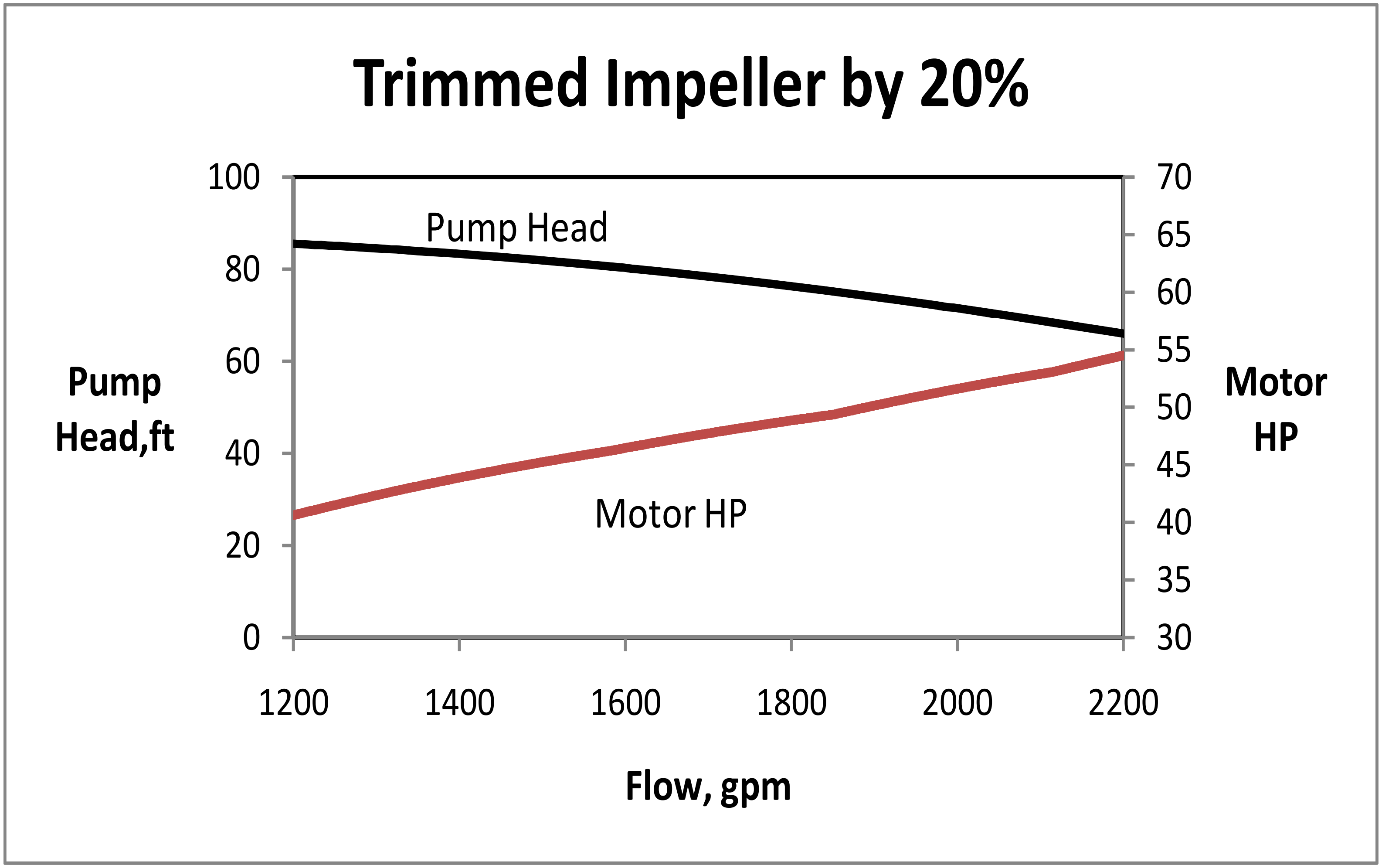
# Challenge 2 – Modify the pumping system - Answers

