

DESIGN OF A PORTABLE AND ATTACHABLE BABY COT

SOWAH BORIS NII-AKO

Department of Biomedical Engineering, Faculty of Engineering Sciences
University of Ghana, Accra, Ghana
E-mail: borissowah@yahoo.co.uk

CLETUS FIIFI ADAMS

Department of Biomedical Engineering, Faculty of Engineering Sciences
University of Ghana, Accra, Ghana
E-mail: cleadams.23@gmail.com

BERNARD OWUSU ASIMENG

Department of Biomedical Engineering
Faculty of Engineering Sciences, University of Ghana, Accra, Ghana
E-mail: boasimeng@ug.edu.gh

ELSIE EFFAH KAUFMANN

Corresponding Author, Department of Biomedical Engineering
Faculty of Engineering Sciences, University of Ghana, Accra, Ghana
E-mail: eek@ug.edu.gh

Abstract:

To solve congestion problems facing many hospitals in developing countries, baby cots are being eliminated and mothers are made to sleep on the same bed with their new-born babies; a practice known as co-sleeping. The work presented here seeks to reduce risks of Sudden Infant Death Syndrome (SIDS) and suffocation associated with co-sleeping by employing the formal engineering design process to develop a portable, safe and cost effective baby cot. The cot is attachable to the mother's bed, has four movement restrictors to regulate the movement of the baby within a given range and a hard surface mattress to ensure the safety of the baby. There are ventilation ports provided to keep the temperature within the cot comfortable. The design can be modified to be used by older babies and may be mounted on a collapsible stand where space limitations are not critical.

Keywords: Baby cot; Co-sleeping; SIDS; Suffocation; Engineering design.

1. Introduction

Several hundred years ago, there were no baby beds and babies were made to sleep with their parents. Baby cots, sometimes known as cribs or cradles, became popular during the 19th century ^[2] and are small beds specifically for infants and generally for young children mostly under the age of four (4). They are usually designed to restrict the baby to the sleeping area by producing very high sides to prevent the baby from climbing. They also provide no footholds. They were typically designed to be small free standing beds that could be placed by the parent's bed for easy accessibility.

The existing baby cots are usually bulky, making it necessary for many hospitals in resource-limited and congested hospitals, especially in developing countries, including Ghana to eliminate them. Personal visits to some hospitals in Accra, Ghana, including the Korle-Bu Teaching Hospital and the University of Ghana Hospital revealed that baby cots are not in use. Healthcare professionals explained that baby cots have been eliminated in order to save space and promote bonding between mothers and their babies. Many hospitals are therefore practicing co-sleeping where nursing mothers are made to sleep on the same bed with their babies. Co-sleeping is defined as an umbrella term that includes the practice of bed sharing with a caretaker or other family members, proximate sleeping arrangements, and room sharing during sleep ^[5]. Unfortunately, the practice of co-sleeping has been associated with the incidence of Sudden Infant Death Syndrome (SIDS) and suffocation ^[5]. A need was thus identified for an alternative to the currently available, bulky or expensive baby cots. Such a cot is expected to occupy little space (portable), while promoting bonding between mothers and their babies (attachable to the mother's bed).

2. Methods

The design of this Portable and Attachable baby Cot (PAC) was done in accordance with the formal engineering design process; an iterative process consisting of several stages including Problem Identification, Background Search, Functional Analysis, Development of Specifications, Concept Generation, Analysis and Selection of Components, Component Implementation, Integration and Testing, and finally Product Presentation ^[19, 21].

