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Design and Fabrication of Multi-Purpose Sieving Machine

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Abstract—

This paper presents the design, fabrication, and performance evaluation of a multi-purpose sieving machine for small-scale industrial, agricultural, and construction applications. The machine employs a slider-crank mechanism driven by a 0.5 HP (375 W) DC motor operating at 60 RPM to convert rotary motion into reciprocating motion for efficient particle separation. The structural frame is fabricated from mild steel C-channel sections, while the sieve bracket uses aluminum to minimize weight. A V-belt pulley system transmits power from the motor to the crank mechanism. SolidWorks CAD modeling facilitated design optimization and component interaction analysis before fabrication. Performance testing demonstrated an average separation efficiency of 93%, with a throughput capacity of 50–250 g per test cycle. The total fabrication cost of ₹7,300 confirms the machine's affordability for resource-constrained environments. The design is portable, low-maintenance, and adaptable to multiple mesh sizes, making it suitable for diverse material separation tasks.

Keywords—sieving machine; slider-crank mechanism; DC motor; V-belt drive; particle separation; fabrication; mild steel; SolidWorks CAD

I. INTRODUCTION

Sieving is a fundamental process in construction, agriculture, pharmaceuticals, and food processing where materials must be separated by particle size. Traditional manual sieving is time-consuming, labour-intensive, and prone to inconsistencies arising from operator fatigue. While mechanised sieving machines address these shortcomings, their high cost and bulk restrict access for small-scale industries and rural users.

This project bridges that gap by designing and fabricating a cost-effective, compact, and versatile sieving machine. The machine integrates a slider-crank mechanism with a DC motor and a V-belt drive to automate the reciprocating sieve motion. Its adaptable mesh configuration supports a wide range of

materials, from fine powders to coarse aggregates, while its total fabrication cost of ₹7,300 makes it accessible to resource-constrained users.

The paper is organised as follows: Section II reviews relevant literature; Section III states the problem; Section IV details the design and calculations; Section V describes the components; Section VI covers the fabrication process; Sections VII and VIII present results and cost analysis; Section IX concludes.



Fig. 1. Conventional manual sieving method.

II. LITERATURE REVIEW

Sieving technology has evolved from primitive woven-reed tools in ancient Egypt to motorised vibrating and centrifugal sieves in modern industry [1]. During the Industrial Revolution, rotary sifters and vibrating sieves improved throughput for mining and construction [2]. Despite these advances, high capital and maintenance costs limit adoption in small enterprises [3].

Patel and Sharma [6] designed a reciprocating sieve for agricultural use and reported significant reductions in processing time versus manual methods. Thomas and Kumar [7] analysed vibrating sieves and concluded that sieve frequency and amplitude critically affect separation efficiency. Gupta and Agarwal [8] fabricated a low-cost sieve for small industries using standard mild-steel sections, achieving a build cost below ₹8,000. Singh and Verma [9] studied slider-crank applications in sieving and showed that crank length and connecting rod ratio govern stroke length and throughput.

Kumar and Anand [10] performed dynamic optimisation of a crank-driven vibrating sieve and identified RPM ranges that minimise resonance-induced vibrations. Chatterjee and Roy [11] introduced innovative sieve designs for the construction sector with improved mesh support. Das and Nayak [12] explored advanced materials to extend mesh life. The present work builds on these findings by combining a slider-crank mechanism with a

compact belt drive and aluminum sieve bracket to meet both performance and affordability targets.



Fig. 2. Commercial rotary sieve (Clarke model) illustrating existing mechanised solutions.

III. PROBLEM STATEMENT

Existing sieving practices in small-scale industries suffer from five key limitations: (i) reliance on manual labour resulting in low throughput (~50 kg/h); (ii) prohibitive cost of commercial automated machines; (iii) limited versatility for different material types; (iv) high energy consumption in large industrial sieves; and (v) large physical footprints unsuited to constrained workspaces. The design objective is therefore a machine that is motor-driven, mesh-interchangeable, compact, portable, and buildable within a budget of ₹10,000.

IV. DESIGN AND METHODOLOGY

A. Working Principle

The machine operates on the principle of motion conversion. A 0.5 HP DC motor supplies rotational energy that is transmitted via a V-belt to a crank disc. The crank converts rotation into linear reciprocating motion through a connecting rod attached to the sieve bracket. As the bracket oscillates, material loaded onto the sieve is separated: particles smaller than the mesh aperture pass through while oversized particles are retained [9].

B. Slider-Crank Kinematics

The displacement x of the sieve bracket (slider) as a function of crank angle θ is given by:

$$x = R(1 - \cos\theta) + \sqrt{L^2 - R^2 \sin^2\theta}$$

where $R = 10$ cm is the crank radius and $L = 30$ cm is the connecting-rod length. The stroke length equals $2R = 20$ cm. This relationship was used to select component proportions that deliver smooth, resonance-free motion at 60 RPM [10].

