

ELIMINATING PUMPING PROBLEMS THROUGH THE USE OF A DARTT™ VALVE¹ OPTIMIZED HYDRAULIC AMPLIFIER

While the plunger pump is simple in operation, the following problems with it are common:

- Gas lock
- Damage due to fluid pound
- Seat damage due to ball dance
- Seat damage due to "Fluid cut"
- Leaving fluid in the well at "pumped-off" condition, due to inability to draw the fluid level down to the pump elevation
- Inability to pump heavy crude
- The high cost of pulling a pump to perform maintenance
- Inability to maximize gas production

A brief discussion of each of these problems is in order, followed by a technical explanation of the cause and solution of each problem.

GAS LOCK

To discuss gas lock meaningfully, it is necessary to review the normal operation of the pump, and then describe the abnormality of gas lock.

NORMAL PUMP OPERATION WITHOUT GAS LOCK

In normal pump operation, the plunger of the pump is in the down position and begins to move upward. The traveling valve within the plunger is closed, and a low pressure area is formed in the void where the plunger had been. That is, a pressure differential (ΔP_1) forms between the inside of the pump and the underside of the standing valve. The higher pressure just outside of the pump forces the standing valve to open. With the standing valve open, the high fluid pressure in the well is forced into the low pressure area within the pump, thus filling the void within the pump with fluid. When the plunger reaches the top of the stroke and starts downward, the pressure inside of the pump exceeds the pressure outside of the pump, and the standing valve is forced closed. This forms a closed chamber within the pump barrel, with the standing valve at the bottom, and with the traveling valve at the top.

1. THE OPTIMIZED HYDRAULIC AMPLIFIER REFERRED TO IS A PATENTED DEVICE MADE BY THE DARTT™ VALVE COMPANY OF HOUSTON, TEXAS, AND THE NAME OF THE HYDRAULIC AMPLIFIER IS TRADEMARKED : "DARTT™ VALVE"

As the plunger continues downward, it attempts to compress the fluid, which is non-compressible, thus causing a pressure differential (ΔP_2) between the inside of the pump and the production column. With the plunger traveling downward within the closed chamber, P_2 causes a force (F_{up}) which pushes against the bottom of the traveling valve ball, attempting to open the ball. When this force is great enough to exceed the force pushing on the traveling valve ball from the fluid column above the pump (F_{down}), the traveling valve ball opens. As the plunger continues downward, the fluid which was below the traveling valve becomes fluid above the traveling valve, largely due to the relocation of the traveling valve, but partly due to the smaller volume within the hollow plunger compared to the volume within the pump barrel. Thus, the fluid within the pump barrel chamber is transferred through the open traveling valve into the production column of fluid above the pump. When the plunger reaches the bottom of the pump, the differential pressure (P_2) diminishes to zero, the traveling valve closes, and the plunger again starts upward, creating a low pressure P_1 within the pump barrel, opening the standing valve, and allowing fluid from the well to enter the pump.

WHAT HAPPENS DURING A GAS LOCK CONDITION

In the real world, "normal" pump operation is unusual and when it does happen, does not continue for long. One of the common occurrences which prevent normal operation is gas lock. During gas lock, the plunger of the pump is in the down position and begins to move upward. The traveling valve within the plunger is closed, and a low pressure area (P_{1-}) is formed in the void where the plunger had been. The higher pressure (P_{1+}) just outside of the pump forces the standing valve to open. This is the point at which the pump action departs from theoretical normal pump operation.

With the standing valve open, the void within the pump is filled with gas instead of with fluid, or part of the fluid entering the low pressure area (P_{1-}) within the pump flashes (changes from a liquid to a gas) This occurs as a result of the natural gas law

(EQ1)

$$PV = nRT$$

where P = pressure of the fluid

V = volume containing the fluid

n = a measure of the quantity of molecules of the fluid

R = is a constant numeric value

T = the temperature of the fluid in absolute temperature

In the case we are considering, T is a constant, R is a constant, and n is a constant; therefore the equation 1(EQ1), becomes

(EQ2)

$$PV = K, \text{ where } K \text{ is a constant}$$

Within the pump, what this natural gas law implies is that a small amount of fluid can enter the pump as a liquid which was under high pressure (due to a tall hydrostatic fluid column in the well), and as soon as it reaches the low pressure area within the pump some or all of it can become a gas. Then as the plunger falls and re-compression of the fluid occurs, the heavy ends of the gas can once again become a liquid, an emulsion containing both liquid and gas, or a mixture containing both liquid and gas.

