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AUTOMATED TORQUE SENSING EQUIPMENT FOR COSMETICS AND PHARMACEUTICALS

by

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Abstract

The limited accuracy of existing closure torque testers and the subjectivity of the measurements imparted by human operators has led to the development of an automated closure testing machine, the Auto-Torque.

As packaging requirements become more stringent in order to provide improved consumer safety and product integrity, improved quality control techniques become necessary. Torque testing of closures has relied for years on a manually operated spring scale with a claimed accuracy of plus or minus four percent (4%) full scale. The closure testing process becomes more inaccurate when you add to this error the inconsistencies due to reading errors, data entry/analysis errors, and operator technique (1). Automation of the closure torque testing process narrows the range of errors down to those of the machine itself which are easily quantified by a calibration procedure. Currently available spring scale closure testers have no provision for measuring downward force needed to engage child-resistant (CR) closures, requiring the user to develop their own apparatus (2).

Currently, the Auto-Torque is being used for university research and by major pharmaceutical companies in both the package development and quality assurance test area to support the productivity of multiple lines.

This paper describes the Auto-Torque's ability to provide the quality assurance needed in the closure torque testing process. Technical problems encountered and their solutions are viewed from a general systems automation perspective.

Introduction

Discussions with Packaging Development Engineers and market researchers pointed to the need for a machine that would meet the following requirements.

1. Automatically clamp the closure and container consistently for a wide range of package types, sizes, and configurations including child resistant (CR) closures.

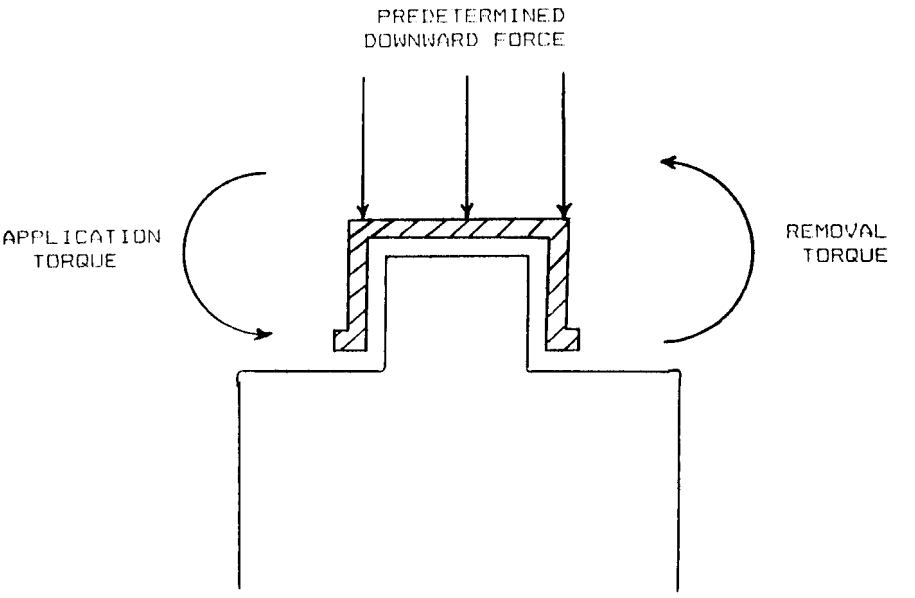


FIGURE 1 - Forces Applied to the Closure and Container by the Auto-Torque

2. Measure application/removal torque and downward force with greater accuracy than is currently available (see Figure 1). In addition, the contact gripper configuration should attempt to emulate the hand.

3. Acquire data in real time, analyze data and present results in graphical or tabular form, including the generation of control charts.

