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Repairs of 5 million pound testing machine
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Roger G. Slutter

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REPAIRS OF 5 MILLION POUND TESTING MACHINE

by

Roger G. Slutter

September 1967

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REPAIRS OF 5 MILLION POUND TESTING MACHINE

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Roger G. Slutter

1. INTRODUCTION

During the Fall of 1964 periodic leakage of oil from the south backlash eliminator began. There did not seem to be any definite correlation between the type of testing being done and the occurrence of leakage. The leakage stopped for periods of time as long as six weeks and then began again without any apparent reason.

During the Summer of 1965 it became necessary to investigate the problem thoroughly so that leakage could be stopped during the time that the machine was in use for the Plastic Design Conference.

The head of the testing machine was lowered on the pedestal and the retainer plate and packing were removed. At this time it was discovered that the backlash eliminator nuts were worn. New packing was installed and a 1/4 inch thick aluminum plate was installed on top of the packing to compress it further. This emergency repair effort proved to be satisfactory as far as stopping leakage was concerned.

Following the emergency repairs the following steps were taken to reduce further wear on backlash eliminator nuts:

1. Tensile testing at fracture loads above 2 million pounds was discontinued.
2. Moving of the fixed crosshead was stopped unless absolutely necessary.

3. Movement of the lower crosshead was reduced by adopting new procedures for handling specimens.

Plans for having repairs made to the machine were developed in consultation with personnel of the Wiedemann Machine Division of the Warner & Swasey Company and the Bethlehem Steel Corporation.

2. CONDITION OF THE TESTING MACHINE PRIOR TO REPAIRS

The leakage of oil from the south backlash eliminator was the most obvious indication of the wear taking place in the backlash eliminator nuts. However, other less obvious indications were observed. The noise level upon fracture of tensile specimens seemed unusually great for fractures involving only a nominal amount of energy being released. Also it was observed that the motor which turns the main screws appeared to be loaded heavily, initially whenever the screws were turned.

It was observed that a large amount of fine bronze was being deposited on the screws over a period of several years. In fact this continues to be the case with new parts installed.

During the Fall of 1965 a pressure gage was installed in the hydraulic line leading to the south backlash eliminator. This gage revealed that the backlash pressure was not being released immediately when the screws of the machine started to turn. It required a head movement of approximately 3 to 4 feet to cause this pressure to drop to zero.
Figure 1 shows the hydraulic system of the testing machine. Inspection of the valve BN which releases the backlash pressure whenever the main screws are turning was functioning properly. However, the backlash pressure was not releasing immediately because of the relatively large quantity of oil which must be removed from the backlash eliminators before the pressure releases completely. This oil must pass through approximately 80 feet of 1/8 inch diameter line.

The weight of the sensitive crosshead is supported by the oil in the backlash eliminators until a sufficient quantity of oil has been drained out to produce metal to metal contact. The amount of oil to be drained is directly proportional to the wear on the nuts. Therefore, as the amount of wear increases the backlash pressure remains on longer after opening of the release valve.

Whenever the backlash pressure is above zero the split backlash eliminator nuts are functioning as a jamb-nut thus increasing the load on the motor which turns the main screws. This situation also tends to increase the rate at which the backlash eliminator nuts wear.

The increase in the volume of oil contained in the backlash eliminators increases the amount that the sensitive crosshead moves when energy is released suddenly as in the case of a tensile fracture in the machine. This apparently resulted in the loss of capsule fluid in the weighing capsule of the head. During periods when tensile specimens were being tested the loss of weighing capsule fluid was excessive. During other periods there was essentially no loss of fluid from the capsule.

When emergency repairs were made in September 1965, it was found that the studs and retainer plates which bolt on the moveable crosshead
to retain the backlash eliminator nuts were bent. The 2" thick retainer plates were deflected about 5/32 inch. The studs were bent so that some had to be straightened before the plates could be removed.