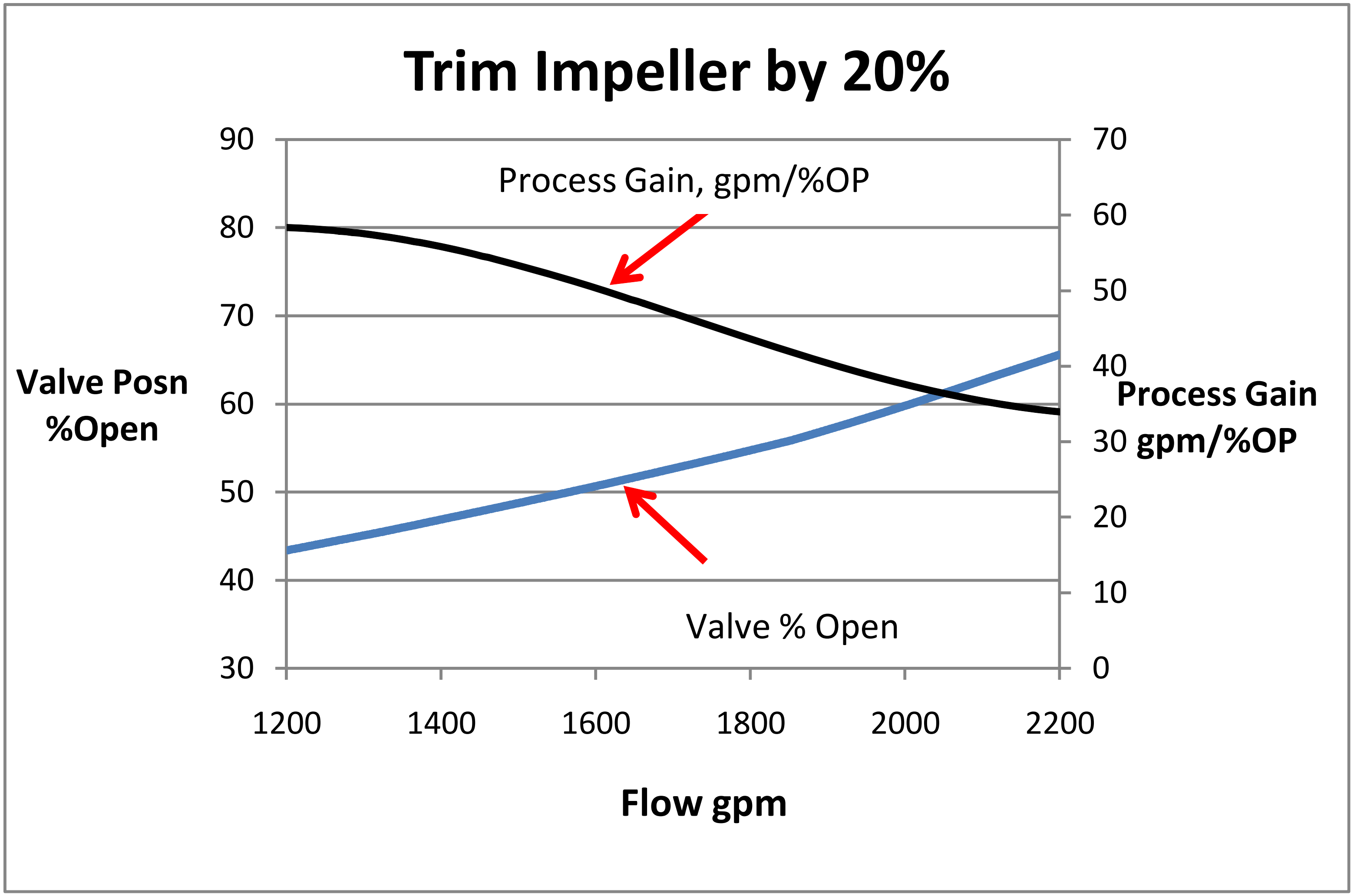
## Option 1 - Trim Impeller by 20%

- The pump head is reduced by an average of 40 ft over the operating flow range. The power consumption is reduced from 72 HP to 48 HP (48 HP=36 kW). At $650 kW-yr, the annual pump power cost is $23400. The annual power savings is almost $11600, easily enough to justify the project.
- The valve pressure drop has decreased by an average of 40 ft, and *valve cavitation has been eliminated* . This will have the additional benefit of reducing valve maintenance costs.
- The reduced pressure drop across the valve means that the valve operates at a less throttled position. The valve position ranges from 43% (1200 gpm) to 65% (2200 gpm) and the average process gain has decreased from 58 gpm/%OP to 46 gpm/%OP. This reduces the impact of stiction by approximately 20%.
- The process gain is still highly variable ranging from 35 to 60 gpm/%OP. This will degrade control performance. The level controller response will be faster at low production rates and slower at high production rates.

