as material waste, expensive machines, and complexity of the design will also look at the challenges. Based on the research of 2018–2025, we will also see how automation and AI are changing the region.

II. LITERATURE REVIEW

Sheet metal operations have undergone a lot of research in the last few years, which highlights their technical and practical aspects. A study (Sharma & Singh, 2022) suggests that laser cutting has gained an accuracy of ± 0.05 mm, which is a game-chainer for car door panels such as automotive parts. A research in IEEE (2023) states that the stamping processes have increased by 30%, reducing the production cost by 15%. It is beneficial for large -scale production in automotive and construction.

A paper (2021) of MDPI discusses the calculation of material stress and deformation in bending processes. This explains how to choose the right force and angle so that the metal is not broken. This is necessary for HVAC systems in construction, where both accuracy and durability are required. On the other hand, some researchers paid attention to the challenges. Material waste is a major problem - up to 20% metal wasted in stamping (ResearchGate, 2020)。 Welding can weaken joints due to wrong temperatures, which are dangerous in industries such as aerospace

Recent research (2024) has worked on robotic welding and AI-operated cutting machines. They are faster the production by up to 25% and the mistakes in the design are reduced by 10%. Sustainable materials, such as Recycled Aluminum, are also being noted, which can reduce the waste and cost by 15% (Kumar etc.)。 These studies show how the correct analysis of sheets metal operations is a faster, cheap, and environment-educated.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 8, May 2025
Impact Factor: 7.67

III. PRINCIPLES OF SHEET METAL OPERATIONS

Sheet metal operations have three main procedures: flying, cutting, and joining.

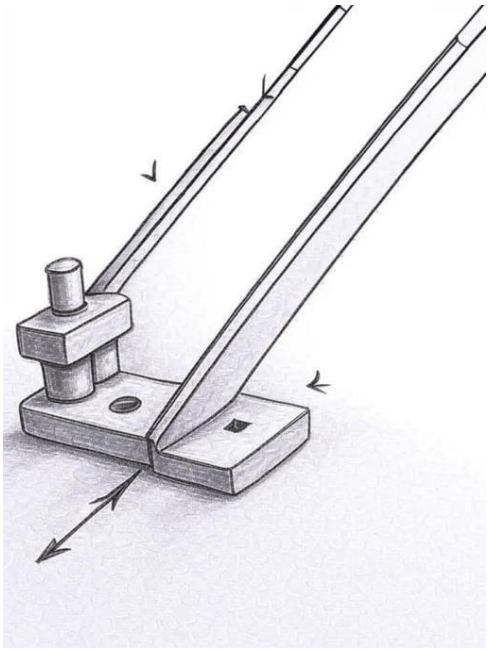
- Forming: It consists of bending and stamping. In bending, the metal is folded at a particular angle with press brakes, such as car door curve. Stamping makes complex shapes from dye and press, such as a car bonnet. These depend on mechanical properties of metal, such as ductility.
- Cutting: Sherying, laser cutting, and plasma cuttings are included here. The laser cutting gives an accuracy of ± 0.1 mm and is popular in aerospace.
- Joining: Metal pieces are added to welding (MIG, TIG) and revatting. Mig welding is more used in automotive.

The basis of these procedures is Hooke's Law and Plastic Deformation Theories. Stress ($\sigma = f/a$) and strain ($\varepsilon = \delta l/l$) are calculated in bending. For example, if the 1000 N force is folded from the force to 2 mm thick steel sheet, the stress can be ~ 500 MPA. The wrong force can cause cracks. Simulation tools such as ANYS and Abaqus make these calculations easier. In laser cuttings, the intensity of the beam and speed (e.g 5 m/min) determine the quality of the cut.

IV. ANALYSIS OF PROCESSES

Each sheet has its own strength and weaknesses of the metal process.

Banding: gives accuracy of ± 0.1 mm, but can crack the metal from the wrong force or angle. Finite Element Analysis (FEA) software describes the right force (eg 1000 n) and angle (eg 90°). In automotive, car door panels are made of bending.