When the plunger reaches the top of the stroke and starts downward, the pressure inside of the pump exceeds the pressure outside of the pump, and the standing valve is forced closed. This forms a closed chamber within the pump barrel, with the standing valve at the bottom, and with the traveling valve at the top.

As the plunger continues downward, the volume within the closed chamber decreases and forces the gas within the closed chamber to become compressed. Since gas can be compressed (as opposed to the characteristic of a liquid which can not be compressed), this gas merely becomes compressed and does not push against the bottom of the traveling valve ball hard enough to cause a force to open the ball. Since this force is not great enough to exceed the force pushing on the traveling valve ball from the fluid column above the pump, the traveling valve ball never opens, and the gas within the closed chamber remains there. When the plunger reaches the bottom of the pump, the traveling valve is still closed, and the plunger again starts upward. But this time, instead of creating a low pressure (P_1) within the pump barrel, the compressed gas within the closed chamber merely becomes less and less compressed, and no differential pressure is formed to open the standing valve; thus no fluid from the well enters the pump barrel. Unless stopped by a vigilant Operator or a sophisticated pump controller, this cycle is repeated until the pump literally wears out from the friction of the un-lubricated plunger against the pump barrel. At this time, the pump must be pulled and replaced.

THE OPTIMIZED HYDRAULIC AMPLIFIER PROVIDES THE CURE FOR GAS LOCK

What went wrong in the "gas lock" cycle? Once we identify what went wrong, then we can work to fix it. What went wrong was that the gas was allowed to remain within the pump, instead of forcing it on up through the pump as if it were normal liquid fluid. The gas stayed within the pump because the traveling valve never was forced to open. So, to fix the problem, the traveling valve must be opened every time the plunger begins its downward stroke and ideally it should be kept open throughout the entire downward stroke. Also, in the upstroke following the flawed downstroke, insufficient differential pressure (P_1) between the interior of the pump and the well existed to force the standing valve to open. Therefore to fix this problem, more differential pressure (P_1) must be formed as the plunger travels within the upward direction. Both of these problems work hand in hand with one another, the one causing the next, which causes the next, and so on. Accordingly, the solutions to these two problems must work hand in hand, one preventing the first problem, thus preventing the next problem, and so on.

What would logically work to prevent these two problems would be a device of some sort which would positively open the traveling valve on the down stroke and which would positively close the traveling valve on the up stroke. Absolutely closing the traveling valve on the up stroke would create the best possible differential pressure (P_1) between the pump interior and the well, thus doing the best job possible of forcing the standing valve to open in the upstroke. Positively opening the traveling valve in the downstroke would empty the pump into the production column and prevent gas compression within the pump, correctly and perfectly setting the stage for filling the pump once again in the following upstroke.

In simple terms, Force is equal to pressure multiplied by area:

$$(EQ3) \quad F = (\text{pounds/sq. in.}) \times (\text{Area in sq. in.})$$

The force (F_{up}) which pressure P_2 exerts against the traveling valve to open it would be increased if one were to cause the natural pressure within the pump (P_2) to push against an area which is larger than the small area within the seat below the traveling valve, and then use this larger force to force the ball to open. The optimized hydraulic amplifier makes use of this simple principle of hydraulics, the pressure pushing against a larger area to make a larger force, to positively force the traveling valve to open every time the plunger is in its downstroke cycle. Also, empirical data has shown that the movement of the plunger (continuously attempting to increase P_2) coupled with the momentum dampening mass of the hydraulic amplifier actuator and with the fluid dynamics of the fluid flow around the optimized hydraulic amplifier actuator act together to keep the traveling valve open with this force throughout the entire downstroke.

In the upstroke, with the inside of the pump now empty (all of its contents having just been transferred to the production column in the preceding downstroke), the traveling valve and the three cascade valves within the optimized hydraulic amplifier positively shut and form a nearly perfect traveling valve seal within the pump. This maximizes the pressure differential P_1 between the inside of the pump and the outside of the pump in the upstroke, causing the standing valve to open, and positively filling the pump with whatever is within the well.

This sequence of operations changes the standard plunger pump from one which can only pump liquid to one which can even pump gas, thus preventing gas lock. That is, the pump pumps just as it should, in accordance with its theoretical design model, regardless of the gas content of the fluid in the well.