It is generally supposed that the retainer plates were bent during fracture of tensile coupons due to backlash. However, calculation of the forces on these plates as the upper head is being moved indicate that a slight binding of the upper head could increase the force on the retainer plates to the point of yielding the plates.

3. SCOPE OF REPAIRS

In addition to the basic problem of providing the machine with new backlash eliminator nuts other minor repairs were also considered. A review of all of the deficiencies of the machine was made and corrective measures were considered. Each item is discussed in one of the following sections of the report.

3.1 Main Hydraulic System

The machine was originally equipped with a variable stroke pump for the main hydraulic system. This pump did not perform satisfactorily and as a result the stroke was fixed at its maximum and a by-pass was installed. The resulting pump then operates at full capacity constantly when the actual pump capacity required for testing is often less than ten percent of the actual pump capacity.

It was suggested that a smaller pump, approximately the size of a pump for a 300 kip capacity machine, be installed. The main pump would be used only in tests where the rate of loading was high. This new
pump could be installed in the same manner as the load maintainer pump which has been added to the machine. The load maintainer pump has sufficient capacity for holding load, but is too small for loading. This pump has a maximum capacity of 1 gpm whereas the maximum capacity of the main pump is 33 gpm. It appears that a 7.5 gpm pump with a 10 Hp motor could be used for most of the work done by the machine.

This item was dropped because it was not considered urgent and is equipment that our technicians could install. The cost of the pump and motor would be approximately $500.00.

3.2 Pneumatic Gripping Devices

These devices are not satisfactory for a testing machine of this size and hydraulic rams should be used in place of air rams. We requested that the engineering group of Wiedemann Division investigate this problem. Their verbal report indicated that it was not practical to install hydraulic rams on this machine at this time. They are currently building machines with hydraulic grips, but none approach our machine in size.

The problems with the air rams consist of deterioration of valve and head gaskets from moisture which condenses in the rams, failure of air ram components on the lower head system, and constant leakage of air. On many occasions it has been necessary to repair leaking valves so that the air compressor can supply the demands of the weighing system.

It was decided to install moisture filters and traps on the air lines at the rams and replace gaskets in the rams. If this is not successful, the air rams should be replaced with hydraulic rams using
a pumping system that is independent of the hydraulic system in the machine. The Wiedemann people have advised that the pull back pressure is too low for power gripping rams, and we agree with this.

3.3 Failure of Liner Plates

Liner plates for the upper head consistently fail during tension tests by pulling the supporting tabs off as the grips and liner plates slide. It was decided that a set of new plates to be used only in the upper head should be acquired. The old liner plates are satisfactory for the lower head where the problem does not exist.

A product used for steel concrete forms called FORMWAX, manufactured by Great Lakes Mining and Manufacturing Company, Milwaukee, Wisconsin, has been found to be the best lubricant for grips. A block of wood placed under the supporting tabs is also helpful in reducing failure of tabs. A better solution would be to glue neoprene strips to the head of the testing machine. A laminated neoprene strip would be best.

It is believed that the problem of liner plate failures can be eliminated by proper setup procedures which include the following:

1. Use new liner plates only in the upper head.
2. Keep liner plates, grips, and grip cavity clean.
3. Use FORMWAX or equivalent on grips.
4. Support liner plates on wood or neoprene.
5. Rough spots on liner plates should be ground smooth as they are discovered.
3.4 Loss of Fluid from Weighing System

Frequently over the past five years it had been necessary to add oil to the weighing capsule. At times the quantity of oil required exceeded 3 pints. Checking of the capsule, console, and lines failed to reveal the location of the leakage. It was generally supposed that leakage must occur somewhere in the flexible lines between the head of the testing machine and the console.

Since replacement of the flexible lines would be a difficult task, it was decided to defer this work until other repairs were completed. Since the leakage could not be located, replacement of the lines may not be the solution of the problem. These repairs would be independent of the other work.