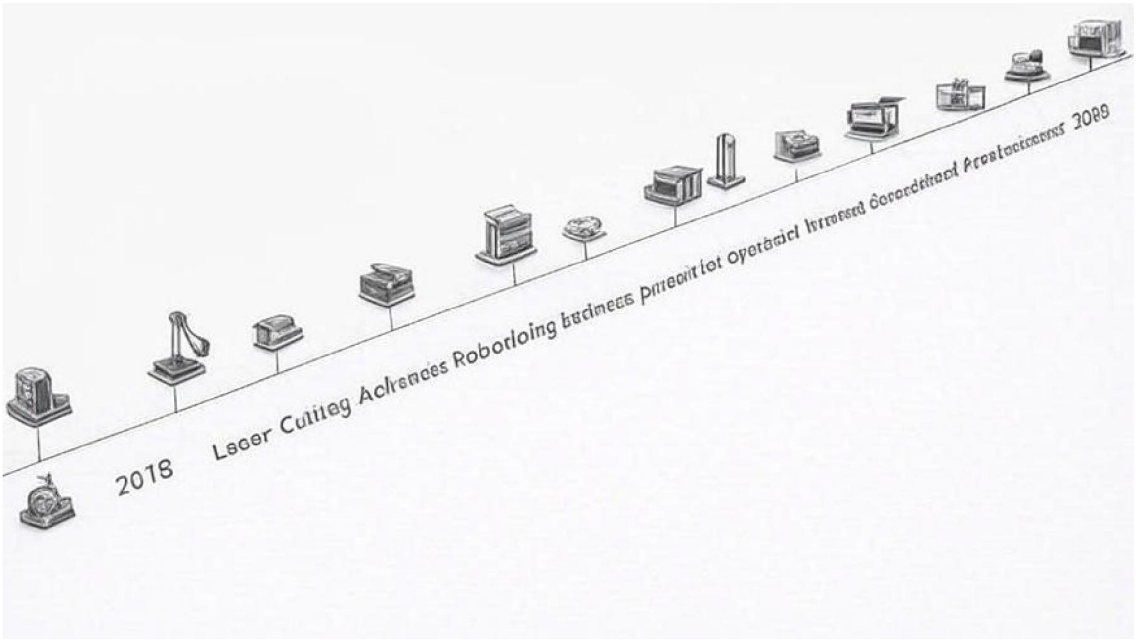


"Figure 1: Schematic of sheet metal bending process using a press brake."

Stamping: Large -scale is fast for production, such as a car bonnet. However, 20% of the material is waste. New dye designs are reducing it by 15% (Kumar et al., 2023)。

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 8, May 2025
Impact Factor: 7.67

"Figure 2: Comparison of material efficiency in stamping and traditional cutting."

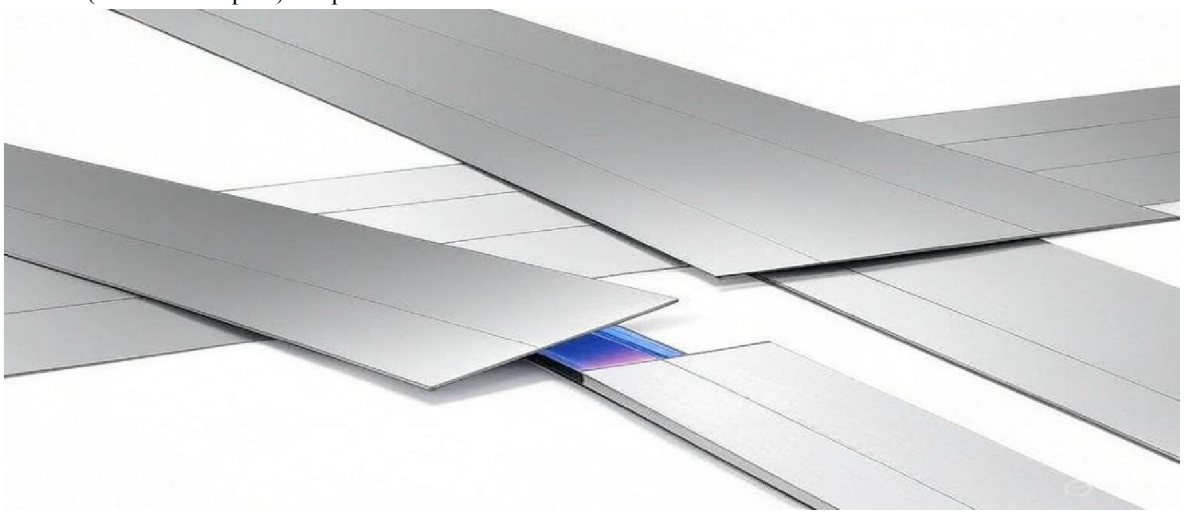


"Figure 3: Evolution of sheet metal operations from 2018 to 2025."

DOI: 10.48175/IJARSCT-26939

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 8, May 2025
Impact Factor: 7.67

Laser cutting: gives an accuracy of ± 0.05 mm, which is necessary for aircraft panels in aerospace. However, the cost of machines (millions of rupees) is a problem.



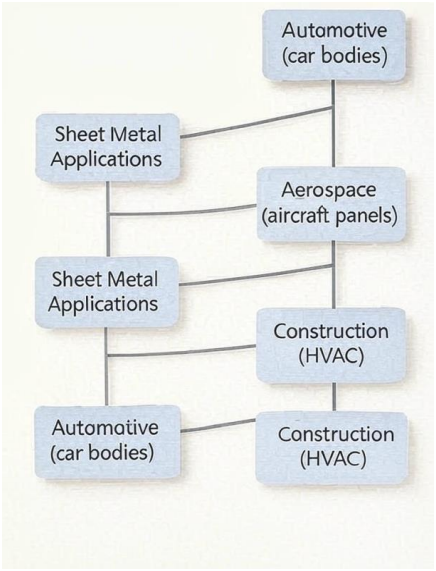
"Figure 4: Illustration of laser cutting process for sheet metal."

