

Design and Development of a Cyclic Load Generator for use in Experiments in Dental Medicine

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Abstract

The objective of this research is to design and build a cyclic load generator for use in experiments on human teeth or other dental restorative materials. A human tooth can be subjected to a chewing force between 200 N and 2440 N, depending on the position it is on the jawbone and also on what it is chewing. Chewing force is composed of axial (compressive) force and lateral (shear) forces on a plane perpendicular to the axis of the tooth being considered. The design of this load generator must then be able to impart a repeated compressive load on the test specimen and must also provide means for adjusting the ratio between lateral and axial loads.

An eccentric cam driven by an electric motor is used to generate a sinusoidal motion on a cam follower. This cam follower in turn imparts a time-varying load on the stationary specimen through compression and rebound of a spring set between the cam follower and the loading head. The shear force to compressive force ratio can be adjusted by inserting a wedge of predetermined angle between the base of the machine and the specimen holder.

The design result is an electrically driven cyclic load generator that can be applied to test eight specimens at the same time. Load force can be altered by either changing the spring constant or by changing the eccentric dimension. The direction of applied force on the specimen can be altered by means of a triangular wedge of different angles. Its applications are for testing the service life of restorative dental filling materials, endurance of a dental implant fixture and retention between the implant fixture and its abutment, etc

1. Introduction

What research scientists in this country have in common are difficulties to find main instruments or machines that fit their specific needs. Many research proposals, though sound in principles are not deemed possible because a suitable research instrument or

machine cannot be acquired. Researches involving application of cyclic loads, for examples, are ones that fall under such circumstances. A universal testing machine may be available but cannot be used as the research platform. The machine is commonly a central facility in an institute that cannot be occupied for an extended period of time, its operating fees may be too costly if held on a test for too long, or it may need some costly and time-consuming retrofitting. In both cases, the specimen and the retrofits have to be removed at the end of the period stipulated in the agreement which means that the test kit have to be put on and off very often and then makes fatigue tests impossible. A special-purpose machine tailor-made for each requirement is one among the many solutions. It will not be costly for it will contain only the functions required and will be fabricated locally. It will not take longer time to design and fabricated than that required to place an order for retrofits for a general-purpose machine, and, it will fit perfectly with the need.

There was a thesis proposed by a graduate student from the Department of Prosthodontics, Faculty of Dentistry that was sound in nature but faced difficulties in acquiring a proper test instrument. It was a proposed study of retentive force of cement between an implant abutment and crown after a predetermined elapsed time of cyclic loading. The student planned to use a universal-testing machine together with a specially designed fixture but later found out that rental fees for such an extended test rendered the scheme impossible, and this was why this research project was originated.

The purpose of this research project is to design and to develop machines that will serve researchers on dental materials. The machine will be used for putting a specimen under time-varying compressive load of the sinusoidal type from approximately (pre-settable) 10% of full load to full load. The magnitude of the load has to be pre-settable. The orientation of the specimen must be adjustable for angles that it makes with the direction of force, the specimen itself shall be held literally static. The machine was designed from scratch and fabricated.

2. Design Concepts and Methods

The machine had to have multiple test heads on a single frame as shown in Fig. 1. Drive had to be from a geared motor capable of connecting power directly from a household outlet. The speed had to be approximately 60 rpm to 100 rpm, fixed or variable. Each test head had to be fixed on the base of the machine frame by capscrews in slots so as to be adjustable axially and transversely. The test head had to be able to fix the specimen at any angle to the direction of force by a fixed-angle wedge. Application of force had to be point-loading type via a cylindrical pin of approximately 1mm-2mm in diameter. This force-transfer pin had to be held in a quick-release collet at the outer end of the plunger. This plunger had to be made of brass for it had to stay virtually static while the steel cam-follower slid outside it. The cam-follower and the plunger were spaced apart by the force-constraining spring. The movement of the cam-follower was controlled by the rotating eccentric cam driven directly by the geared motor

