Developments on Flow Rate And High Pressure Stability of Peroxide Dosing Pumps For The Chemical Industry

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Performance and reliability of peroxide dosing pumps are essential for every low density polyethylene (LDPE) plant. High stability of flow rate and high pressure is the most important feature for this pumps. The paper compares the results of hydraulic pressure inside the actuating system as well as flow rate and high pressure level on the discharge connection of the pump. Recording was done with a flow meter and a high pressure transducer, both suitable for a maximum pressure of 400 MPa. Direct measurement inside the high pressure cylinder and the influence of a pressure accumulator in the high pressure injection line at low capacity and full load condition round out this work.

1. Introduction

A high pressure process is used for the generation of Low Density Polyethylene (LDPE), which takes mainly place in a tubular reactor at about 300 MPa and 300° Celsius. Such kinds of plants are built with an annual output of up to 400,000 tons and are in operation permanently which requires a high reliability. The core piece of an LDPE plant is the tubular reactor, which has a total length of up to 3,000 m. This unit is used for the polymerization process which converts ethylene gas with a monomer structure into polyethylene with a chain structure. In order to set up the polymerization process in an economical manner, peroxides are fed to the hot compressed ethylene gas in different reactor sections. As the quantity of the peroxide which initiates an exothermic reaction is a significant process parameter, a precise dosing is required at an injection pressure of approximately 300 MPa. This task is taken over by peroxide dosing pumps which deliver up to 100 l/h of peroxide to the various injection points into the reactor and thus have a decisive influence on the polymerization process.

2. Basic Principle of Dosing Pumps

Dosing pumps operate according to the pressure intensifier principle. High pressure intensifiers are double acting as a rule. Sometimes the pumps are equipped with a stand-by intensifier to ensure high availability. Pressure intensifiers are oil hydraulically driven by means of a servo hydraulic rate control system, which ensures a constant volume of oil flow independent of the pressure, and thus peroxide is also delivered by the transmission ratio. Moreover, this control concept enables the manipulation of the acceleration phase of the plunger after the change of direction. The behavior of the pump can be controlled electronically during the compression phase.

To ensure a high dosing accuracy, a continuous filling degree of the high pressure cylinder is essential. In order to ensure this happen, a booster pump is fitted upstream of the pressure intensifier on the suction side. Figure 1 shows the system diagram of a peroxide dosing pump with stand-by intensifier and high pressure accumulato.