The major objectives of the project were efficiency, competitive cost, aesthetic appearance, safety and convenience. These major objectives together with other supporting objectives were organized into an objective tree as shown in Figure 1 below:

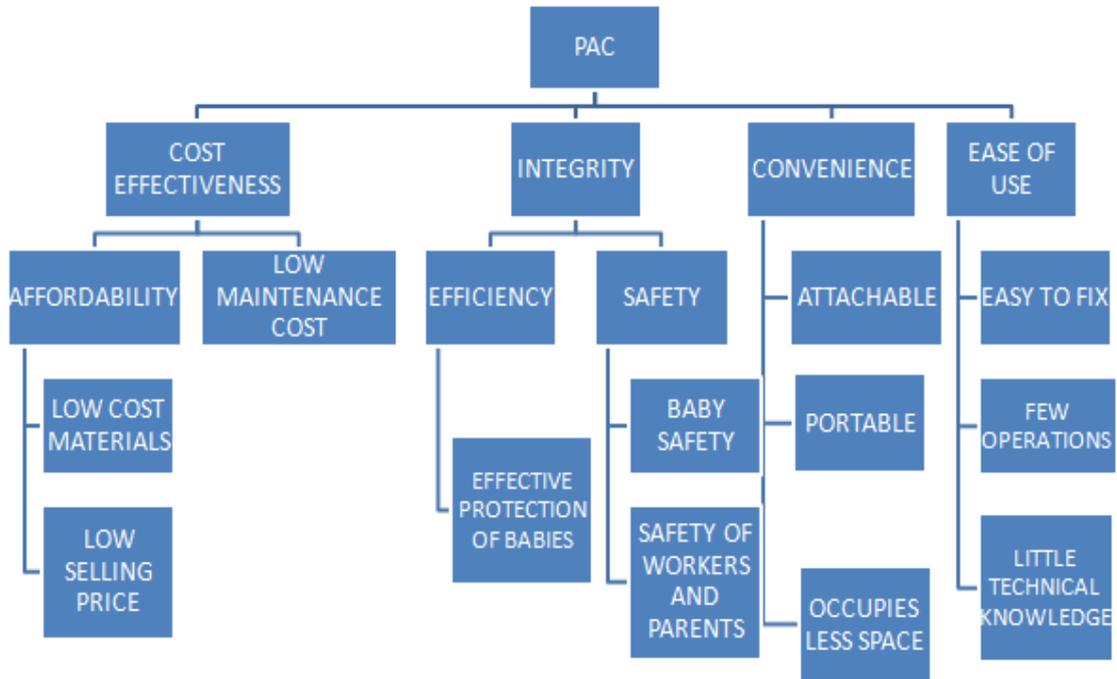


Fig. 1. Objective Tree for the Design of PAC

3. Design, Testing and Evaluation

Figure 2 below shows an annotated schematic diagram of the designed baby cot. The various parts of the cot are subsequently described and other representations of the cot are shown in Figures 3 and 4. The bill of materials is presented as Table 1.

