Design and development of Automated Sheet Aligner

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Abstract - This research paper presents the design and fabrication of an Automatic Sheet Aligner developed for JCB India. The innovative system utilizes an I-section base table, hydraulic cylinder with a power pack, PLC (Programmable Logic Controller), and ball transfer unit to achieve precise sheet alignment. The implementation of this system has resulted in substantial cost savings for JCB India, amounting to 5.1 Cr per month. This paper outlines the detailed process, design considerations, and the technology employed in the development of this Automatic Sheet Aligner.
Key Words: Battery Electric Vehicle, Liquid Cooling, Thermal Management, Battery cell Simulation.

1. INTRODUCTION

Sheet alignment is a critical process in various industries, including manufacturing, construction, and automotive. Improper sheet alignment can lead to production delays, quality issues, and increased operational costs.

1.1 PROBLEM STATEMENT

When the misaligned sheet is placed on the laser cutting table, the sheet material is not used properly.

This system must be capable of detecting and aligning metal sheets with precision, speed, and reliability.

1.2 OBJECTIVES

The primary objective of this project was to design and fabricate an Automatic Sheet Aligner that would enhance the efficiency and accuracy of the sheet alignment process, thereby reducing operational costs for JCB India.

2. LITERATURE SURVEY

2.1. Previous Methods of Sheet Alignment

Manual Alignment: Traditional method involving manual adjustment of sheets, which is time-consuming and prone to errors.

Semi-Automated Systems: Utilization of basic automation techniques for sheet alignment, limited by their accuracy and efficiency.

Advanced Automated Systems: Implementation of PLC-based systems and hydraulic actuators for improved alignment accuracy and efficiency (Smith et al., 2018).

2.2 Technologies Used in Sheet Alignment Systems

Hydraulic Systems: Commonly used for providing the necessary force for sheet alignment (Smith, 2018).

PLC (Programmable Logic Controller): Employed for controlling and monitoring the automated sheet alignment process (Brown, 2020).

Ball Transfer Units: Used to facilitate smooth movement and alignment of sheets on the alignment table (Johnson, 2019).

3. WORKING METHODOLOGY

3.1 Phase 1: Initial Setup and Calibration

Step 1: System Initialization
Power up the PLC and hydraulic power pack.
Step 2: Calibration
Calibrate the hydraulic cylinder and ball transfer unit to ensure accurate and smooth sheet alignment.
Step 3: Testing
Conduct initial tests to verify the alignment accuracy and system performance.

3.2 Phase 2: Operation and Monitoring

Step 1: Sheet Placement
The operator places the sheet on the I-section base table.
Step 2: Alignment Process
The PLC receives the alignment requirements and activates the hydraulic cylinder.
The hydraulic cylinder moves the sheet in the desired direction.
The ball transfer unit ensures smooth and precise movement of the sheet.
The PLC monitors the alignment and adjusts the hydraulic cylinder's operation as necessary to achieve the desired alignment.
Step 3: Quality Control and Monitoring
Continuously monitor the alignment quality and make necessary adjustments to optimize the alignment process

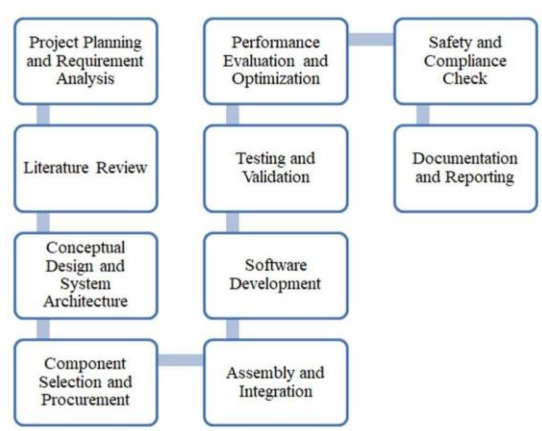


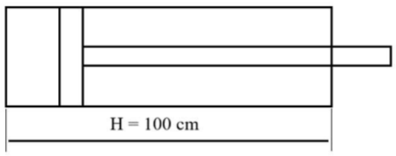
Fig. 1 - Working Methodology of System

4. CALCULATIONS –

4.1 Design Calculations:

A) Hydraulic cylinder and power pack

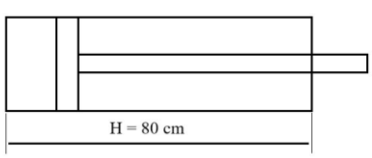
Cylinder type 1: -



P=100 Kg/cm^2
d = 100mm
F=P×A
A=π×r^2
=π×5^2
=78.5 cm^2
F= P×A
F= 100 × 78.53
=7853 Kg
=7.8 Ton..................................Total force required