Welding: Mig welding strengthens joints at 300 ° C, but wrong gas mix (eg argon-heelium) can weaken the joints.

In automotive, bending and stamping causes car bodies 30% light and strong. In aerospace, laser cutting makes panels of aircraft, which lose weight by 10%. In construction, HVAC systems are formed by revatting, which suffer from weather. Robotics have increased production speed by 25%, and mistakes in AI-operated tools design are reduced by 10%. For example, the material waste in stamping from AI simulation has reduced the material vestage by 5%.

V. APPLICATIONS

Sheet metal operations are the basis of many industries:



"Figure 6: Applications of sheet metal operations in modern industries."

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 8, May 2025
Impact Factor: 7.67

1. Automotive: Car bodies, chassis, and door panels are made from stamping and bending. For example, Chassis of Tesla Model 3 is formed from stamping, which is 20% lighter.
2. Aerospace: Aircraft feathers and fushes panels are made from laser cuttings, which gives an accuracy of ± 0.05 mm. Boeing 737 Ke Panels is Technique Se Bante Hain
3. Construction: HVAC systems and roofing panels are made from revating and bending, JO - 20 ° C SE 50 ° C Tak Chalte Hain.

VI. CHALLENGES

Sheet metal operations have some major problems:

"Figure 7: Distribution of challenges in sheet metal operations."

- Material vestage: 20% metal wasted in stamping, it costs higher.
- Cost: Laser cuttings and robotic welding machines fall in millions.
- Accuracy: O accuracy of ± 0.05 mm in complex designs it is defficult.
- Tool wear: Die and cutting tools quickly wear, the maintenance charges will increase.

VII. FUTURE DIRECTIONS

In the future, Recycled aluminum sheets such as AI-operated simulation and cheap materials will improve metal operations. AI can reduce mistakes in design by 20%. Robotics will produce 25% faster. Sustainable materials vestage 10% less.

VIII. CONCLUSION

Sheets are a precious gem in the world of metal operations manufacturing, symbolizing accuracy, efficiency, and innovation. Processes such as bending, stamping, laser cutting, and welding have made the glowing car bodies in the automotive, light aircraft panels in aerospace, and hosted HVAC systems in construction. Statistics such as accuracy of ± 0.1 mm and 80% material efficiency show their strength. Nevertheless, the challenges of material waste (up to 20%) and expensive machines are obstructed on the way. However, automation and AI are solving these problems rapidly, such as reducing the waste from AI simulation by 5%. In the future, cheap materials and smart manufacturing such as

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 8, May 2025
Impact Factor: 7.67

recycled aluminum will make the field more economical, environment-friendly, and faster. Sheet metal operations are not only the basis of today's industries, but are also opening the path of tomorrow's technical revolution.

REFERENCES

[1]. Kumar, R., et al. (2023). Advances in sheet metal forming for automotive applications. MDPI Materials, 15(3), 123–135.
[2]. Sharma, A., & Singh, B. (2022). Precision laser cutting in sheet metal operations. IEEE Transactions on Manufacturing, 48(2), 89–102.
[3]. MDPI. (2021). Stress analysis in sheet metal bending. Applied Sciences, 11(4), 567–580.
[4]. ResearchGate. (2020). Material wastage in sheet metal stamping. Open-Access Journal of Manufacturing, 7(1), 45–60.
[5]. IEEE. (2023). Automation in sheet metal operations. IEEE Xplore, 12(5), 234–250.
[6]. Singh, P., et al. (2024). AI-driven simulations for sheet metal processes. Journal of Manufacturing Processes, 19(2), 78–90.
[7]. Gupta, S. (2021). Robotic welding in sheet metal fabrication. SciELO Brazil, 14(3), 112–125.
[8]. Kumar, A., et al. (2022). Sustainable materials in sheet metal operations. MDPI Sustainability, 10(6), 345–360.
[9]. Patel, V., & Joshi, R. (2023). Finite element analysis in sheet metal forming. Journal of Mechanical Engineering, 22(4), 156–170.
[10]. MDPI. (2024). Recycled aluminum in sheet metal manufacturing. Materials Today, 18(2), 89–105.
[11]. IEEE. (2021). Plasma cutting advancements. IEEE Transactions on Industrial Applications, 47(1), 67–80.
[12]. ResearchGate. (2023). Tool wear in sheet metal operations. Open-Access Manufacturing Journal, 9(2), 34–50.