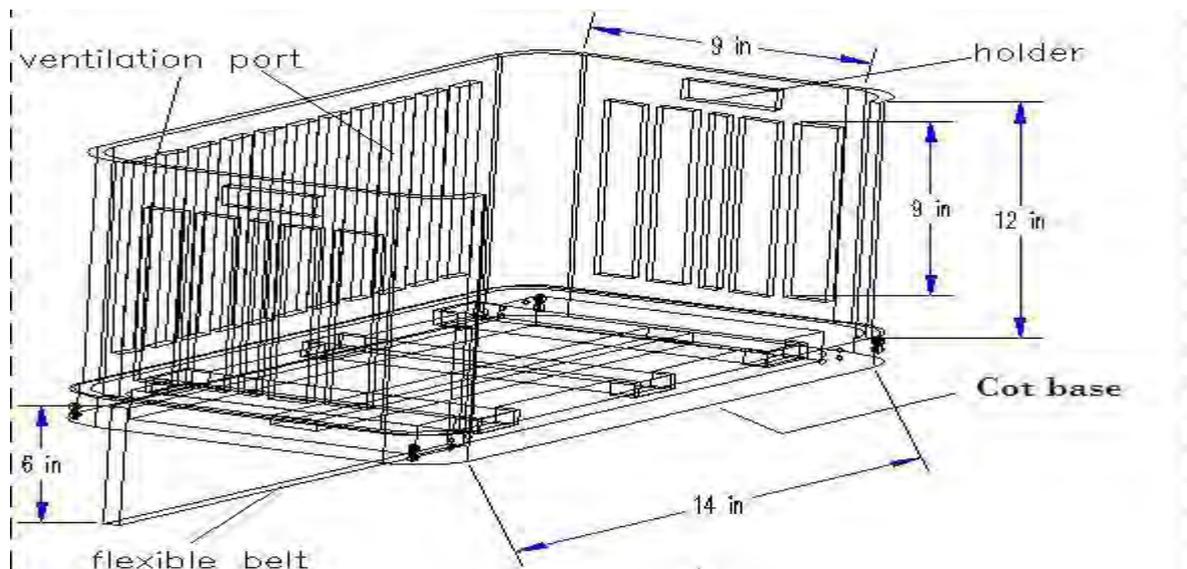


Fig. 2. Schematic diagram of the baby cot

3.1 Sleeping surface

This consists of the mattress and the base of the baby cot. A high density and hard surface mattress made from polyurethane of thickness up to 15 cm was selected in conformity to standards ^[6]. Additionally, restrictive materials to ensure safety against suffocation were provided ^[20]. The restrictive materials (rectangular shaped foams) are fastened to the mattress by Velcro strips.

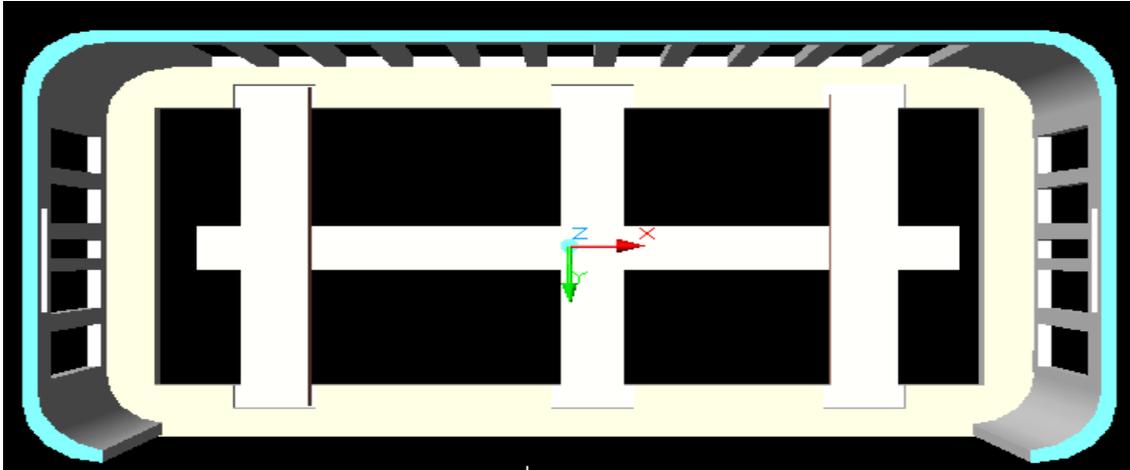


Fig. 3. Top perspective view showing the sleeping surface of PAC without the mattress.

3.2 Ventilation ports

These are vertical gaps left in the baby cot to aid in ventilation to help prevent suffocation. The collapsible baby cot is rectangular in shape with one open end to allow for easy access of the baby by the mother; a means of promoting bonding between the baby and the mother. The baby cot has a total of fifteen (15) ventilation ports, each having dimensions of 0.055 m by 0.3 m.

3.3 Attachment

There are three points of attachment in this design. Firstly, the attachment of the three (3) vertical sides to the base (sleeping surface). Secondly, the attachment of the sides together and finally, the attachment of the assembled baby cot to the bed of the mother. The sides are attached to the sleeping surface by hinges and the sides are held together by metallic locks. There are two flexible belts attached to the side adjacent the open end. These flexible belts are fixed to the cot by the help of washers and screws. The free ends of the flexible belts have two holes perforated on each to be used to attach to the bed using washers and screws.