FLUID POUND

NORMAL PUMP OPERATION WITHOUT FLUID POUND

As the plunger begins to travel downward, it attempts to compress the fluid, which is non-compressible, thus causing pressure (P_2) within the closed chamber which pushes against the bottom of the traveling valve ball, exerting a force to open the ball. When this force is great enough to exceed the force pushing on the traveling valve ball from the fluid column above the pump, the traveling valve ball opens. As the plunger continues downward, the fluid within the chamber escapes through the open traveling valve into the column of fluid above the pump.

WHAT HAPPENS DURING FLUID POUND

Empirical data from field observations has shown that in the real world, "normal" pump operation is unusual and when it does happen, does not continue for long. One of the common occurrences which prevent normal operation is the partial filling of the pump with gas instead of completely filling the pump with liquid, thus setting up a fluid pound strike situation. Immediately before the impending fluid pound strike, the plunger of the pump is in the up position and begins to move downward. Moving downward with the plunger are the rod string, the fluid in the production column, the traveling valve ball, and the pumping unit mechanical system, all of which have mass and momentum.

In this situation, within the pump barrel are some gas and some liquid. The gas, being lighter than the liquid, floats on the liquid and is thus above the liquid. As the plunger begins its downward travel into the barrel of the pump, it travels only through gas. The gas is compressible and presents practically no opposition to the falling plunger production column fluid, and rod string mass which travel virtually unopposed (P_2 is small because the gas is compressible), toward the liquid in the lower portion of the pump barrel. The traveling valve remains closed due to the greater force (P_{down}) from the above liquid column within the production tubing compared to the small force (P_{up}) presented by the gas pressure against the very small area of the traveling ball valve within the seat. No gas or liquid is yet escaping from the closed volume within the pump, because the traveling valve is still closed.

Eventually the falling plunger meets the liquid, which is incompressible, and instantly stops. The plunger stops, the rod string attempts to stop but actually compresses like a spring, snaking and bending within the tubing all of the way up to the surface, and the pumping unit attempts to continue in the downward direction; but instantaneously it can not. The mass of the traveling valve ball stopping instantaneously causes the traveling valve ball to seal within its seat even more tightly during this instant; And the liquid, by nature, can not be compressed.

All of these forces come together to oppose one another during an instant where an almost infinite force ($F_{\text{down-inst}}$), (the result of the momentum of the traveling valve ball, the plunger, the production fluid, and the rod string) meets an almost infinite force (F_{up}) resulting from P₂, the result of the attempted compression of the liquid within the pump.

Empirical observations have shown that this situation has caused, among other symptoms:

- 1) the ground surrounding the well to shudder,
- 2) hydrogen embrittled rods to break
- 3) fiberglass rods to shatter
- 4) traveling balls to crack
- 5) traveling valve seats to crack
- 6) traveling valve balls to be driven into seats so fiercely that the two become welded together
- 7) traveling valve cages to split apart
- 8) pumping unit gears to break

Immediately after the instant of fluid pound, F_{up} resulting from P₂ causes the traveling valve to open and begin the transfer of fluid into the fluid column.

Observation has shown that the fluid pound instant is repeated on every stroke until something breaks. During observations of many such situations, the resulting fluid pound shattered or cracked steel traveling balls of up to 2 1/4" in diameter, broke ball cages in all directions, shattered seats, drove balls into seats with such force that they were welded together, and caused "rod shock" which broke rod strings, particularly those having hydrogen embrittlement due to H₂S in the well. These cracked balls and bent and broken cages were collected and are available for examination upon request. And all of these things occurred simply because the traveling valve was not opened when it should have been.

THE OPTIMIZED HYDRAULIC AMPLIFIER STOPS FLUID POUND

What went wrong in the "fluid pound" cycle? Again, once we identify what went wrong, then we can work to fix it. What went wrong was that the gas within the pump did not cause sufficient pressure within the pump P₂ to present sufficient force F_{up} to the underside of the traveling valve to open it as it would have opened had the pump been full of liquid. To prevent this problem the traveling valve must be opened very soon after the plunger begins its downward stroke and keep it open throughout the entire downward stroke. Positively opening the traveling valve in the downstroke would prevent the instantaneous shock of attempted fluid compression within the pump in the downstroke and instead allow the fluid within the pump to simply leave the pump normally into the production tubing through the open traveling valve.