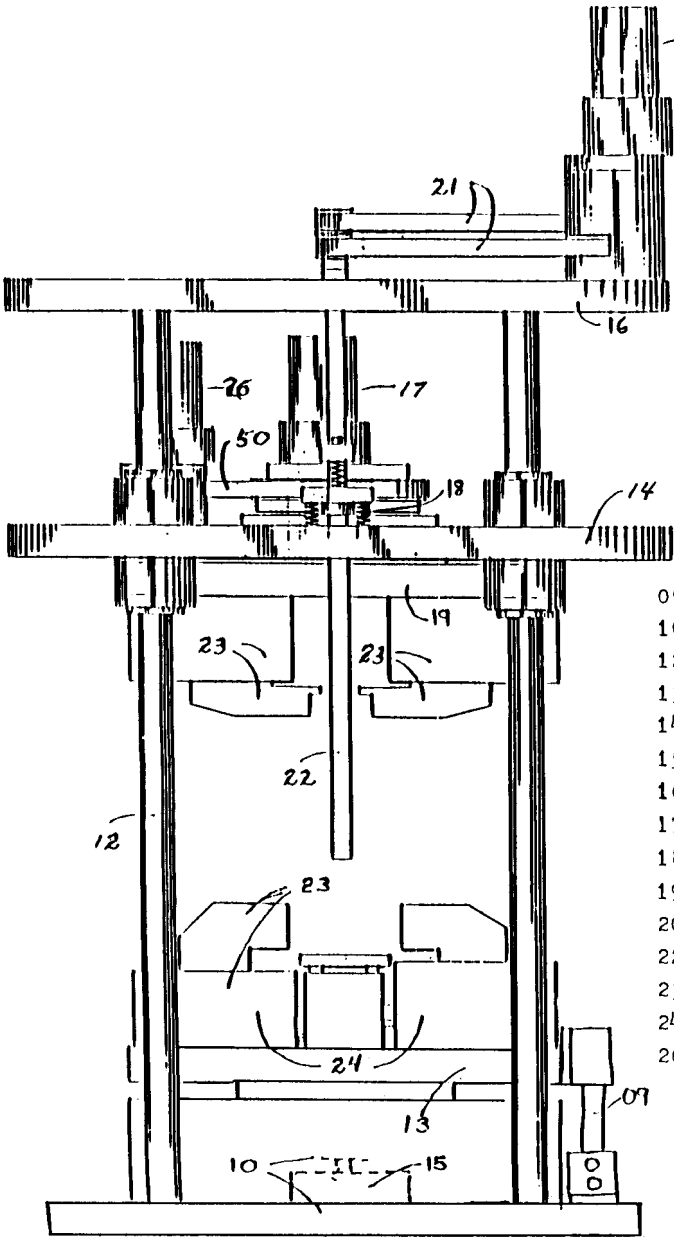
4. Be user friendly and provide an operator interface simple enough for the first time user or unskilled operator.

5. Prove rugged and reliable in production environments.

6. Be easily adapted to fully automatic loading/unloading and testing for on-line quality control, i.e., close the loop on the closure adjustment process.

7. Allow easy calibration/verification of results and computer system validation.

Different requirements of Packaging Development Engineering and Quality Assurance Inspectors are met with different software packages. The laboratory software for Packaging Development Engineering is capable of sophisticated analysis such as torque retention studies whereas the quality assurance software is optimized for rapid analysis and display of data.



09 TORQUE LOAD CELL
10 BASEPLATE
12 GUIDE RODS
13 LOWER ROTATING PLATE
14 MOVING PLATE
15 FORCE LOAD CELL
16 SUPPORT RING
17 CAP MOTOR
18 SPRINGS
19 UPPER ROTATING PLATE
20 FORCE SERVO MOTOR
22 BALL SCREW
23 CHUCK JAW ASSEMBLY
24 BOTTLE CLAMP MOTOR
26 TORQUE SERVO MOTOR