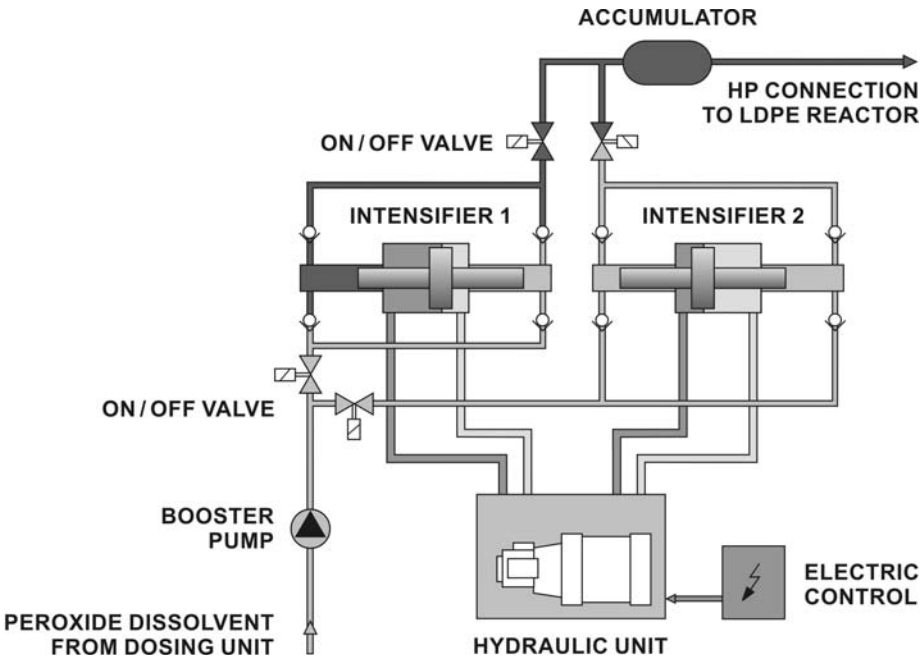

Figure 1: System diagram of pump with stand-by intensifier and accumulator

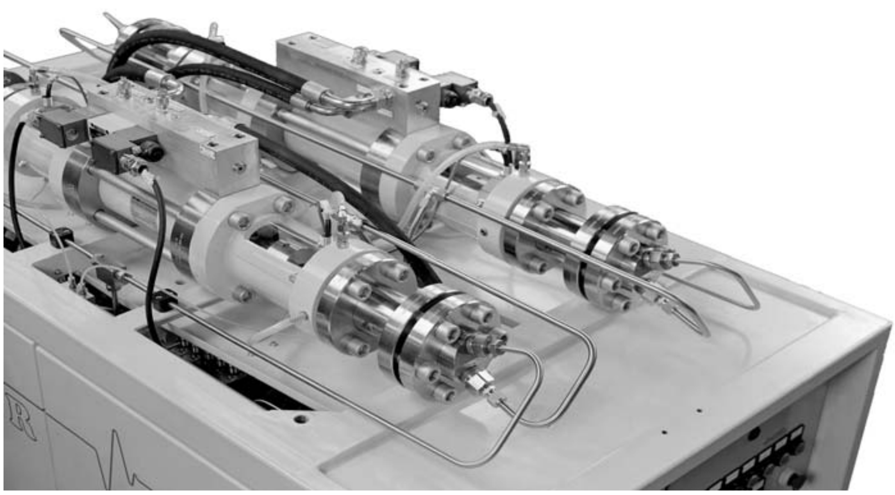

Figure 2: Top view of peroxide dosing pump with stand-by intensifier

For a high plant availability, high pressure components are fitted redundantly and have been designed to be maintenance friendly. After automatic switch over, the integrated block-and-bleed system can be activated, by which the pressure intensifier to be maintained is emptied and locked-off from the high pressure system. By this means, high pressure components, such as seals and check valves, can be maintained easily even if the other intensifier is in operation. The peroxide dosing pump is directly linked to the tubular reactor via a high pressure tubing sytem. The peroxide is injected via special injection lenses located on three or more different places along the reactor.

3. Parameters And Operating Conditions

To analyze the dosing pump and to carry out the optimization on this basis, the following examinations with parameters mentioned as follows were measured: Discharge pressure, flow rate at the discharge outlet and hydraulic oil pressure. For different variations, the program for the servo valve was adapted. The behavior of the measured parameters were recorded for different boost signals, inside the high pressure cylinder and with an accumulator in the high pressure line. For investigation, a dosing pump with a maximum flow rate of 78 l/h (1,3 l/min) togther with a high pressure valve with different orifice diameters was used.

4. Measurement Equipment And Testing Points

The examination was carried out by means of a DEWE-BOOK-16 measuring system. Figure 3 shows the measurement equipment at the outlet of the pump consisting of a flow meter and a high pressure transducer. The following sensors were used: Hydraulic oil pressure sensor, manufacturer Tecsis, (pressure range 0-25 MPa), high pressure sensor, manufacturer IMT Industrie-Meßtechnik, (pressure range: 0-400 MPa), Flow meter, manufacturer Küppers Elektromechanik (flow range: 0.3-1.5 and 0.5-4 l/min).

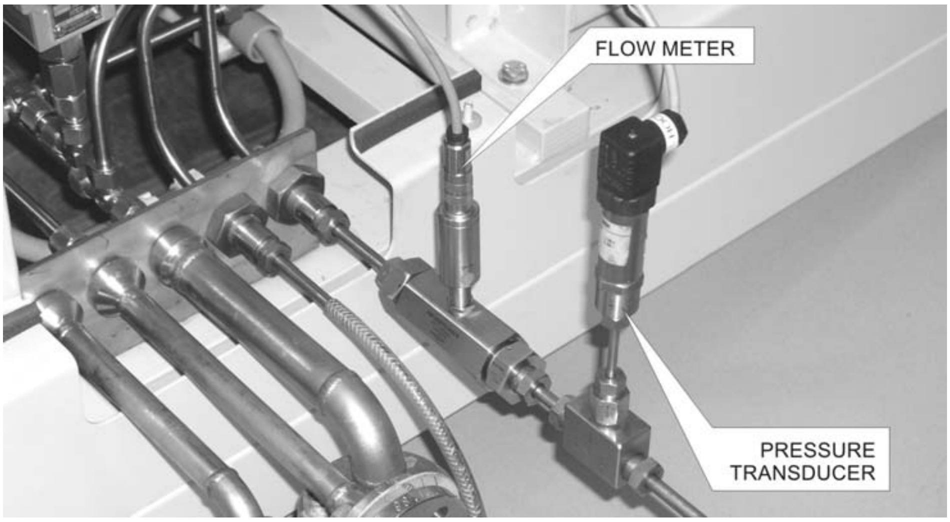

Figure 3: Measurement equipment installed at the discharge side of the pump

5. Reciprocating Pump Control

Reciprocating pumps suffer the problem that there is a delivery gap (pressure drop, flow reduction) at the reversal point of the plunger. To overcome this problem, a short and fast stroke can be selected. However, choosing a longer stroke to reduce load cycles, a larger plunger diameter to enhance the lifetime of the sealing system and a servo valve to compensate this factor, this delivery gap can be compensated and improved at the reactor inlet.