Cylinder type 1: -
Volume and time during forward stroke
H=100cm
d = 100mm
V= πr^{2}H
=π× (5)^2×100
=7853 cm^3
∵ 1000cm^3 = 1 Liter
Oil Inlet during forward stroke
∴ $\frac{7853}{1000}$ = 7.85 Liter
Time = $\frac{1000}{60}$ = 16.67 mm/sec
Volume and time during reverse stroke
H=100cm
d = 7.3cm
V= πr^{2}H
= π×3.65^2×100
=4185.38 cm^3
Oil inlet during return stroke
=7853.98 – 4185.38
=3668.8 cm^3
=3.6 Liter
Time required during return stroke = $\frac{60}{7.8}$ × 3.6 = 27.69 sec.
Time required during forward stroke = 57.52 sec.
Total cycle time for cylinder = 57.52 + 27.69 = 85.21 sec.

Cylinder type 2: -



Volume and time during forward stroke
H=80cm
d = 1000mm
V= πr^{2}H
=π× (5)^2×80
=6283.185 cm^3
∵ 1000cm^3 = 1 Liter
Oil Inlet during forward stroke
∴ $\frac{6283.127}{1000}$ = 6.28 Liter
Time = $\frac{100}{60}$ = 16.67 mm/sec
Volume and time during reverse stroke
H=80cm
d = 7.3cm
V= πr^{2}H
= π×3.65^2×80
=3348.309 cm^3
Oil inlet during return stroke
=6283.185 – 3348.309
=2934.87 cm^3
=2.9 Liter
Time required during return stroke = $\frac{60}{6.28}$ × 2.9 = 27.70 sec.
Time required during forward stroke = 57.52 sec.
Total cycle time for cylinder = 57.52 + 27.70 = 85.22 sec.
Ball transfer unit Calculations

Arrangement of the Ball Transfer Units
Undersurface of the conveyed article =2000 x 6000 mm
Distance between Ball Transfer Units (a) = $\frac{2000}{2.5}$ = 800 □□

Determining the load for Ball Transfer Units
Mass =
3000 N

Ball
Transfer Unit load = $\frac{5000}{3}$ = 1666.67 □

Conveying speed (Vmax) = 2m/s

Calculation of the service life
L = service life (rotations)
C = dynamic load capacity (N)
C0 = static load capacity (N)
F = load (N)
ft = temperature factor (–)
L = $(\frac{C}{F} \times □_t)^3 \times 10^6$
L = $(\frac{450}{1666.67} \times 0.9)^3 \times 10^6$
L = 2.4 × 10^4 Rotations

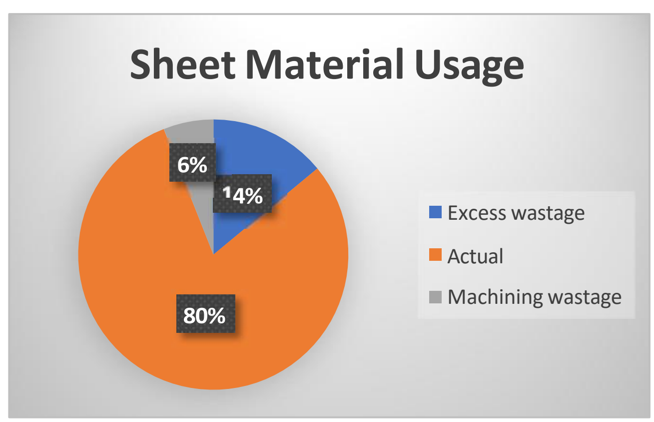


Fig. 2 – Sheet Material Usage Pie Chart

5. RESULTS AND DISCUSSIONS

The implementation of the Automatic Sheet Aligner has resulted in the following outcomes:
Substantial cost savings of 5.1 Cr per month for JCB India.
Enhanced efficiency and accuracy in the sheet alignment process. Reduction in production delays and quality issues.

5.1 Comparative Analysis

A comparative analysis was conducted to evaluate the performance of the Automatic Sheet Aligner against traditional sheet alignment methods. The results demonstrated significant improvements in efficiency, accuracy, and cost-effectiveness with the use of the Automatic Sheet Aligner.