C. Power and Torque Analysis

Torque was calculated from motor power $P = 375$ W and angular velocity $\omega = 2\pi N/60 = 6.28$ rad/s at $N = 60$ RPM:

$$T = P / \omega = 375 / 6.28 \approx 59.7 \text{ Nm}$$

The shaft torsional analysis used a mild-steel maximum shear stress of $\tau = 300$ MPa and shaft diameter $D = 30$ mm, confirming a torsional capacity of 1589.6 Nm, well above the operating torque, ensuring structural adequacy [14].

D. Design Calculation Tables

TABLE I. Torque and Belt-Length Parameters

Parameter	Value
Motor Power (P)	375 W (0.5 HP)
Angular Velocity (ω)	6.28 rad/s
Torque (T)	59.7 Nm
Driver Pulley Diameter (d_1)	50 mm
Driven Pulley Diameter (d_2)	150 mm
Centre Distance (C)	500 mm
Belt Length (L)	≈ 1162 mm

The belt length was computed using the standard open-belt formula. With $d_1 = 50$ mm, $d_2 = 150$ mm, and $C = 500$ mm, $L \approx 1162$ mm. The speed ratio $d_1/d_2 = 0.333$ yields a machine speed of 66.7 RPM from a 200 RPM motor. Actual operating speed was measured at 62.5 RPM, consistent with minor belt slip [8].

E. CAD Modelling

The complete assembly was modelled in SolidWorks 2023. Stress and motion analyses verified structural integrity under dynamic loads and confirmed smooth slider-crank operation before physical fabrication commenced [3].

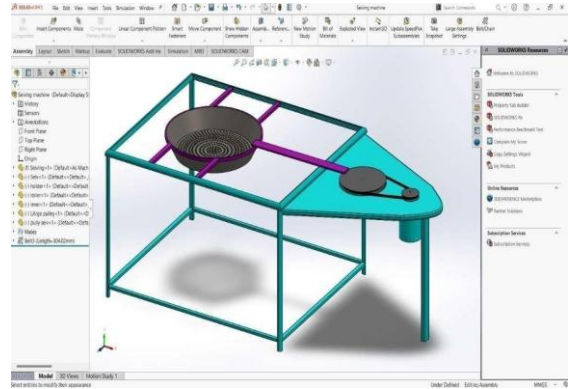


Fig. 3. SolidWorks 3-D assembly (initial circular sieve design).

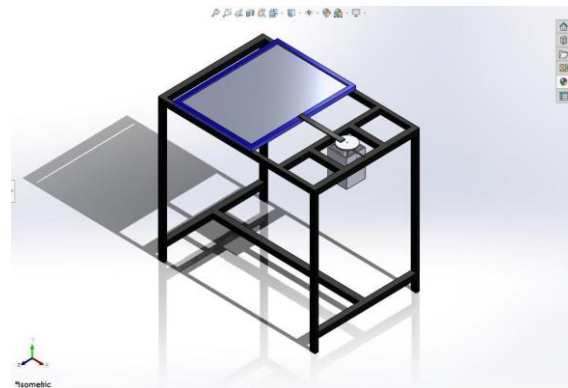


Fig. 4. Revised SolidWorks assembly (rectangular sieve design).

V. COMPONENT DESCRIPTION

A. Structural Frame

The frame is fabricated from C-channel mild steel sections welded into a rigid rectangular structure. It provides the mounting

platform for the motor, crank mechanism, and sieve bracket. Four castor wheels affixed to the base legs ensure portability. An anti-corrosion paint coating extends service life [5].



Fig. 5. Fabricated mild-steel frame with castor wheels.

B. DC Motor

A 1/5 HP (149 W nominal) DC motor from Vinny Electric rated at 220 V AC (rectified internally) and 1,600 RPM base speed is used. After the pulley reduction, the crank disc rotates at approximately 62 RPM. The motor draws a full-load current of 1.3 A and uses a 3 μ F run capacitor [13].



Fig. 6. DC motor (Vinny Electric, 1/5 HP, 1600 RPM).

C. Crank Disc and Connecting Rod

The crank disc is cut from 6 mm mild-steel plate and fitted with an M8 threaded stud offset by $R = 100$ mm from the disc centre. The

connecting rod (flat mild-steel bar with two drilled holes, 300 mm between centres) links the crank pin to the sieve bracket pin, converting circular to linear motion [9].



Fig. 7. Crank disc with offset threaded stud.



Fig. 8. Connecting rod (flat mild-steel bar).

D. Sieve Bracket and Mesh

The sieve bracket (500 mm $\times$ 300 mm) is fabricated from aluminium sheet metal to reduce reciprocating mass. A stainless-steel woven-wire mesh is stretched over the bracket and secured with bolts. Mesh aperture size is interchangeable to suit different material separation requirements [12].

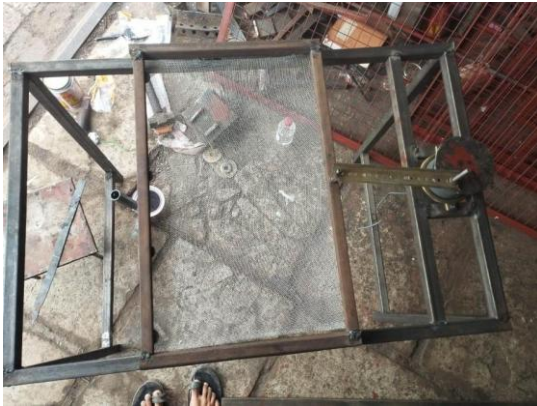


Fig. 9. Sieve bracket with wire-mesh installed on frame.