The additional advantage of a servo valve controlled hydraulic system is the possibility to change the flow rate from the target to the maximum in the time span where the plunger changes direction and in the compression phase, which is about 10 % of the stroke at 300 MPa. To be able to investigate the best design of the control signal (boost signal) for the mentioned time gap, measuements of the oil hydraulic and outlet pressure as well as changes in output volume were made. The optimum signal was found in between three zones.

In the following Figure 4 there are shown three cases with different boost signals. Also the typical behaviour of the hydraulic system can be seen.

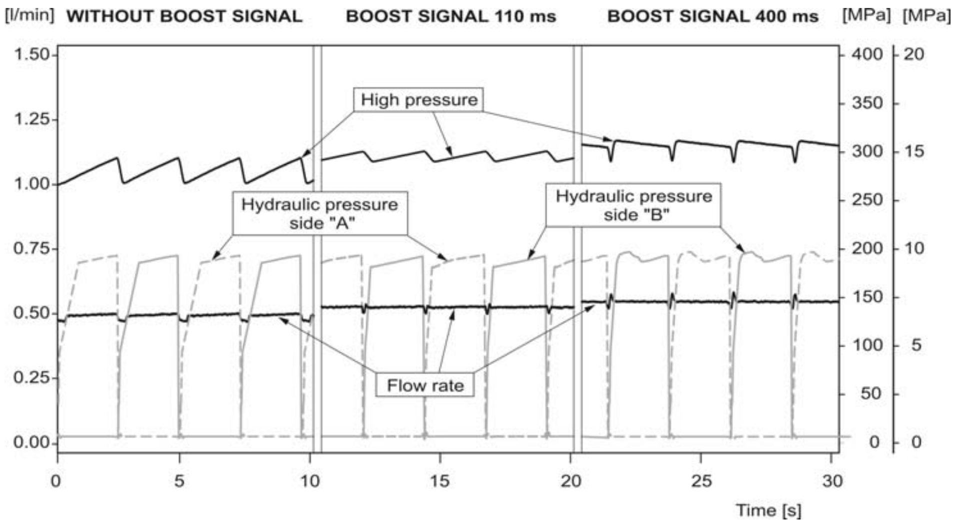

Figure 4: Influence of boost signal onr flow rate and high pressure

In the first case, without a boost signal the system does not reach its potential as it does not use the whole power reserves of the hydraulic system. The second case with a signal of 110 ms gives an acceptable result for flow rate and high pressure. In the third case the boost signal is too dominating, which results in a fish tail profile of the flow rate which is not approved. The parameters of the boost signal could be programmed that way that it always acts in the right intensification of the shifting.

6. Measurements Inside High Pressure Cylinder

To be able to make the pressure process in the high pressure cylinder measurable, the check valve was moved, as shown in Figure 5, so that the high pressure tube, in which the sensor is located, still belongs to the volume of the high pressure cylinder.

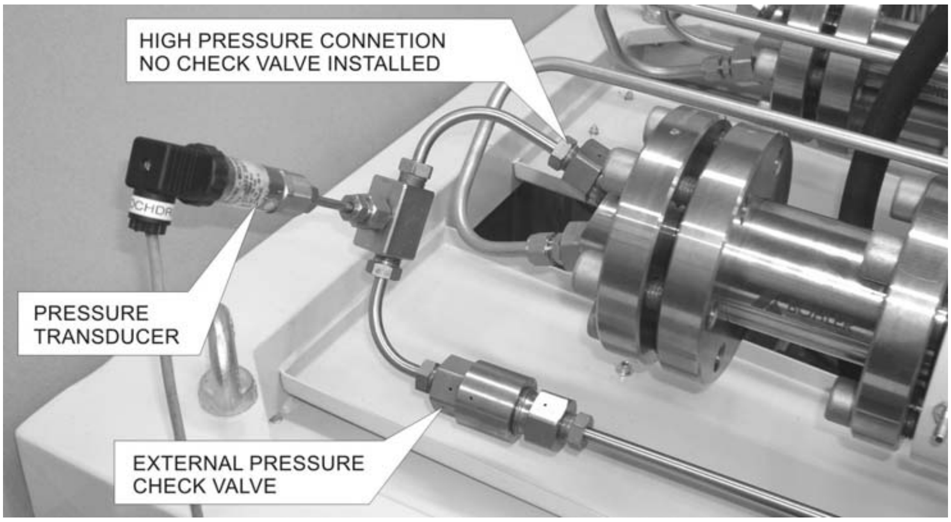

Figure 5: Measurement equipment for high pressure cylinder

The results are shown in Figure 6. The pressure profile of the hydraulic oil system is visible alternately, with a maximum value of about 10 MPa.