The optimized hydraulic amplifier makes use of the simple principle of hydraulics, the pressure pushing against a larger area to make a larger force, to positively force the traveling valve to open every time the plunger begins its downstroke; and the optimized hydraulic amplifier keeps the traveling valve open with this force and the other forces listed in the section on gas lock to keep the traveling valve open throughout the entire downstroke. Thus, the simple addition of the optimized hydraulic amplifier to the pump eliminates fluid pound. The net result is reduces stress on the traveling valve ball, reduced stress on the sucker rods, smoother strokes, longer pump life, fewer sucker rod failures, fewer tubing leaks, fewer pumping unit gear box failures, and lower overall maintenance costs.

Note that once the optimized hydraulic amplifier has been installed within a pump, the practice of "tagging the pump" in an attempt to jar the ball off of the valve seat is no longer needed; and so the maintenance costs caused by the violent forces set in motion during pump tagging are eliminated.

The question has been posed: "Where did the gas come from which caused the fluid pound in the first place?"

Investigations have shown that the gas comes from five main sources:

1. Gas from the formation coming into the pumping chamber
2. Gas formed from the "light ends" of the production fluid being exposed to the low pressure area within the pumping chamber during the up stroke of the plunger.
3. Gas formed from the "light ends" of the production fluid being exposed to the relatively high-temperature of the pump barrel which has been in contact with the moving plunger.
4. Gas formed by the constant movement of the plunger in the barrel which causes gas to break out of solution, similar to that observed after shaking a bottle of soda pop.
5. Gas formed by fluid flow through pump orifices, similar to that optimized in a paint spray gun nozzle.

Observation of these gas sources shows that there is little, if any, that even the most experienced operator can do to eliminate these gases. The best thing that the operator can do is to be ready to deal with them. The installation of the optimized hydraulic amplifier to positively open the traveling valve in the downstroke prevents the problem before it can occur.

SEAT DAMAGE FROM BALL DANCE

Ball Dance is the action of the traveling ball as the plunger is forced into the pump barrel. During each stroke the ball opens and closes a great many times, first pivoting to the left, and then to the right, seeming to "dance" on the seat. As the traveling ball is knocked about so violently by the fluid flow, it frequently chips the entire sealing surface of the seat. After the seat is chipped and rough, making a seal between the traveling ball and seat impossible, and the pump must be pulled and repaired.

One of the causes of ball dance is that the ball is not of sufficient mass to keep it from moving around quickly. In terms of 2-dimensional mathematics, this ball dance movement of the traveling ball is governed largely by the following equation:

$$\frac{d^2x}{dt^2} + [2\gamma] \left[\frac{dx}{dt} \right] + (w_0^2)(x) = \frac{F_0}{m} \cos(wt)$$

From this equation, it can be seen that the movement of the ball is diminished when the mass of the ball (or the sum of the masses of the ball plus the actuator of the hydraulic amplifier) is increased. Thus, adding the hydraulic amplifier to the pump can be expected to reduce ball dance; and empirical observation has indeed shown this to be true.

Another of the causes of ball dance is that the fluid dynamics on a sphere which is not connected to a stabilizing shaft. The ball is free to move about in 3-dimensional space, while the hydraulic amplifier actuator is held steady in the x and y axis by the tight fit between the amplifier valves and the amplifier housing. The result of this has been shown empirically to be that the hydraulic amplifier actuator actually holds the traveling valve ball from its seat during almost the entire downstroke, thus effectively preventing damaging action between the ball and its seat.

“FLUID CUT” SEAT DAMAGE

Fluid cut is a type of fluid erosion which occurs when a grain of sand becomes wedged between the traveling ball and seat and becomes captive there. The fluid being pumped travels between the ball and seat and around the grain of sand, thus causing the erosion. Replacement of the traveling ball and seat is required when they are damaged to the point that the seal between the ball and the seat is not longer possible.

The installation of the optimized hydraulic amplifier into the pump physically forces the traveling valve to open more than enough to dislodge the sand, thus allowing the sand to be washed away in the downstroke immediately following the upstroke in which the sand was caught between the ball and the seat; thus preventing fluid cut damage from occurring. Further, during the upstroke where the sand is lodged between the traveling ball and seat, the seal between the traveling ball and seat is compromised, allowing leakage and promoting incomplete pump fill. The optimized hydraulic amplifier contains three valves which provide back-up service to the traveling valve. When the traveling valve is not working due to sand, the special hydraulic amplifier valves take its place in the upstroke. Thus, with the special hydraulic amplifier in the pump, the sand has no effect on the ability of the pump to operate correctly, even in the upstroke where the sand has propped the traveling valve in the open position.

