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The effect of heat and compression on the behaviour of flask press springs

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Keywords: heat effect; spring tension; flask press clamps

SUMMARY

In a previous study a method for calibrating the load delivered by flask press springs was described. This method did not allow for changes in the mechanical properties of the springs when exposed to boiling water and spring compression. The effect of 20-25 cycles of heat exposure and spring compression associated with flask press usage for the curing of denture base resin on the mechanical characteristics of flask press springs was determined in 5 flask presses. The results indicate a mean increase of 7,35 per cent in the load delivered by the flask presses. These findings suggest that strain age hardening of the springs occurred. This factor needs to be considered in controlled studies on the curing of denture base resins.

OPSOMMING

'n Vorige ondersoek het gehandel oor 'n metode waardeur die lading wat op 'n drukflesveer uitgeoefen word gekalibreer kon word. Hierdie metode het egter nie voorsiening gemaak vir die moontlikheid dat blootstelling aan kookwater en samedrukking veranderings in die meganiese eienskappe van die vere kon veroorsaak nie. Vyf drukflesse is gebruik om die uitwerking van ontbloting aan hitte en veresamepersing op die meganiese eienskappe van die drukflesvere vas te stel. Betrokke drukflesse is elkeen onderwerp aan 20-25 kuursiklusse. Die resultate toon 'n gemiddelde toename van 7,35 persent in die lading wat deur die drukflesse gelewer word. Hierdie bevindings dui op verouderingsverharding wat as gevolg van vervorming van die vere plaasgevind het. Hierdie faktor behoort in aanmerking geneem te word by gekontrolleerde studies met betrekking tot die kuur van kunsgebitharse.

INTRODUCTION

A simple technique for the rapid and accurate calibration of flask press spring loads for studies in which denture base resins require to be processed under uniform loading conditions, was described by Wolfaardt and Austin (1979). Whilst their system offered a simple solution to the problem of standardizing flask press loads in experimental studies, it was not clear whether prolonged usage or exposure of the calibrated presses to heat would alter the load delivering characteristics of the springs. Hardening in an alloy may be defined as a process in which the yield stress and the resistance to indentation are increased (Moon, 1978). Hardening may occur in 2 ways: age hardening and strain hardening.

Age hardening refers to a process which will produce an increase in strength properties as a function of time. Strain hardening is that increase in strength properties of a material which occurs as a function of the deformation process (Greener, Harcourt and Lautenschlager, 1972). Most age hardening procedures produce transformations in the solid state which are functions of time and temperature. These transformations produce discontinuities in the normally perfect crystallographic lattice which will impair and impede both the motion and generation of dislocations under conditions of applied stress (Greener, et al, 1972).

In a similar fashion strain hardening occurs in a polycrystalline metal where dislocations of the lattice build up. Greater stress is then required to produce further slip and the metal becomes stronger and harder (Phillips, 1973).

Any process that interferes with dislocation motion will raise yield stress, increase resistance to indentation and often lowers the ductility (Moon, 1978). Both these factors may be active in the flask press calibration design described by Wolfaardt and Austin (1979). Firstly there is the repetitive stressing of the compression springs and, secondly, the exposure of the springs to low heat whilst under stress. It would seem likely that a hardening of the springs may occur. This study was carried out to determine whether the load delivery characteristics of the flask press springs changes with usage.

MATERIALS AND METHODS

The technique used was that described by Wolfaardt and Austin (1979) for the rapid and accurate calibration of flask press spring loads. This technique performed with a high degree of precision when used to calibrate flask presses for the delivery of a standardized 175 kg load. The coefficient of variation at this load ranges from 0,6 - 1,1 per cent in 5 new commercially produced presses.

The 5 modified commercially available flask presses* calibrated by Wolfaardt and Austin (1979) were used to deliver a standardized 175 kg. load to flasks for the experimental heat curing of polymethyl methacylate denture base resin. The presses were then subjected to 20-25 heat curing cycles. The heat cycles were applied in 2 ways in random order.

i) Slow curing cycle
   a) 73 ±1°C for 90 minutes
   b) Boil for 30 minutes
   c) Air cool to room temperature 23 ± 10°C

ii) Rapid curing cycle
   a) Boil for 60 minutes
   b) Air cool to room temperature 23 ± 10°C

The exposure to heat took the form of intermittent exposure with cooling to room temperature between heating cycles. At the end of this procedure the modified flask press clamps were mounted on the tensile testing machine** using the technique described by Wolfaardt and Austin (1979).

The moving crosshead of the tensile testing machine was then racked up until the calibrated travel was achieved on the dial gauge. The load delivered by the compression springs was recorded.

For each flask press clamp 5 recordings were made and these recordings were carried out on a random basis. The Student's paired t-test was used to determine whether any significant change had occurred in the load delivered by the flask press clamps with usage.

RESULTS

The mean loads delivered by the flask press clamps after calibration and then after usage when the same degree of spring compression has been applied are shown in Table 1.

Table 1. The mean load delivered with initial calibration to 175 kg.

Flask Press No.	Mean load delivered at first reading in Kilograms	Mean load delivered at calibrated movement after 20-25 cycles in Kilograms
1	174,9	196
2	172,8	182
3	174,5	194
4	174,3	184
5	174,5	179

There was a mean increase of 7,35 per cent in the load delivered by the springs after exposure to 20-25 resin curing cycles. The results were subjected to a Student's paired t-test and the differences were found to be significant ($t = 4,10$; $P<0,05$).

DISCUSSION

The results of the study show that the springs undergo strain age hardening with usage and indicate the need for calibration of the springs at regular intervals during usage. This finding, although theoretically predictable, does not appear to have been taken into account in other studies in which standardized conditions have been assumed after the load delivery characteristics of the flask presses have been roughly set (Tuckfield, Worner and Guerin, 1943).

Although the significance of variations in spring press loads has yet to be clearly established, it would seem to be an important variable in any study attempting to define the behaviour of acrylic denture base resin under laboratory conditions and it would seem to be important to recognise that flask press spring loads may vary with usage after initial calibration.

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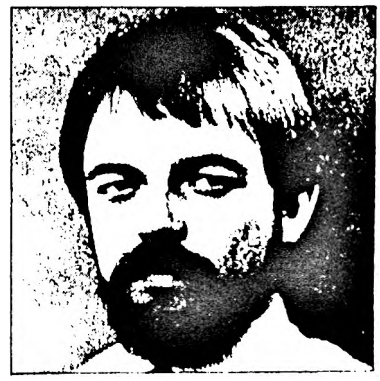
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Dr. John F. Wolfaardt qualified at the University of the Witwatersrand in 1976. He was awarded the Amalgamated Dental Company Gold Medal, Grant Smith Gold Medal, Operative Dentistry Medal of the Dental Association of South Africa and the PROSSA prize in Clinical Fixed Prosthodontics. After completing his National Service in the South African Navy, he practiced for a short period in Bulawayo and then returned to the University of the Witwatersrand, where he took over the Maxillo-Facial Prosthetics Unit. He has almost completed research work for an M.Sc. degree.

Dr. John Austin is a B.V.Sc. graduate of Pretoria University. After qualifying, he spent 8 years in general veterinary practice before joining the MRC/University of the Witwatersrand Dental Research Unit as a research officer in 1972. His research interests include the biological testing of dental materials and ultrastructural studies on oral mucosa and teeth.



* Hanau No. 2 Flask Press — Teledyne Hanau, Buffalo, New York, U.S.A.
** Instron Table Model, Type 1026, High Wycombe, England