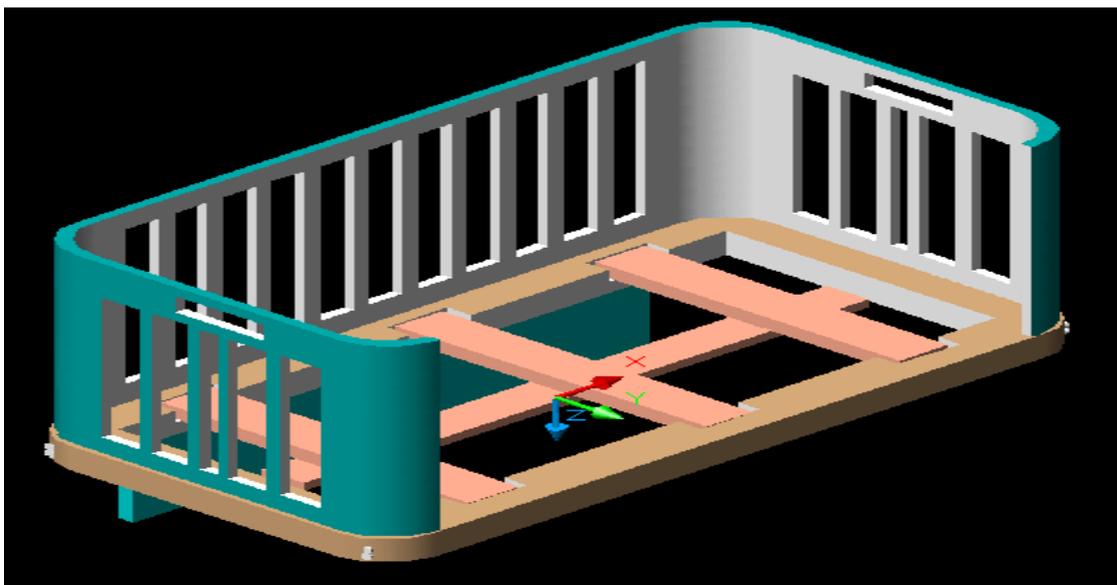


Fig. 4. A 3-dimensional representation of the PAC

Table 1. Bill of Materials for the Portable and Attachable Cot

NUMBER	PART	QUANTITY	DESCRIPTION	COST (GH¢)	COST (US \$)
1	Base	1	Plywood of thickness $\frac{3}{4}$ m, length of 0.75 m and width of 0.40 m.	10	5
2	Sides	2	Ofram wood of length 0.4 m, width of 0.4 m and thickness of 0.06 m.	10	5
3	Back	1	Ofram wood of length 0.75 m, width of 0.4 m and thickness of 0.06 m.		
4	Restrictive materials and sleeping surface	1	A mattress of length 0.74 m, width of 0.48 m and thickness of 0.07m made of polyurethane foam.	15.75	7.90
5	Fasteners to the bed	8 pairs	Screws of length 0.05 m and core diameter 0.01 m. A washer of diameter 0.009 m.	1.6	0.80
6	Joint fasteners	3	Hinges.	9	4.50
7	Fasteners to the mattress	4	A Velcro strip of length 0.15 m and width 0.01 m.	1	0.50
8	Attachment material	2	A strong and flexible belt made of car tyres (rubber).	2	1

3.4 Mode of operation

Since the baby cot is collapsible, it must be assembled before use. The three sides are first erected by attaching each side to the sleeping surface using the hinges found on the sleeping surface. These sides are then held together by means of metallic locks. The flexible belts are then attached to the side adjacent to the open end by means of screws and washers. The free ends of the flexible belts are finally screwed to the bed by aligning the washers and perforated holes.

3.5 Mechanical testing

Mechanical testing (stress analysis) was done on a virtual model, which was identical to the real piece in terms of dimensions, shape and material properties. Stress analysis was performed on the casing of the crib because the presence of the ventilation ports makes it easily susceptible to shearing as compared to other parts. In Figure 5, the casing is hinged at the face labelled B whilst the force is applied to the face labelled A. Upon applying forces of varying magnitudes, it was observed that the minimum force that would cause shearing is 2 kN. The blue coloration in Figure 5 is the pictorial display of distortion relative to the true shape of the crib under the action of the 2 kN force.