# Challenge 2 – Modify the pumping system - Answers



# Challenge 2 – Modify the pumping system - Answers



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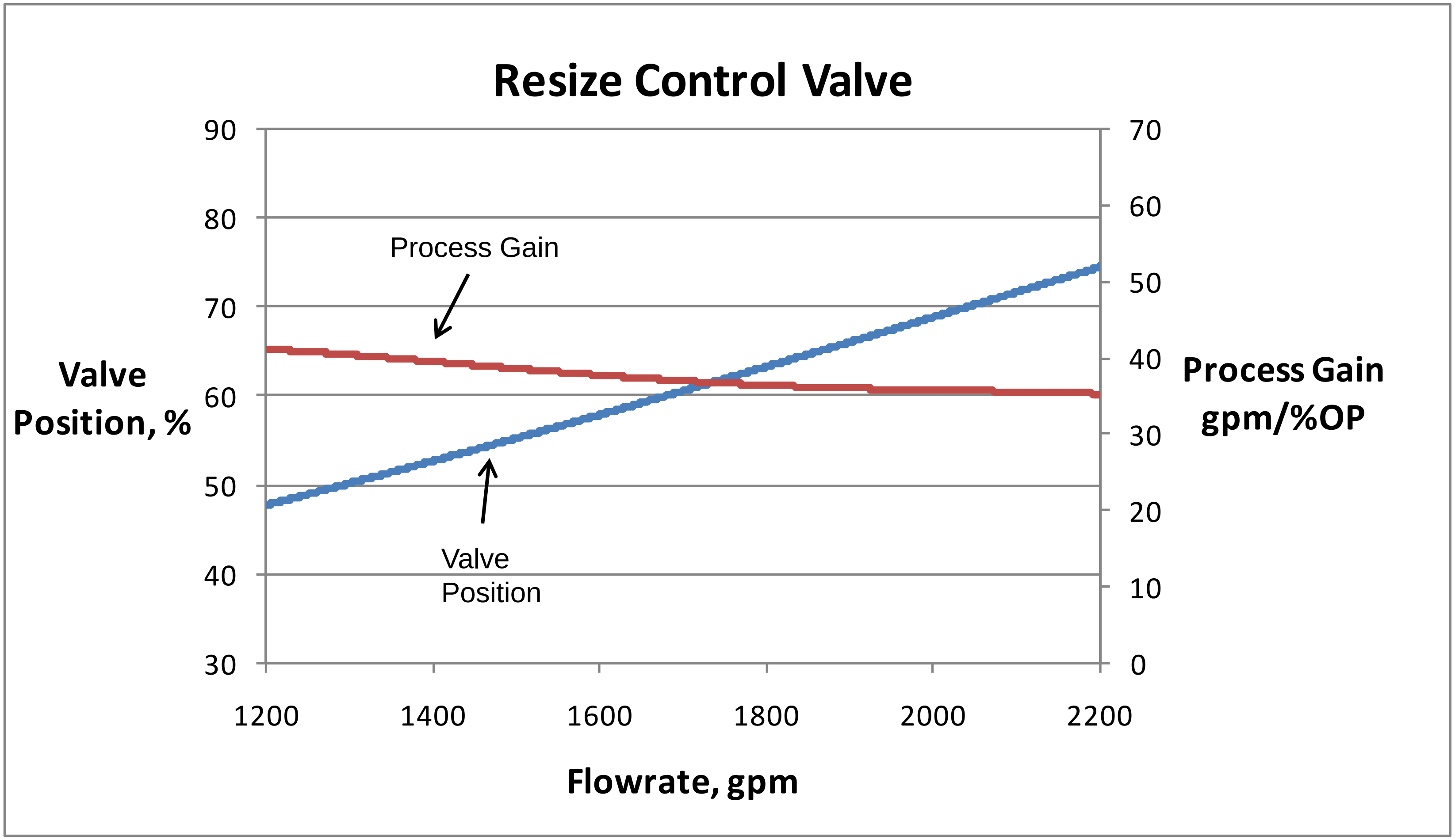
# Challenge 2 – Modify the pumping system - Answers

## Option 2 – Resize the Control Valve (8 inch to 6 inch)

- Resizing the control valve will not have any effect on power consumption. It is the pump, not the valve, that determines power consumption.
- Is there a process control benefit to resizing from an 8 inch to a 6 inch control valve? In the original design there is a wide range in the process gain (ranging from 70 to 45 gpm/%OP) that will compromise overall control performance. The high process gain amplifies the effects of backlash and stiction. The pressure drop across the control valve is high and the valve cavitates in the 1200 to 1600 gpm flow range. After switching to a 6 inch V150, the process gain is lower and much more linear. The process gain varies from 42 to 36 gpm/%OP. This will improve control performance and reduce process vulnerability to backlash and stiction. The bad news is that the pressure drop is still high and the smaller valve cavitates over the entire flow range - leading to higher maintenance costs.