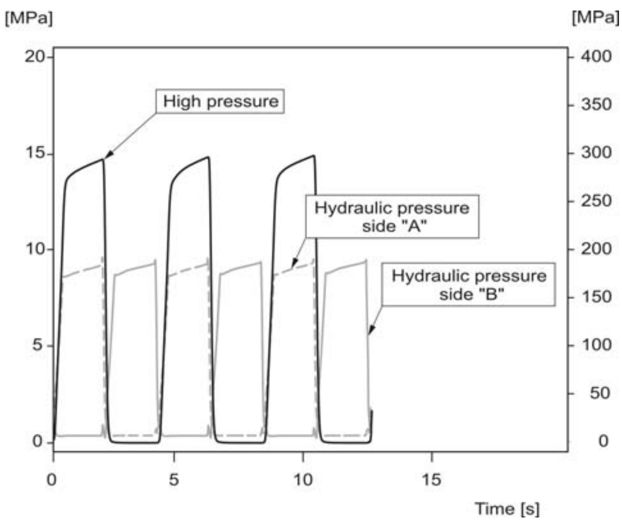

Figure 6: Direct measurement ineide of high pressure cylinder

For clarity, only one high pressure side of the cylinders is shown with a maximum value of 300 MPa. The graph indicates the correlation between the low pressure and high pressure sides, so the high pressure profile can be calculated on the basis of the hydraulic oil behavior.

7. With And Without Accumulator

In certain cases the installation of an accumulator within the high pressure line may inprove the pressure and flow characteristic of a peroxide dosing pump. Figure 7 shows the results of measurement with and without accumulator.

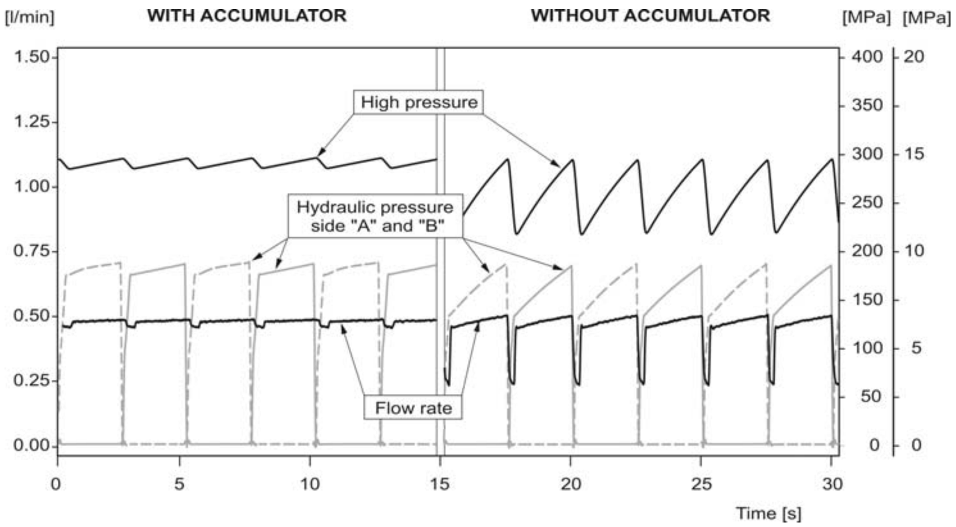

Figure 7: Flow rate and pressure level with and without high pressure accumulator

8. Conclusion

The measurements on flow rate and high pressure at the outlet were conducted to find the right parameters for the servo valve control. Also the dependency of the high pressure based on the hydraulic oil pressure was analyzed so system parameters can be modeled and optimized using available low pressure readings. Due to this benefit, the flow rate could be further smoothed using electronic control. Constant volume flow is a significant criterion. Using an electronic control for a servo valve controlled pump flow, a significant improvement can be verified. Another characteristic which was analyzed is the infulence of an accumulator in the high pressure line.

9. References

Trieb, F., Karl R., Moderer R., 2006, High Pressure And Flow Rate Measurements on Peroxide Dosing Pumps Under Laboratory And Site Conditions, ASME-PVP 2006 Conference, Vancouver, Canada