FIGURE 2 - Major Components of the Test Head

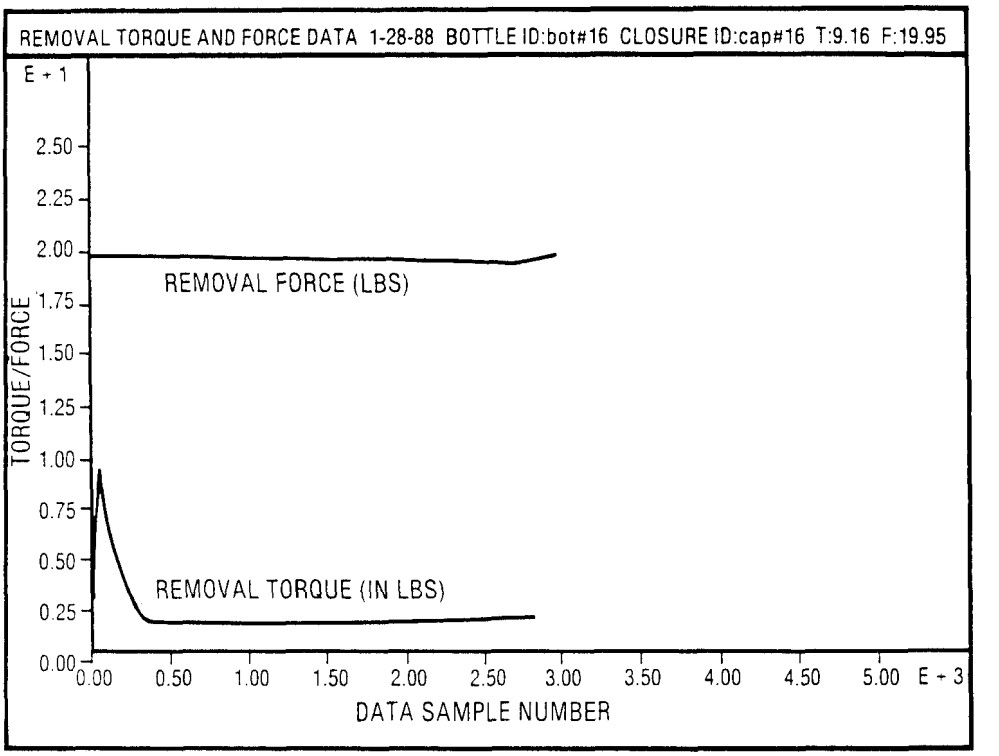


FIGURE 3 - Removal Torque and Force for a 38mm Child Resistant Closure

System Design

An Auto-Torque consists of three major components: a test head, an electronics cabinet and a computer.

The test head (see Figure 2) contains self centering jaws to clamp the container and closure, a force motor/lead screw mechanism, a torque motor/rotator and load cells. Interchangeable jaws allow for reliable gripping of odd shaped bottles.

Electrical interfaces between the computer and the test head are included in the electronics cabinet along with power supplies and motor drivers.

An IBM PC or compatible computer was chosen due to its wide industrial acceptance, reliability and ease of use. A color display is used to provide a vivid graphical user interface.

The Auto-Torque Software is a menu driven system which lists the options available to the user, prompts the user for any