INABILITY TO DRAW THE FLUID LEVEL IN THE WELL DOWN TO THE LEVEL OF THE PUMP

It has been observed that, in an effort to minimize flash-gas and the resulting fluid pound, it has been the practice of most operators to maintain a level of fluid within the well which is in the 300ft. - 500ft. range. In some wells which are not equipped with the special hydraulic amplifiers, the actual level is frequently dictated by the Pump-Off Controller which shuts down the well upon sensing fluid-pound vibration. In other wells which are not equipped with the special hydraulic amplifiers, the actual level is set by a gas lock condition within the pump. That is, the pump simply quits pumping and the "smart" pump-off controller de-energizes the pump motor, even though there is still a column of fluid in the well above the pump. The problem is that although the pump is then shut down, the well is not really "pumped off". Worse, the high level of fluid left in the well prevents the formation of a low- hydrostatic pressure within the well; thus hampering the formation from delivering its fluid to the well. The desired condition is for the empty well to appear as a low-pressure area within the formation, with the formation pressure much higher; thus causing the formation fluids to continuously flow from their area of high pressure to the area of low pressure, the emptied well. With a column of fluid remaining within the well, the low pressure area does not exist, and no new fluid is given up by the formation to the well.

Logically, if the Operator could empty the well of fluid, then this empty well would become a low pressure area within the formation; and fluid would flow from the formation into the well. This would allow the well to deliver an increased flow rate to the pump.

When one installs a optimized hydraulic amplifier into the pump, fluid pound is eliminated, gas lock is eliminated, and the pump is emptied into the production column on each and every downstroke. This sets the stage within the next upstroke for the tight-valving of the optimized hydraulic amplifier system to create a low pressure area within the pump, compared with the pressure within the well. Accordingly, in the upstroke, the fluid in the well is forced into the pump, eventually transferring all fluid from the the well into the pump, unless the formation can provide as much fluid to the well as the pump can deliver. In this way, pumping right down to the seating nipple is possible, and becomes the normal mode of operation when the pump is equipped with a optimized hydraulic amplifier to control the operation of the traveling valve. In most wells reviewed after installing the optimized hydraulic amplifier, pumping the liquid level down to that of the seating nipple has resulted in increased fluid production initially and over extended durations.

INABILITY TO PUMP HEAVY CRUDE

In most heavy crude production, conventional balls float off their seats as if suspended in a weightless environment, thus preventing the pump from loading during the upstroke. Further, in crudes having gravities of 10 - 18, problems have been recorded of the traveling valve at times sticking closed due to the surface tension between the ball and seat. At these installations, even after weights have been added to the rodstring, the rods would not fall and the plunger would not travel downward in the pump to transfer the pump contents into the production column above the standing valve. While these problems when viewed from the surface, seem to indicate gas lock, what was actually happening within the pump was the exact opposite of gas lock. Only the symptoms are the same.

After installation into a pump, the optimized hydraulic amplifier backs up the traveling valve in operation. When the traveling valve ball has floated off the seat in the heavy crude and the pump is in the upstroke, the optimized hydraulic amplifier valves within the hydraulic amplifier perform the job of closing the bottom of the plunger so that a low pressure area, P_2 , can be formed to provide for more crude to be forced into the pump through the standing valve. Also, when the surface tension of the heavy crude has practically glued the traveling valve ball to its seat, and the pump is in the downstroke, the optimized hydraulic amplifier forces the traveling valve to open. Empirical observation has shown that the installation of the optimized hydraulic amplifier in heavy crude increases production and, in some wells, makes production possible where it would be impossible without the optimized hydraulic amplifier.

INABILITY TO MAXIMIZE GAS PRODUCTION

A common practice in the Oil & Gas industry is: To "Kill a well, fill it with salt water". Then the well can be worked on. Logic dictates that the reverse is true: "To produce all of the gas possible from a well, remove all of the salt water from the well, and expose the formation to the empty well."

In gas wells, it has been observed that high levels of water frequently exist within the wells. Any water above the seating nipple reduces the quantity of gas which can be produced. Empirical evidence from Operators shows that they have noted that a water level reduction of only ten feet can make a huge increase in gas production. These high levels of water frequently exist because of the fluid pound which exists when attempts are made to pump the water to a lower level. The fluid pound occurs because of the great quantity of gas within the water/gas pump charge during each upstroke, particularly in wells with packers.

Empirical field observations have shown that the addition of a special hydraulic amplifier to a pump, provided the pump is large enough, allows an operator to pump all of the water from the well right down to the seating nipple with no fluid pound problem. In all wells reviewed after installing the optimized hydraulic amplifier, relieving the pressure on the formation has resulted in marked increases in gas production.