During the last few months prior to repairs an inspection of the capsule fluid levels at frequent intervals began to reveal that the oil was being lost as a result of fracturing tensile specimens. Extensive use of the machine at high loads for calibration work did not result in any loss of oil from the capsule. It was, therefore, concluded that repair of the backlash eliminators might also solve the problems of loss of capsule fluid.

Experience with the machine during the six months following repairs indicate that the loss of capsule fluid is no longer a serious problem. However, it is still necessary to check the level of oil in the capsule at regular intervals and especially following a series of fracture tests of high loads.
3.5 Crack in Main Column of Machine

A crack has existed near the base of the north column of the machine for approximately seven years. When the crack was first observed the prestressing nuts were checked and found to be tight. The length of the crack has been carefully observed and this length has remained constant over the past five years.

The problem of whether or not the crack should be repaired by welding was discussed with Mr. Buckingham of Wiedemann Machine Division. It was his opinion that nothing should be done in view of the fact that the crack is not extending.

It is obvious that the cause of this crack results from the fact that the center of gravity of the column cross-section does not coincide with the center of gravity of the anchor stud pattern. Therefore, a relatively large moment exists near the base of the columns at high loads. At fracture the tension moment shifts to the inner face of the columns. The stress concentration factors for the inner face of the columns are high due to unfavorable geometry. It is surprising that both columns are not cracked, but a careful inspection of the south column did not reveal any cracks. The crack in the north column has removed the high moment at the base of the column and may have also reduced the moment at the base of the south column during backlash. Thus it seems that the crack has removed the problem and should be left unaltered.

3.6 Handling Equipment for Tension Specimens

The wearing of the backlash eliminator nuts occurs only when the sensitive crosshead is being moved. Any means of reducing
movement of the head should be considered. In placing both compression and tension specimens in the machine it is convenient to move the lower head well above or below the point necessary for providing clearance for the specimen in order to place the specimen more easily.

In handling compression specimens, the head of the machine is used in place of a crane to position specimens. Often this is done with cables longer than necessary because they happen to be readily available. By exercising closer discipline, the head travel can be reduced. Also the movement of the head can be reduced by using the loading pedestal whenever possible. The only type of equipment which would reduce head travel further would be a forklift truck.

To reduce head travel when tension specimens are being placed it is necessary to develop a handling device for this purpose. Several types of devices have been considered. These include the following:

1. A small bridge crane or electric chain hoist mounted on the upper head.

2. A device mounted on the lower head and lifted with the crane that would raise specimens into position and drop the specimen into the lower head.

3. A beam crane mounted on a column which could swing a specimen over the lower head.

The first of these schemes was considered for the new machine at the Bureau of Standards, but it was considered impractical and has been abandoned. This device would interfere with both movement of the elevator and moving the upper head. The second device is more
promising, but it also interferes with moving the upper head and is
difficult to adapt to all specimens. The third device seems to be the
most promising. It can be mounted in slots that are intended for
mounting the upper head. When the beam is in the north-south position
the elevator and upper head can be moved without difficulty. The
device can be moved easily with the 20 ton bridge crane. The main
design problem involved in this device is that of obtaining sufficient
capacity and at the same time provide a device that can be easily
manipulated. The design of this equipment is being studied.

4. REPAIRS OF MACHINE

Repairs were started on January 9, 1967 and were completed
in two weeks except for some cleaning of machine parts which was
completed by our technicians. A crew of four men from the Bethlehem
Steel Corporation under the supervision of Mr. Gilroy and Messrs.
P. M. Rollison and G. S. Seaman from the Weidemann Division completed
the work of removing the old backlash eliminator nuts and installing
new ones. The project manager for Bethlehem Steel Corporation was
Mr. J. D. McGinley from the Pottstown Plant.

Figure 2 shows the old nuts being lifted from the head using
the hydraulic stroke of the machine. The nuts were then moved up the
screws by preventing the nuts from turning. Figure 3 shows one set of
nuts at an intermediate location on the screws. It was necessary to move
one set of nuts at a time.
Figure 4 shows the nuts near the top of the machine. The screws were turned by hand and were picked by the crane as they came off of the top of the screws as shown in Fig. 7.