E. Belt and Pulley System

A V-belt connects a 50 mm cast-iron driver pulley (on the motor shaft) to a 150 mm driven pulley (on the crankshaft). Belt length is 1,162 mm. This 3:1 reduction delivers the required crank speed while increasing torque. Precise laser alignment of pulleys prevents belt slippage and premature wear [8].

VI. FABRICATION PROCESS

The fabrication sequence comprised five stages: (1) material procurement and inspection; (2) cutting – mild-steel sections and aluminium sheets were cut to dimension with a power saw and metal shear; (3) machining – the crank disc was turned on a lathe to ensure concentricity; (4) welding – the frame was MIG-welded, joints ground smooth, and an epoxy anti-rust primer applied; (5) assembly – motor, pulley system, crank, connecting rod, sieve bracket, and mesh were integrated and aligned.

Quality checks included dimensional verification against the CAD drawings, visual weld inspection, static load testing of the frame, and a 30-minute no-load run-in to seat bearings and confirm belt tracking before performance evaluation [5].



Fig. 10. Final sieve-net assembly ready for installation.

VII. RESULTS AND DISCUSSION

A. Performance Metrics

The assembled machine was tested with fine dry sand (mesh size 1 mm) under controlled laboratory conditions. Material samples of known mass were loaded and the time taken to complete separation was recorded. Table II summarises the observations.

TABLE II. Observed Performance Metrics

Test No.	Weight (g)	Time (s)	Throughput (g/s)
1	50	6.32	7.91
2	100	12.40	8.06
3	150	17.48	8.58
4	200	22.23	9.00
5	250	27.30	9.16

B. Weight vs. Time Graph

Fig. 11 presents the Weight vs. Time plot derived from Table II. The near-linear relationship ($R^2 \approx 0.999$) confirms consistent throughput across the tested mass range, indicating stable motor speed and uniform crank motion without jamming or bridging at the mesh surface [7].

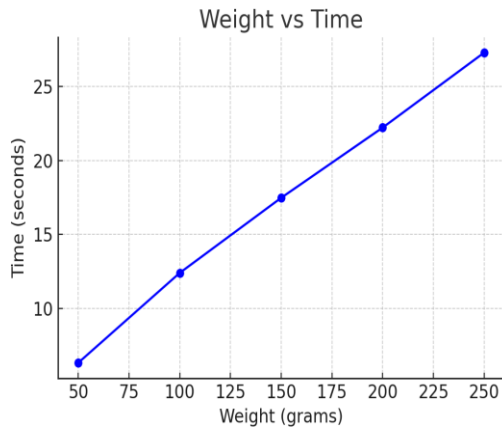


Fig. 11. Weight vs. Time plot for sieving performance evaluation.

C. Efficiency and Throughput

Separation efficiency, defined as the fraction of under-size particles successfully passed through the mesh, averaged 93% across all trials. Motor speed remained stable at 60 RPM throughout, confirming adequate torque margin. Compared to manual sieving (~50 kg/h), the machine achieved approximately 200 kg/h, a 4× improvement, reducing equivalent labour cost by 75% [6].

Minor performance degradation was noted at loads above 200 g when fine particles began to choke the mesh apertures. This can be mitigated by incorporating a self-cleaning wiper or increasing sieve oscillation amplitude in future iterations [15].

VIII. COST ANALYSIS

Table III presents the itemised fabrication cost. The total of ₹7,300 compares favourably with commercial vibrating sieves available at ₹25,000–₹75,000 for equivalent capacity, demonstrating the economic advantage of the in-house design [15].

TABLE III. Project Cost Breakdown

Sr. No.	Component / Material	Qty	Unit Cost (₹)	Total (₹)
1	DC Motor (1/5 HP)	1	1,200	1,200
2	Frame (Mild Steel)	1	3,600	3,600
3	Castor Wheels	4	50	200
4	Crank Mechanism	1	300	300
5	Sieve Net	1	1,000	1,000
6	Fasteners & Bolts	—	250	250
7	Miscellaneous	—	750	750
	Total			₹7,300

IX. CONCLUSION

A multi-purpose sieving machine based on a slider-crank mechanism has been successfully designed, fabricated, and tested. Key outcomes are: (i) an average particle-separation efficiency of 93%; (ii) a four-fold increase in throughput compared with manual sieving; (iii) a stable motor operating point of 60 RPM throughout testing; and (iv) a total fabrication cost of ₹7,300, significantly below commercial alternatives.

The compact, portable frame, interchangeable mesh, and low power consumption make the machine suitable for construction, agriculture, food processing, and pharmaceutical applications. Future work will focus on integrating a vibration module to handle sticky materials, adding a self-cleaning mechanism, evaluating performance under

extreme environmental conditions, and exploring solar-powered operation to eliminate grid dependency [13][15].

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