The simulation also indicated that forces between 0.5 kN and 2 kN result in an observable distortion but do not lead to shearing. This suggests that the fasteners that attach the casing to the base of the crib, at the site of distortion, may shear or bend even if the crib does not fracture. To this end, forces greater than 0.5 kN may cause damage to the crib, as shown in Figure 6.



Fig. 5. Result of mechanical test on a virtual model. The direction of force applied is indicated by the arrows. The blue colour shows distortion relative to the true shape of the crib under the action of a 2 kN force



Fig. 6. Fracture due to a 4 kN force

3.6 Advantages of the design

The portable and attachable baby cot is:

- Stable and robust
- Very safe to use
- Well-ventilated
- Light in weight, occupies little space and is collapsible for easy portability
- Affordable and has low maintenance cost as it is fabricated from readily available local materials
- Easy to fix/assemble and use
- Attachable to the maternity bed to allow mothers to easily access their babies, thus promoting bonding and easy breast-feeding

To determine whether the design performs its specified functions effectively and efficiently, a prototype was fabricated and the attributes of the prototype were evaluated against the design objectives and specifications that were originally defined.

Further testing on the prototype showed that the product can be folded making it easier to be carried around. The means of attachment to the bed was very strong making it safe to attach to the bed. Additionally mechanical tests performed on the prototype indicated that the design would be able to support various weights and stresses above the specified values without failing. The mattress used had a hard surface which helps reduce the possibility of suffocation. The end facing the mother is opened to ensure that the mother can easily access the baby to promote bonding.

Table 2. Product Evaluation

OBJECTIVE	SPECIFICATION	EVALUATION	ACHIEVED?
ALLOW FOR VENTILATION	-Number of ventilation ports \leq 50 -Sizes of ventilation ports \leq 0.06*0.4 m	The number of ventilation ports was 15 and the size of each port was 0.055 m by 0.3 m	Yes
ATTACHED TO THE BED	-Number of joints < 10 -Detachment time < 20 minutes	The number of joints was 6 and the detachment time was approximately 5 minutes	Yes
EASY TO FIX AND USE	-Steps to fix PAC <10 -Steps to use PAC <10	The number of steps to fix and use PAC was less than 10 each	Yes
SAFE AND DURABLE	-Number of sharp edges 0 -Yield strength of the material \geq 1.74 kPa -Comfortable temperature within the cot -Effective restrictions	The design has no sharp edges. The yield strength of the wood used was greater than the specified value The temperature within the cot was identical to ambient temperature. There were 4 restrictive materials to regulate the movement of the baby but these materials are not so strongly attached to the sleeping surface.	Yes
PORTABLE (Occupies less space)	-Length (0.75 m) -Height (0.40 m) -Width (0.40 m)	The design conformed to the specified dimensions and also to further ensure that moving it is much easier, the product can be collapsed when not in use	Yes
ATTACHABLE	-Flexible belt	The flexible belt used was very strong and can easily be bent without failing to ensure that PAC is strongly attached to the bed	Yes
AFFORDABILITY	- Total cost <GH¢ 250.00 -Selling price < GH¢ 300.00	-Total cost = GH¢ 84.65 [Approximately US\$ 43] -Selling price = GH¢ 105.81 [Approximately US\$ 53]	Yes

4. Conclusion

Testing and evaluation show that the designed system met the requirements for an efficient, portable and attachable baby cot. This cot addresses some of the problems posed by existing designs. Additionally, it ameliorates the sleeping restrictions mothers face when they are made to sleep on the same bed with their babies. It may also help to address the problem of high suffocation and SIDS risks encountered as a result of

co-sleeping. The mechanical tests performed on the prototype indicate that the design would be able to support various weights and stresses above the specified values without failing.

To add value to the product and improve its aesthetic appeal a bag can be designed to carry the cot. The cot can be modified to be used by older babies outside the maternity wards. A collapsible stand can also be fabricated for use in venues where space availability does not pose a problem and there is a preference to keep the cot off the mother's bed.

Acknowledgment

Mr. Kwabena Kan-Dapaah is gratefully acknowledged for academic guidance during the initial stages of the project.