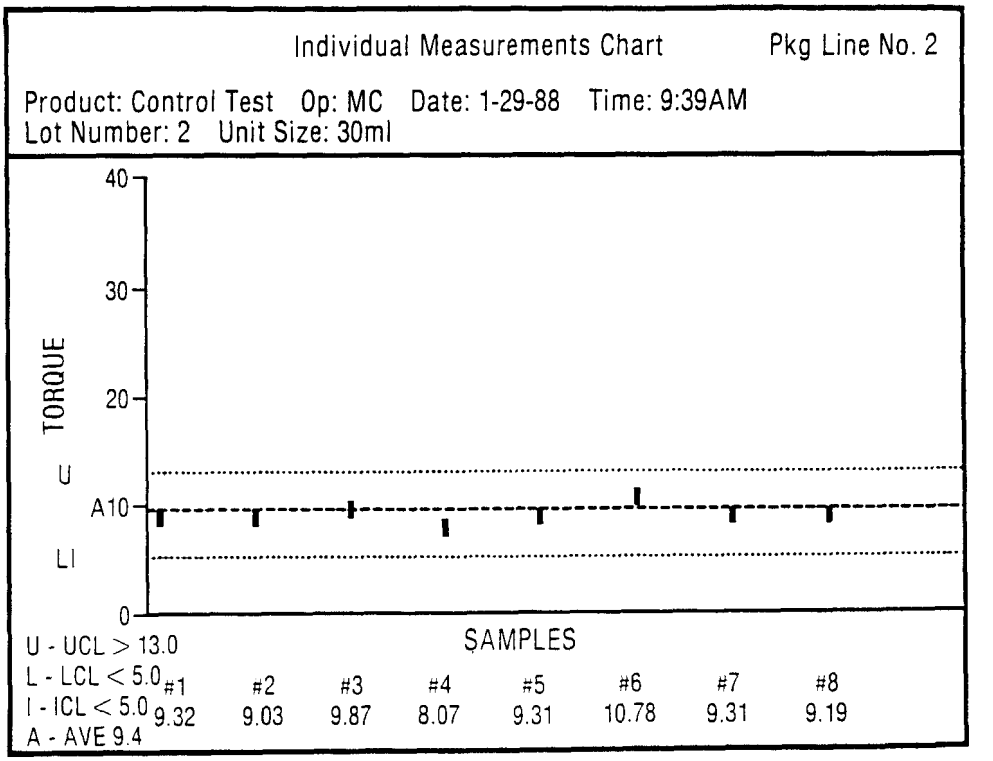


FIGURE 4 - Control Chart of Individual Specimens for One (1) Hour Time Period

information required to perform the chosen action, controls the hardware during testing, and displays the results of the tests in either tabular or graphical forms. Software is written in Turbo Pascal# and runs on an IBM PC under the MS-DOS+.

Design Considerations

The Auto-Torque seems deceptively simple, its function is to clamp the container and closure, apply downward force in the case of CR closures and remove the closure while monitoring force and torque. However, as is always the case when automating a function previously performed by humans, subtle actions of the operator become difficult tasks for a computer to emulate. For example, how does one determine when a closure was removed? To an operator the answer is obvious but a computer requires an algorithm to mechanize the decision making process.

After several approaches were tried, it was determined that a preset minimum downward force would be maintained (for CR

closures) via closed loop control while the closure is rotated through a preset angle. The peak torque reading is retained as the removal torque value.

Calibration of the Auto-Torque is simple and straightforward but requires some special consideration in order to measure the machine's full accuracy. The starting point is ASTM standard D3474-80 "Checking the Calibration of Torque Meters Used in Packaging Applications" which describes wrapping a string around a circular plate attached to the torque meter, over a pulley and hanging dead weights from the string. When the accuracy approaches 1% of full scale, factors such as string diameter, pulley runout and pulley friction become critical. For example, using a 0.050 inch diameter string on a 5 inch diameter circular plate would result in a 1/2% error. Such an error would not be noticeable with a manual spring scale type tester but would decrease the accuracy available with the Auto-Torque by almost one half. In real numbers, for a full scale torque of 40 inch pounds, the Auto-Torque's accuracy is 0.3 inch pounds whereas a spring scale tester's accuracy is 2 inch pounds (4% of 50 inch pounds full scale). It is also important to do the torque calibration with weights on the platform representative of the downward force expected to be applied to the cap so that bearing friction is taken into account.

Data Analysis and Report Generation

After a simple removal torque test is performed, a chart is generated which shows the maximum torque value. Figure 3 shows a 38mm child-resistant closure being removed within milliseconds, as well as depicting a downward force applied to the closure. A high speed load cell collects the discrete signals which result in the individual data points being plotted.

Plots of various tests available to the user include: application force and torque, removal force and torque, retention study, linearity study, and rotational force plus a full feature statistical package and data management capability.

In addition, the Quality Assurance Inspector can generate a control chart with pre-set limits to determine trends relating to the stability of ratating line and multiple head cappers. Simultaneous running product lines can easily be supported by the Auto-Torque. Figure 4 shows an individual measurement control chart with eight (8) specimens taken over an hour time period; an X control chart can also be configured to assist the Quality Assurance Inspector.

Closing the Loop

Now that the Auto-Torque is available to automate torque testing, the next logical step is to automate the sampling process. This will be accomplished with the use of an inexpensive pick and place robot and a bottle diverter on the line. Report generation could be hardcopy, magnetic media and/or a direct connection to the factory mainframe.

Given automatic torque testing, sampling and report generation, the final step is to close the loop on the capping process by allowing the Auto-Torque computer to adjust the torque setting of the capping machine.

Conclusion

The Auto-Torque automatic closure testing machine provides an accurate, repeatable and reliable means to improve the package testing quality control process. Computer control further improves productivity by automating statistical data analysis and reporting as well as data acquisition.

Availability of automatic closure testing sets the stage for automatic sampling and ultimately, automatic closed loop control of the closure process for cosmetics and pharmaceuticals.

FOOTNOTES

*IBM is a trademark of International Business Machine Corp.
#Turbo Pascal is a trademark of Borland Int.
+MS-DOS is a trademark of MicroSoft

(1) ASTM D3810 "Standard Test Method for Minimum Application Torque of Type 1A Child-Resistant Closures", pg702, note 3 & 4

(2) ASTM D3471-82 "Standard Test Method for Top-Load-To-Engage Removal Lugs on type 1A Child-Resistant Closures".