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Cost effective moulded seating for the handicapped child

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Abstract

For many severely handicapped children requiring external trunk support there is probably no better solution than to provide custom moulded seating. This will improve the patient's posture, reduce the occurrence of pressure sores and facilitate such activities as feeding. However, if large numbers of patients are to be supplied with this type of equipment, it is important that it should be manufactured at the lowest cost compatible with an acceptable quality.

These manufacturing problems have been studied in considerable detail and a production method using vacuum consolidation casting together with a modified vacuum forming process has been developed. This has made it possible to produce custom moulded seating efficiently with the minimum of capital equipment. Much attention has been paid to the final appearance of the article and this has been enhanced by the use of commercially available items for the supporting structure and for the finishing of edges, etc.

It is suggested that other orthoses could be redesigned for production using an approach similar to that described in this paper.

Introduction

The severely handicapped patient may have difficulty in maintaining a comfortable seating position and this problem is frequently solved only by fitting pads, cushions, etc. to a standard wheelchair. If one considers the patient with a spinal deformity and associated problems, a conventional wheelchair will offer mobility but often with comfort and posture a poor second. In providing functional seating for the handicapped the main objective is to enable the patient to enjoy a comfortable and secure posture with the maximum independence and mobility.

One solution to these problems is the provision of a moulded seat and this has been shown to be successful by workers at Mary Marlborough Lodge, Oxford (Nicholas and Strange, 1971) and Chailey Heritage (Nelham, 1975) who have developed the techniques necessary to manufacture these items.

A seat which is individually moulded to the patient is intended to stabilize the pelvis and produce an even pressure distribution. This results in the relief of pressure areas together with improved respiration and a contribution towards the prevention of progressive growth deformities. Furthermore there are social and functional benefits which accrue from the improved posture; the successful moulded seat improves independence and can frequently improve a patient's functional abilities, as well as facilitating the tasks of feeding etc. for the attendant of the severely handicapped patient. In addition, it has been shown by Motloch (1978) that the choice of an optimum posture can significantly reduce spasticity in the athetoid patient.

The Orthotics and Disability Research Centre at Derby has been involved in the supply of custom seating since 1976 during which time considerable experience has been gained in manufacture and use and a number of new manufacturing methods have been developed which make it possible to produce a functional, low cost, device. This seat consists of a moulded polyethylene foam lining with a polyethylene skin to provide rigidity. After fabrication, the seat shell is attached to a tubular framework which provides stabilization and may be used as an interface for equipment such as a baby buggy or wheelchair frame (Fig. 1).

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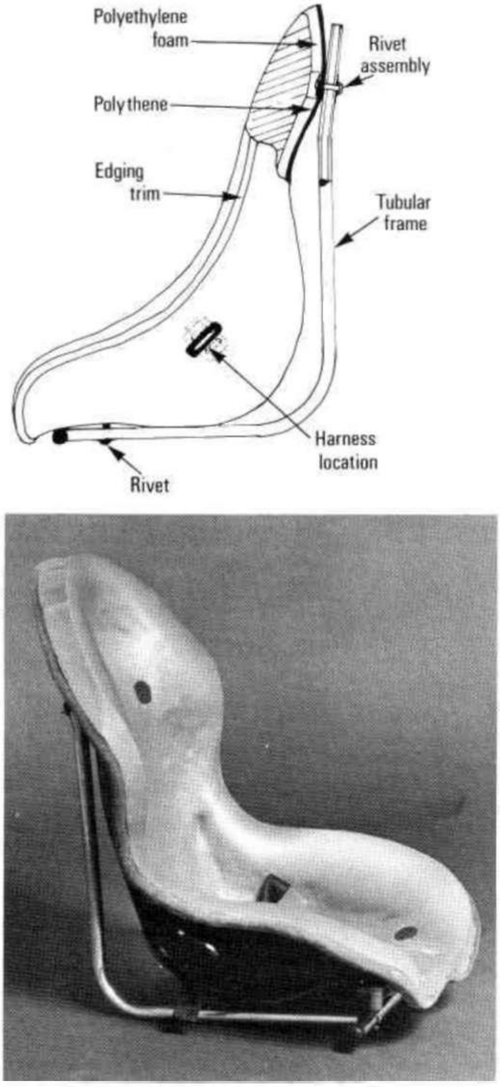

Fig. 1. Top, main features of the Derby moulded seat. Bottom, finished seat.