THE HIGH COST OF PULLING A PUMP TO PERFORM MAINTENANCE

Second only to the cost of electricity, the cost of pump maintenance is the most expensive item in the mechanics of oil and gas production. While eventual pump wear becomes so great that the fit between the plunger and the barrel becomes too loose for proper pumping efficiency, the most frequent repairs to pumps are to the traveling ball and seat.

Replacement of the traveling ball and seal is required when they are damaged to the point that the seal between the ball and the seat is no longer possible. This seal is most frequently destroyed by Fluid Cut, Fluid Pound, or Ball Dance. The optimized hydraulic amplifier acts to prevent these three types of damage. When the damage does not occur, the pump is allowed to remain in productive service and pulling costs are avoided.

Saving the replacement cost of a traveling ball and seat is not a large monetary item; however, saving the cost of pulling the pump even one time, running it through the pump repair shop, and reinstalling it generally saves the entire cost of a optimized hydraulic amplifier many times over. Since the normal life of a optimized hydraulic amplifier has by observation been forecast to be several years, it is logical to forecast that the elimination of many pump pulls are made possible by the installation of just one optimized hydraulic amplifier; thereby saving both the cost of the pump pulling operations and pump ball and seat maintenance, as well as the elimination of the lost production revenue lost when the pump would have been out of service during the pump repair period.

The close third category in production costs is pump maintenance cost required by the wearing of the pump and barrel due to inadequate lubrication during gas lock conditions. Empirical observation in the field has shown that the optimized hydraulic amplifier's action to open the traveling valve during each downstroke acts to lubricate the pump. That is, in the event that liquid had not been drawn into the pump during the last upstroke from the well through the standing valve, then the optimized hydraulic amplifier opens the traveling valve, allowing the entry of liquid from the production column into the pump to displace the gas within the pump and providing pump lubrication which would not exist otherwise.

THE OPTIMIZED HYDRAULIC AMPLIFIER IS BUILT FOR DURABILITY

It would be illogical to replace one problem with another, and therefore the optimized hydraulic amplifier is constructed not to fail. The optimized hydraulic amplifier is normally constructed from high grades of stainless steel which are NACE materials and are suitable for corrosive conditions. The normal material of which the optimized hydraulic amplifier is made exhibits a tensile strength of in excess of 100,000 psi. Empirical observations of the amount of wear within a optimized hydraulic amplifier after the end of one year of operation show that wear is so minor as to not be measurable. Further, the optimized hydraulic amplifier contacts the traveling ball in the upward direction and merely assists it in doing what it is designed to do in the first place. Therefore, there are normally no huge forces at work against the optimized hydraulic amplifier, and so it can be expected remain undamaged for long periods.

The fourth largest expense category observed in pump maintenance is that of being plugged by sand. The natural operation of the optimized hydraulic amplifier actuator as it lifts the traveling valve ball from its seat with an inclined plane causes the ball to pivot and to spin. This large amount of spinning helps to keep heavies like sand in suspension. But even more importantly, this action causes fluid to flow on every stroke, not giving sand a chance to become embedded in the sealing surface between the ball and seat (with minimum pumping speeds of 5 strokes per minute). The optimized hydraulic amplifier's actuator action works on every stroke to help keep the pump from plugging with sand.

THE OPTIMIZED HYDRAULIC AMPLIFIER CAN NOT DAMAGE THE PUMP

Although the optimized hydraulic actuator comes into contact with the traveling valve ball, the it is important to note that the actuator has been engineered and it has been demonstrated that it will not damage the ball. It is of ultimate importance that the traveling ball be perfect and undamaged. The optimized hydraulic amplifier actuator has been specially heat treated to make it a relatively soft Rockwell 37 hardness, while balls are of Rockwell hardness of 55 through 300. Further, the optimized hydraulic amplifier actuator only impacts the ball as a wedge, not as a direct blow; and valve timing within the optimized hydraulic amplifier valve is set up so that the energy available from the actuator at the moment of contact with the ball is momentum energy from pressure forces earlier within the stroke. Finally, and most importantly, this impact is in the upward direction, forcing the ball away from the seat and into the unbounded volume of the cage.

SUMMARY

The optimized hydraulic amplifier eliminates many pumping problems while reducing maintenance costs and making production increases possible. In many instances, the optimized hydraulic amplifier has been shown to allow production when none was possible before its installation.