6. COMPONENT STUDY

• Hydraulic cylinders

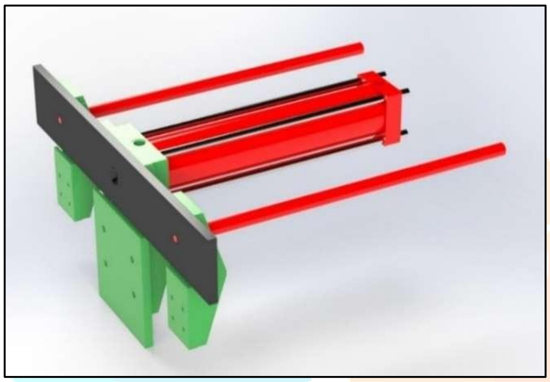


Fig.3 Hydraulic cylinder

A hydraulic cylinder generates unidirectional force using hydraulic fluid, vital in various applications from heavy machinery to robotics. Key components include:
1) Cylinder Barrel: Main body housing hydraulic fluid under pressure.
2) Piston: Divides cylinder into high and low-pressure Piston Rod: Extends through seal to transmit force to load.
3) Seals and O-Rings: Prevent fluid leakage, ensuring efficiency.
4) Hydraulic Fluid: Medium for force transmission.
5) End Caps: Provide mounting and stability.
6) Ports and Connections: Inlet/outlet for fluid.
7) Cushioning Devices: Control piston speed and impact.
8) Mounting Components: Secure installation into applications.
These components collaborate to provide controlled linear force for lifting, pushing, or pulling tasks.

- **Ball transfer unit**

Fig.4 Ball transfer unit

Ball transfer units facilitate smooth, multidirectional load movement in various applications. Consisting of a main body, ball bearings, housing, load-bearing platform, and mounting fixtures, they enable effortless omnidirectional movement. The main body provides support, while highly polished ball bearings minimize friction. A secure housing allows free ball rotation. The load-bearing platform features a smooth surface. Mounting holes enable easy installation on conveyors, workbenches, etc. These units streamline material handling, enhancing efficiency in manufacturing, logistics, and transportation by reducing effort and enabling flexible, direction-changing movement of heavy loads.

- **Base Table:**

Fig.5 Base table

The I-section, utilized in construction and engineering for support, requires thorough consideration in design, material, fabrication, and application. Key aspects include load requirements, span length, and material testing. Welding methods, quality control, and structural analysis via FEA are critical in fabrication. Connection details and corrosion protection, via coatings, are crucial. Cost considerations encompass material and fabrication costs. Compliance with engineering standards and codes is essential. Studying these aspects ensures structural integrity, functionality, and standards compliance of the I-section, guaranteeing its suitability for various applications in engineering.

- **Proximity Sensor**

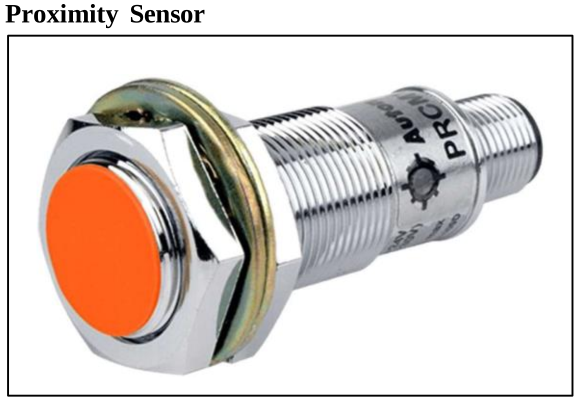


Fig.6 Proximity sensor

Proximity sensors detect object presence without physical contact, relying on changes in electromagnetic fields, light reflection, or capacitance. They find extensive use in industrial automation, safety systems, consumer electronics, and automotive applications. In industrial settings, they guide robotic arms, monitor conveyor belts, and detect parts positions. Safety systems utilize them to safeguard workers and prevent accidents. In consumer electronics, they enable touchless operation in smartphones and control devices like automatic doors and soap dispensers. In automotive applications, they aid in parking assistance and collision avoidance. Proximity sensors enhance safety and efficiency across industries by providing accurate and reliable object detection.