Patient assessment and seating manufacture

Clinical assessment

When a patient is referred for a seat, it is likely that a number of other solutions have already been tried without success and it is, therefore, important that the patient's seating problems should be carefully assessed before deciding to provide a specific type of support. Clinical assessment of the patient is carried out by a multidisciplinary team containing the clinician, occupational therapist, engineer and parents or attendant. The assessment will take into account the degree of disability, the presence of deformity and the rehabilitation goals for the particular patient. For instance, if the patient has a fixed deformity, this will to a great extent decide the final form of the seat, whereas a 'floppy' cerebral palsy patient can be moulded in an optimum functional position.

Casting of the patient

The first stage of the manufacturing process is the production of a plaster of Paris cast of the patient in the required position. This is considered to be the most important part of the whole process in that the accuracy of the initial cast will decide the quality of fit of the final item.

The technique used to cast the patient is that of vacuum consolidation in which a thin flexible bag containing lightweight plastic beads becomes rigid when held under vacuum (Nichols and Strange, 1971; Nelham, 1975; Germans et al. 1975).

The bags used for this process are easily manufactured from 0.25 mm latex sheet and filled with 3 mm dia. beads of expanded polystyrene. The moulding process is carried out as follows:

(i) The bag is laid on the floor so that it has an overall even thickness of approx. 75 mm and partially evacuated until an easily pliable texture is obtained.

(ii) The bag is lifted while under a vacuum of 50 mm Hg and placed in the wheelchair to form a basic seat shape.

(iii) The patient is positioned in the wheelchair and the bag is formed around him in the required position to provide the necessary support. This is carried out by two people (engineering technician and O.T.) unless additional help is required in difficult cases.

(iv) The bag is fully evacuated and becomes sufficiently rigid to support the patient.

(v) The patient is left in the chair for 15–20 minutes in order to assess the comfort of the position, after which he is removed and then replaced to give an indication of the repeatability of the required posture.

(vi) Provided that the steps of (v) have been successfully carried out, the patient is removed from the chair and a positive replica is produced using 200 mm (8 in) slab plaster of Paris bandage. Once the plaster has set, the vacuum is released and the cast easily removed. Finally the cast is prepared for the moulding of the seat by coating it with a plaster slurry to produce a smooth surface finish.

Moulding the seat

Materials used

The moulded seating shell is manufactured from polyethylene foam (Plastazote* density 40–50 kg/m³). This moulded shell is reinforced with a moulded outer skin of low density polyethylene (Vitrathene*).

Moulding process

The plastic moulding is carried out by a low cost vacuum forming process known as drape forming. The drape forming apparatus consists of a wooden framework with a solid base and hinged lid which is a wooden frame holding a high stretch synthetic rubber sheet. The lid can be closed and clamped shut against a rubber seal which excludes air during the moulding cycle, during which a vacuum is introduced causing the rubber sheet to drape itself around any mould within (Fig. 2).

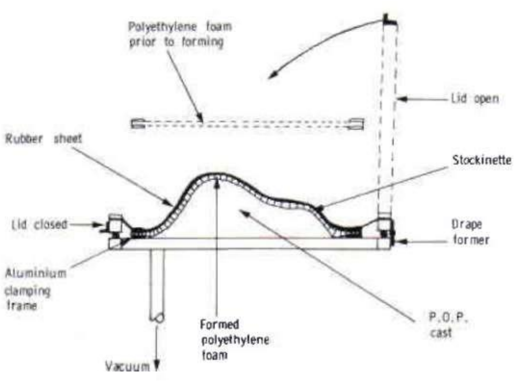

Fig. 2. Thermo-forming of polyethylene foam.

Using this equipment the polyethylene foam shell is produced in the following manner:

(i) The cast is located on a polystyrene bead bag on the drape forming machine. This bead bag serves to stabilize the cast during the moulding process and to provide internal reinforcement.

(ii) The foam is clamped in an aluminium frame and heated in an oven to 140°–160°C. The frame is required to assist handling and to prevent creasing of the material during moulding.

(iii) The cast is covered by a layer of stockinette which serves to improve the surface of the final moulding and acts as a "wick" to ensure a consistent vacuum around the cast during moulding.

(iv) The heated material is placed over the cast, after which the lid of the drape former is closed and clamped and a vacuum is applied to form the foam around the cast. The material is left in the drape former until cool and then removed and roughly trimmed, leaving excess material to allow for final trimming after the second stage of moulding.