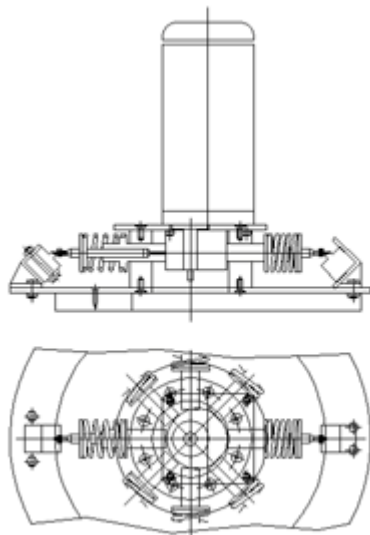


Fig. 1 The design layout.

Given the maximum magnitude of force of 288N, a compression-type of helical spring was sought of first. By judging from the proportions of the would-be machine, the displacement of the spring was roughly approximated. The spring was designed from the known wire size available in the market and ordered by the lot. Each spring in the whole lot was tested on a spring tester for its spring-constant before going further to deciding on the eccentric. From there, the whole machine was then completely designed and fabricated.

3. Results

Generally, the machine was designed to hold eight specimens on a circular platform. The platform is raised for access to bolt heads underside for fixing specimen

holders through slots. The central core houses the drive unit that comprises a motor, a gearbox and an eccentric cam. The axis of rotation of the drive train is vertical with a cooling fan attached to the end of the motor.

The eccentric cam drives all plunger units through each of the eight holes at the base of the housing. The plunger unit comprises a cam-follower, a spring, a plunger with a collet chuck at the end for holding the loading pin. This loading pin exerts a cyclical “concentrated” load on the specimen by the variable displacement of the spring while the specimen remains virtually static. The specimen is fixed on the specimen holder by bolts and nuts. The angle that the specimen made with the horizontal can be altered by inserting a wedge under the holder.

The specimen is initially set into position by firstly setting the cam displacement on that head to zero. The wedge and the specimen holder are then moved against and aligning to the loading pin, and fastened to the platform with a little preload. The preload is required to ensure that the plunger assembly would not fall apart but this preload causes a “nonzero” minimum load of the cycle.

The machine was initially intended for testing some dental materials for the sake of studying the life of such materials under fatigue load. It will be useful for research work because of its multiple test-head feature where eight specimens can be set to test under the same environment. With some modifications made, the machine will be capable of testing an implant fixture by the standards under preparations by ISO.

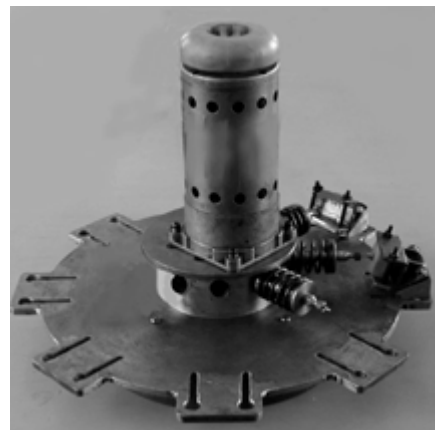


Fig. 2 The machine shown with loading heads partially assembled and fan shroud removed.

4. Conclusion and Recommendation

Since the purpose of this research project was to assist researchers in acquiring machines or instruments to fit their needs, special-purpose machines were the final products. A machine was designed and fabricated for a graduate student of the Faculty of Dentistry to use in experiments required by the thesis proposed. The machines mentioned is a cyclic load generator with eight test heads.

The requirements informed by the student and the advisor were translated into design drawings which were then sent to machine shops to fabricate and assemble. The machine was then put into the hands of the student for use and evaluation. Minor adjustments were made during these processes, some necessary alterations and modifications were also made.

The result of this research project is a low-cost machine tailored to fit the requirements of the would-be users. It was a very successful machine that worked very satisfactorily and in line with the design concept. One feature that was left to be desired was the cycle counter for each test head, a modification that could not be made at present because of time and budget constraints. It can take the place of a universal-testing machine in its "repeated load" mode. It can be used to test any specimen under fatigue loads at up to eight pieces at one time.

5. Acknowledgment

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