Design and Development of a Cam-Driven E-Cradle with Automated Swinging Mechanism

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Abstract— *In modern households, especially in nuclear families, continuous infant care has become a challenging task due to increasing professional commitments of caregivers. This paper presents the design and development of a Cam-Driven E-Cradle, an automated baby cradle system aimed at reducing manual effort while ensuring infant comfort and safety. The proposed system utilizes a low-speed, high-torque motor coupled with a cam and linkage mechanism to generate smooth and controlled oscillatory motion that mimics natural rocking. The cradle is designed using lightweight and durable materials to ensure stability, portability, and ease of use. A speed control mechanism is incorporated to regulate the swinging motion, providing a safe and comfortable environment for the infant. The system operates with minimal power consumption, making it economical and suitable for both urban and rural applications. Performance evaluation demonstrates significant improvements over conventional manual cradles in terms of efficiency, safety, user effort, and comfort. The results indicate that the developed system provides consistent motion, reduces caregiver fatigue, and enhances convenience.*

Keywords— Cam-Driven Mechanism, Automatic Baby Cradle, E-Cradle, Oscillatory Motion, Low-Speed Motor, Mechanical Design, Safety and Comfort.

I. INTRODUCTION

In today's fast-paced world, individuals are busy with professional and personal commitments. This is particularly evident in nuclear families, where both parents are often working, making continuous care of an infant a challenging task. Traditional baby cradles require continuous manual attention from a caregiver, which may not always be possible. Hence, there is a growing need for an automated solution that ensures both comfort and safety for infants while reducing dependency on caregivers.

The proposed **Automated Cradle (E-Cradle)** presents an innovative approach to address this necessity. The system incorporates an automated swinging mechanism driven by a low-speed, high-torque motor coupled with a cam and U-frame arrangement. This mechanism enables smooth oscillatory motion of the cradle, simulating the natural rocking action typically provided by a caregiver. The design focuses on achieving safe, reliable, and energy-efficient operation.

Safety and comfort are the main considerations in the development of the cradle. The structure is designed using lightweight yet strong materials to ensure durability and portability, making it suitable for use both at home and in public places. Protective measures such as covering sharp edges with rubber enhance infant safety. Additionally, the cradle is designed to consume minimal electricity.

Unlike conventional cradles, which are often less user-friendly and require continuous manual effort, the proposed system offers automation, ease of use, and improved comfort. It is particularly aimed at meeting the needs of middle-income families by providing an economical yet effective solution.

II. MATERIAL AND METHODS

2.1 Materials

The fabrication of the electromechanical cradle involved the selection and procurement of suitable materials and components based on strength, durability, weight, and cost considerations.

Component	Material/Specification
Main structural frame	Mild steel (MS) square tubes
Swinging mechanism (link arm, pulley, shaft)	Aluminium alloy and nylon components
Speed controller enclosure	ABS plastic
Baby support (carry bag/hammock)	Cotton fabric with foam padding
Hinges	Stainless steel

TABLE 1
COMPONENT SIZE SPECIFICATIONS

Sr. No.	Component	Parameter	Size / Dimension
1	Frame	Tube Size	25 mm × 25 mm × 2 mm
		Height	900 mm
		Base Width	800 mm
2	Swinging Mechanism	Link Arm Length	200 mm
		Pulley Diameter	100 mm
		Shaft Diameter	12 mm
3	Speed Controller	Enclosure Length	100 mm
		Enclosure Width	60 mm
		Enclosure Height	40 mm
4	Carry Bag / Hammock	Length	850 mm
		Width	400 mm
		Depth	250 mm
5	Hinges	Plate Size	50 mm × 50 mm × 2 mm
		Pin Diameter	4 mm

2.2 Why Use It?

The primary reason for using an automatic swinging cradle is to bridge the gap between an infant's need for constant rhythmic motion and a caregiver's need for rest and safety. From a developmental standpoint, the cradle mimics the continuous movement a baby experienced in the womb, which helps trigger their natural calming reflex and promotes longer, deeper sleep cycles.