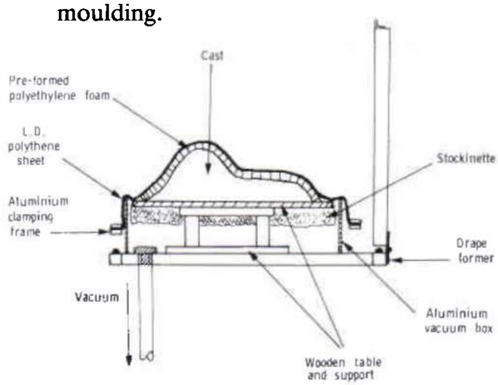

Fig. 3. Vacuum forming of low density polyethylene sheet.

A slightly different technique is used to produce the rigid polyethylene backing for the seat (Fig. 3).

(i) The material is clamped in an aluminium frame and heated to a temperature of 140°–160°C until soft.

(ii) With the lid open, an aluminium box is placed on the drape former and connected to the vacuum supply. This box, which can be made in different sizes to suit large or small seats, can be used as a conventional vacuum forming chamber.

(iii) The moulded polyethylene foam shell is placed on the original cast standing within the vacuum chamber covered with stockinette. The heated polyethylene still held in the frame is placed over the top of the box and the vacuum applied to form the outer skin around the shell.

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*PLASTAZOTE—Trade name of Bakelite, Xylonite Ltd.
*VITRATHENE—Trade name of Stanley Smith & Co. Ltd.

(iv) The outer skin and the shell are then removed from the machine and the seat is checked with the patient to determine the position of trim lines and the angle of fixation. Finally, the foam and outer shell are bonded together using contact adhesive and then trimmed.

Fabrication and fitting of tubular frame

Following a survey of possible methods of producing a supporting structure for the moulded seat, it was decided to adopt a tubular frame on account of the ready availability of both tube fittings in a large number of sizes, materials and finishes.

The frame is constructed in the following manner:

(i) The frame is bent to shape and assembled using available fastenings from the tube in use.

(ii) By drilling through the tube and seat, a nickel plated steel pin, together with a 25 mm washer, is positioned through the hole and a snap-on cap hammered into position. Four are usually fitted to hold the frame securely to the seat in the required position. Where the pins pass through the foam lining a 25 mm disc is trepanned out and a different coloured plug inserted. If the seat is only required as a wheelchair insert, the frame work is ideal for stabilization of the seat.

(iii) If required the frame can be specifically tailored to interface with some other piece of equipment. One example of this is the baby buggy adaptation for which a standard list of parts has been produced enabling the modifications to be carried out.

Finishing operations

Fitting of straps

Nylon webbing, together with the necessary buckles etc, is fitted into the optimum positions determined during the trial fitting with the patient. If a full harness is required this is bought in from a commercial supplier as a ready made item. Where straps must pass through the seat, injection moulded inserts are pressed into slots in the polyethylene outer skin to act as guides for the webbing.

Finishing of edges

It is important that the standard of overall finish should be as high as possible and, therefore, to improve the appearance of the edges and to cover any sharp corners, a strip of the type of beading used in the automotive industry is fitted around the edge of the outer shell and the polyethylene foam liner is buffed to give a uniform smooth finish.

Conclusions

It has been shown that it is possible to produce a well fitting moulded seat using readily available materials and easily manufactured vacuum forming equipment. Particular emphasis has been placed on two aspects of the design.

Appearance

Probably the most influential feature of any merchandise is its appearance. Indeed it is likely that a patient will reject a seat on grounds of appearance even though it may serve a useful purpose in terms of posture, etc. Earlier work with moulded seating has proved this statement to be true, especially in the case of small children where the mother has objected to the appearance of the seat. Considerable effort has been given to improving the seat in this way and much has been achieved by utilizing readily available manufactured items of high quality.

Cost

There is evidence in the United Kingdom that the potential demand for moulded seating is high. It is essential, therefore, that any equipment supplied to meet this demand is economically viable, in particular labour costs should be kept to a minimum. In the case of the Derby Seat the approximate materials costs are £20–£40 ($45–$90 U.S.) and the approximate time, including casting etc, is between 4 and 6 hours depending on the size and complexity of the final item. These costs could be reduced even further by utilizing to a greater extent items already available which could be purchased for less cost than they could be produced internally. Various possibilities are under consideration as alternatives to present methods.

The design principles described in this paper are equally applicable to other orthotic equipment. It seems likely that a number of traditional orthoses could be "value engineered" in this manner to produce an article which is more acceptable to the patient and produced at a lower cost.

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