References

- [1] Ako. Retrieved on February 25, 2013 from <http://tropix.cirad.fr/africa/ako.pdf>
- [2] Baby New Home. Baby Cots. Retrieved on February 20, 2013 from <http://www.babynewhome.com/baby-online-shop/babycots>
- [3] Budinski K.M, Budinski G.K(1999), Engineering Materials- Properties and Selection, 6th Edition, New Jersey, Prentice Hall.
- [4] Collapsible Baby Cots. Retrieved on February 20, 2013 from http://www.google.com/patents/US20060117478?printsec=abstract&dq=attachable+baby+cots&ei=KZF_T5vJLcbA0QXNiLz1Bg#v=onepage&q&f=false
- [5] Co-sleeping. Retrieved on February 20, 2013 from <http://pediatrics.uchicago.edu/chiefs/ClinicCurriculum/documents/Cosleeping-Francis.pdf> (page 1- 4)
- [6] European Committee of Standardization. EU Safety Standards. Retrieved from http://ec.europa.eu/consumers/citizen/my_safety/docs/MEMO_sleeping_prod_en.pdf
- [7] Fleming PJ, Levine MR, Azaz Y, Wigfield R, Stewart AJ (June 1993). "Interactions between thermoregulation and the control of respiration in infants: possible relationship to sudden infant death". *Acta Paediatr Suppl* **82** (Suppl 389): 57-9
- [8] Folding Baby Cot. Retrieved on February 22, 2013 from http://www.google.com/patents/US3839754?printsec=abstract&dq=baby+cots&ei=B4t_T5rgCMA90QWypMCSBw#v=onepage&q=baby%20cots&f=false
- [9] Frake. Retrieved on February 25, 2013 from <http://tropix.cirad.fr/africa/frake.pdf>
- [10] Health Canada. Costumer Product safety. Retrieved on March 9, 2013 from <http://www.hc-sc.gc.ca/cps-spc/pubs/cons/child-enfant/sleep-coucher-eng.php>
- [11] Infant Sleep Information Source. Bed-sharing and Safety. Retrieved on March 9, 2013 from <http://www.dur.ac.uk/resources/isis.online/pdfs/ISISPDFbed-sharingMay2012FINAL2.pdf>
- [12] Injury information. Suffocation. Retrieved on February 20, 2013 from <http://www.injuryinformation.com/accidents/suffocation.php>
- [13] Liner for an infant bed. Retrieved on February 20, 2013 from http://www.google.com/patents/US6421857?printsec=abstract&dq=baby+cots&ei=B4t_T5rgCMA90QWypMCSBw#v=onepage&q=baby%20cots&f=false
- [14] McKenna JJ, McDade T (June 2005). "Why babies should never sleep alone: a review of the co-sleeping controversy in relation to SIDS, bed sharing and breast feeding". *Paediatr Respir Rev* **6**(2): 134-52
- [15] Milwaukee County, (2011). Co-sleeping tied to alarming number of infant deaths. February 20, 2013 from <http://www.jsonline.com/news/milwaukee/87602592.html>
- [16] Moon RY, Horne RS, Hauck FR (November 2007). "Sudden infant death syndrome". *Lancet* **370** (9598): 1578-87
- [17] Raising Children Network. Safe sleeping tips for babies and newborns. Retrieved on March 9, 2013 from http://raisingchildren.net.au/articles/safe_sleeping.html
- [18] The baby bond, (2002). Co sleeping and SIDS fact sheets. Retrieved on February 20, 2013 from <http://thebabybond.com/Cosleeping&SIDSFactSheet.html>
- [19] Ullman, D.G. (2005), The Mechanical Design Process, McGraw-Hill Companies, Inc., USA.
- [20] Women and Newborn Health Service. Safety tips for cot sleeping. Retrieved on March 9, 2013 from <http://kemh.health.wa.gov.au/brochures/consumers/wnhs0489.pdf>
- [21] Youssef H. (2003), Engineering Design Process, Thomson Learning (Brooks/Cole division) Inc., USA.