For parents and caregivers, the device serves as a vital support tool that mitigates the physical strain and mental exhaustion associated with manual rocking, especially during the postpartum period. The proposed system is simple, affordable, and straightforward to install, making it well suited for small household applications where safety, comfort, and efficiency are priorities.

2.3 Market Survey

The automatic baby cradle segment has seen notable expansion, especially in regions like India, China, and Southeast Asia where nuclear families and working parents are more common. Brands such as R for Rabbit, Baybee, and LuvLap dominate the Indian market, offering products priced between ₹5,000 and ₹12,000 depending on features.

According to strategic projections, the global electric cradle market is expected to grow steadily through 2033, with Asia-Pacific leading in volume and innovation. Key drivers include increased awareness of infant sleep health, demand for hands-free parenting tools, and the rise of e-commerce platforms.

2.4 Cradle Design and Diagram

The proposed Automatic Swinging Cradle features a swinging mechanism that moves the baby bag, powered by a compact electromechanical system that converts electrical energy into controlled oscillatory motion. The swinging rhythm is calibrated to mimic natural rocking patterns, providing gentle and soothing movement.

Constructed using lightweight yet durable materials such as reinforced polymers and rubberized safety linings, the cradle prioritizes both portability and child safety. The frame is designed for easy relocation, with castor wheels and locking mechanisms to support mobility.

Figure 1: Cradle with Swinging Mechanism

III. RESULTS AND DISCUSSION

The performance of the developed Cam-Driven E-Cradle was evaluated and compared with a conventional manual cradle based on several operational parameters.

TABLE 2
COMPARATIVE RESULTS

Sr. No.	Test Criteria	Before (Manual Cradle)	After (Automatic Swinging Cradle)
1	Swinging Efficiency	Requires manual rocking for 20–30 minutes repeatedly	Continuous automatic swinging for adjustable duration
2	Energy Source	Human effort (manual rocking)	Electricity / battery / rechargeable power
3	Operating Cost	No direct cost but requires constant human effort	Very low electricity cost after initial setup
4	Noise Levels	Silent but depends on manual movement	Very low noise motor, smooth operation
5	Safety & Stability	Risk of uneven swinging	Controlled and uniform motion with safety mechanism
6	User Effort	Physically tiring for parents	Minimal effort; automatic operation
7	Time Convenience	Parents must stay near cradle	Saves time; cradle swings automatically
8	Comfort for Baby	Irregular motion depending on person rocking	Smooth and consistent swinging improves comfort

Key Findings:

- **Swinging Efficiency:** The developed system provides continuous and uniform swinging automatically for a desired duration, reducing human intervention.
- **Noise Level:** Very low due to the use of a low-speed motor and smooth cam-driven mechanism.
- **Safety and Stability:** Controlled and consistent oscillation reduces the risk of discomfort or accidental disturbance.
- **User Effort:** Caregivers are no longer required to continuously rock the cradle.
- **Infant Comfort:** Smooth and uniform motion provides a more effective soothing effect compared to irregular manual rocking.

IV. CONCLUSION

The development of the Cam-Driven E-Cradle presents an effective solution to the challenges associated with traditional infant care in modern households. This project demonstrates the successful integration of mechanical design, automation, and user-centric considerations to create a system that enhances both infant comfort and caregiver convenience.

Key Contributions:

1. Cam-driven swinging mechanism producing controlled, uniform oscillatory motion
2. Significant reduction in manual effort and caregiver fatigue
3. Stable structural frame with efficient actuation mechanism
4. Low-power operation ensuring energy efficiency
5. Lightweight, durable materials with mobile design for portability

The design emphasizes simplicity, affordability, and practical usability, making it suitable for both urban and rural applications.

Future Work:

- Integration of cry detection sensors for automatic activation
- Smartphone-based remote control and monitoring
- Solar charging capability for off-grid operation
- Adjustable swing speed and amplitude settings

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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