It was necessary to enlarge the opening provided in the upper tie plate to get the retainer plates through. This was done at the start of the work and a bolted connection was used in replacing the channel member so that it could be removed easily in the future.

An inspection of the worn bushings confirmed many of the observations made previously. The bushings from the south screw were worn more than the bushings from the north screw. The thickness of threads was approximately 5/16 inch on the upper nut and approximately 3/8 inch on the lower nut. The nuts from the north screw were approximately 1/16 inch thicker.

The area which had originally been filled by the threads of the bushings was now filled with bits of steel, chips of bronze, weld splatter, and other pieces of material which had been collected from the screws. The 1/2 inch space between the upper and lower nuts was also filled with dirt. The bushings clean the screws and the material remains within the backlash eliminator nuts and contributed to continued wearing.

In checking the threads of the new nuts it was found that the width of the thread was approximately 0.015 inches greater on one set than on the other. It was decided to place the heavier thread on the south screw.
Rough areas on the screw threads were examined during this period. When the machine was originally installed a large amount of effort went into cleaning and filing the screws of the machine. However, some areas were left slightly rough with the assumption that these areas would wear smooth. From the recent inspection, it appears that these areas became rougher rather than wearing smooth. Much of the time during the weeks of January 16 and January 20 was consumed in filing screws.

In addition to installing new backlash eliminator nuts the 1-1/4 inch diameter studs on the upper surface of the head were replaced with longer studs and new thicker retainer plates were installed. New packing was also installed in the backlash eliminators.

Changes in the hydraulic piping to shorten the release time for the backlash eliminators was also considered. This would be accomplished by placing the relief valve on the head rather than in the pit. Also a larger diameter line to the backlash eliminators was considered. Decisions on these matters were delayed until performance of the machine after repairs could be evaluated. Figure 8 shows the new nuts, packing, and retainer plates prior to installation in the machine.

5. PERFORMANCE OF MACHINE AFTER REPAIRS

After completion of repairs it was found that leakage from both sides of the machine occurred when the system was first pressurized. Only after a load which increased the pull back pressure to its maximum
was applied did the leakage stop. During the six months following repairs, there has been no leakage. This and previous experience has shown that backlash eliminator leakages can be stopped by application of a compression load until the pull back pressure reaches a maximum.

The pressure gage on the backlash eliminator line was replaced after repairs. It was found that the pressure dropped to zero as soon as the screws began to turn. This made it unnecessary to consider any immediate changes in the hydraulic lines. However, this may be considered again at a future date.

During the fracture of a tensile specimen the pressure gage failed and was replaced. This indicates that the pressure at fracture probably exceeds 1500 psi. If this is true, the original retained plates were undoubtedly bent as a result of tensile fractures.

Following repairs a program of tensile tests of oil well casings were conducted on the machine. This same program had been conducted a year earlier with the old nuts in the machine. It was obvious that the repairs had improved the performance of the machine. There was much less noise upon failure of the oil well casing joints than in the previous tests.

A problem that had existed prior to repairs was the drifting of the head of the testing machine during evenings and weekends. This problem resulted in replacement and repair of the relief valve on several occasions. It now appears that leakage of oil from the backlash
eliminators was the real source of this problem. It has not been a problem since repairs were made.

New liner plates were obtained for the upper head. These plates were designed with deeper supporting tabs and will be used only in the upper head.
Fig. 2  Backlash Eliminator Nuts Being Removed from the Lower Head of the Machine

Fig. 3  A Set of Backlash Eliminator Nuts Being Moved Up the Screw
Fig. 4 A Set of Backlash Eliminator Nuts at the Top of a Screw

Fig. 5 Blocking of a Main Screw
Fig. 6  Removal of a Pillow Block

Fig. 7  Turning Nuts by Hand at the Top of the Machine
Fig. 8 New Parts for Machine