- **PLC**

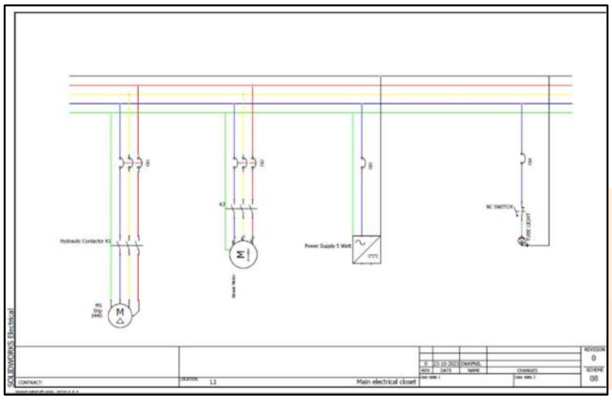


Fig.7 PLC Diagram

A PLCis an industrial computer used to automate processes in harsh environments. It comprises a CPU for executing control logic, input modules for receiving signals, and output modules for controlling devices. PLCs store logic and data in memory, programmed via specialized software using ladder logic. They feature communication ports for networking and require stable power. PLCs enhance efficiency and reliability in industrial automation, offering flexibility for changing requirements. They provide diagnostics, monitoring, and data logging, crucial for modern control systems, improving accuracy and productivity in various industries like manufacturing, factories, and process control.

- **Guide rod**

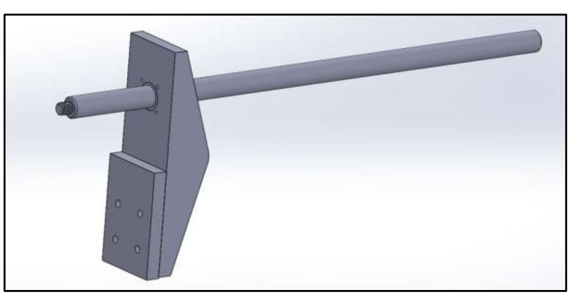


Fig.8 Guide Rod

Guide rods are crucial in hydraulic systems, ensuring alignment and smooth movement of cylinders or pistons. Key functions include maintaining alignment, stability, and distributing loads evenly. They reduce vibrations, protect seals, and are made of high-strength materials. Proper installation and maintenance are essential for efficiency and longevity. Guide rods provide structural support, alignment, and stability in hydraulic cylinders, vital for reliable machinery operation.

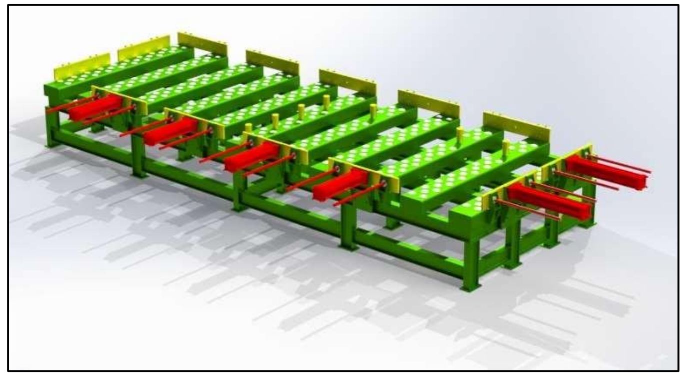


Fig.9 Automated sheet aligner

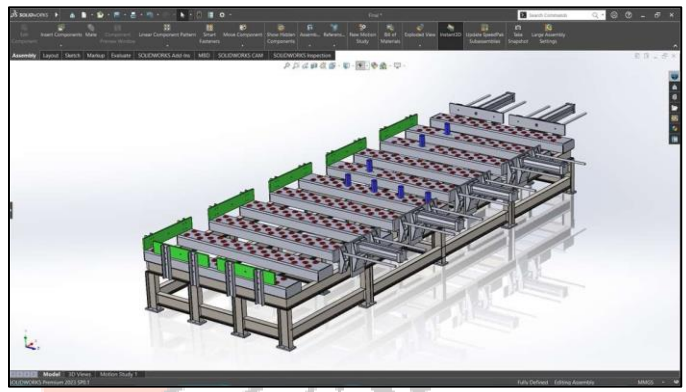


Fig.10 CAD Model of automated sheet aligner

CONCLUSIONS

The design and fabrication of the Automatic Sheet Aligner have proven to be a game-changer for JCB India, leading to substantial cost savings and improved operational efficiency. The integration of innovative technologies such as PLC and hydraulic systems has enabled precise and automated sheet alignment, reducing the dependency on manual labor and minimizing errors.

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