Debottlenecking of existing polyester plants

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The enormous need for polymers worldwide emerged a typical problem to polymer plant owners. Although their plants have been designed for a certain capacity, a higher throughput is always requested. Sometimes the capacity is increased by more or less than 200%. Most of the machines and reactors are suitable for higher capacities, but it is a well known problem that especially polymer discharge pumps are a typical bottleneck.
The purpose of these discharge pumps is to extract high viscous polymers under vacuum conditions from the reactor and to pump these melts to filters / screen changers and pelletizing units. Typically pressures up to 250 bar can be built up.
Normally extraction pumps themselves are designed for a much higher capacity, but the max. speed and capacity is limited by the pressure loss on the suction side. By increasing capacity and pump speed the pressure loss rises in the same way. In worst case the pump can not be filled with the polymer melt. This would cause directly a dramatical decrease of polymer flow, sometimes even cavitation with all its negative results occurs.
For decades WITTE is one of the world leading gear pump manufacturers. Due to our enormous know how and our knowledge in gear pump technology we are proud to present the optimal solution to customers for the above described problem. On one side it is the main aim of customers to maximize capacity but on the other hand the costs for machinery and erection must me minimized. In this certain case an increase of capacity by approx. 200% was requested! A simple speeding up of the existing pumps was not recommended due to high pressure loss / cavitation. In addition to that high shear rate would have a negative influence on the quality of the polymer. For these reasons it was strongly recommended to install pumps with a larger specific capacity. By giving the guarantee that these specially designed gear pumps do fit in the dimensions of the former pumps there was absolutely no need for any changes in the already existing pipework. Not only the product flanges on the suction and discharge side, even the total height could be adapted to the dimensions of the former pumps. This led to the positive effect that the still stand time was minimized.

The following table shows you the main overall dimensions of these two pump types:

Pump Type	POLY 716-8 (110/110)	POLY 3200-10 (180/180)
Spec. Capacity [cm^3/Rev.]	716	3200
Axial Distance [mm]	110	180
Gear Width [mm]	110	180
FlangeSuction Side [mm]	250	400
FlangeDischarge Side [mm]	125	200
Overall Height [mm]	430	640

As you can imagine the size of the suction flange was a major problem. The relationship between the length and the diameter of the inlet and the pressure loss will be explained by the law of Hagen-Poiseuille:

$$\Delta p = l \cdot \frac{l}{d} \cdot \frac{r}{2} \cdot w^2$$

λ: factor [-]
l: Inlet Length [m]
d: Diameter [m]
ρ: Spec. Gravity [kg/m^3]
υ: kinemtatic Vicosity [m^2/s]
w: Flow Velocity [m/s]

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Although a reduction of the inlet length reduced pressure loss a little bit, the only way to solve the problem was to optimize the design of the flange on the suction side. As explained above the pressure loss is reverse related to the fourth dimension of the diameter. In addition to that mirror polished surfaces helped to lower $NPSH_{required}$. Another obvious problem we had to deal with is that the total height of a typical polymer extraction pump of size 180/180 – equal to a spec. capacity of 3,2 l/rev. – had to be reduced by approx. 33%. Nevertheless the housing must be strong enough to deal with the forces and torque loads of the vessel and the related pipework. These requisitions led to specially designed, forged pump housings. The material of choice was stainless steel 1.4313 (~ E415). Next to its excellent welding properties this martensitic steel offers a much higher tensile strength compared to 1.4571 (316Ti).

Finally it can be stated that these specially designed extraction pumps fulfilled customer´s requisition to its best. Although the capacity was increased by 3 times, the quality of the polymer is still as high as before debottlenecking. Is there a better proof that can be given by the customer…?

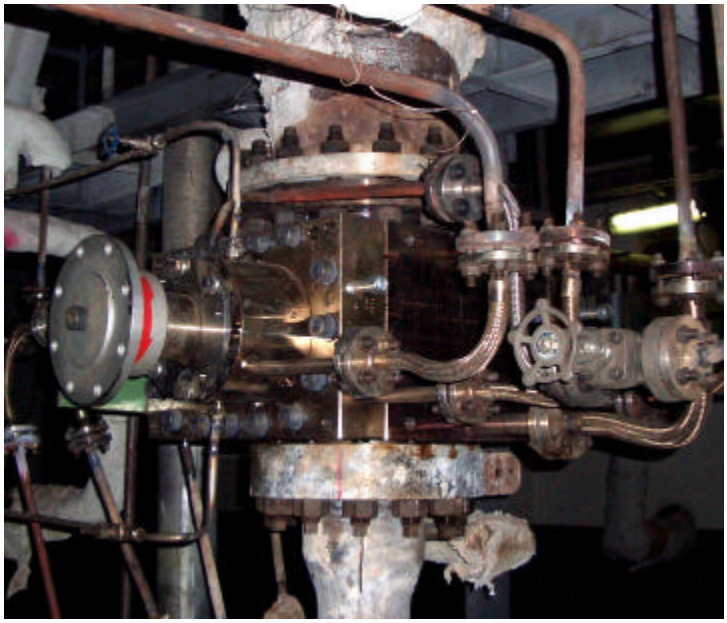

Photo of specially designed POLY 3200-10 (180/180) which perfectly fits in the dimensions of the much smaller POLY 716-8 (110/110) pump.