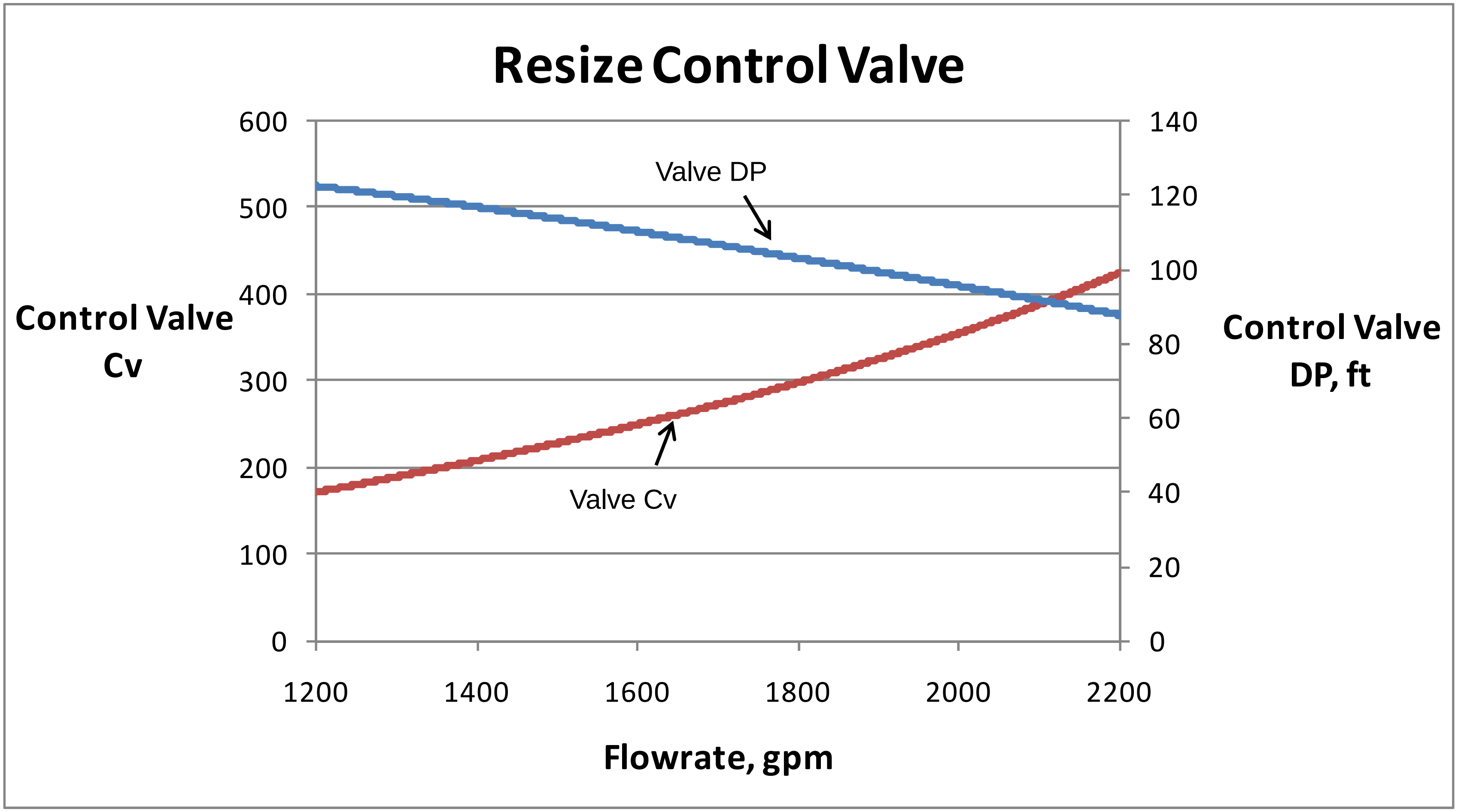
# Challenge 2 – Modify the pumping system - Answers

## Option 2 – Resize the Control Valve 8 inch to 6 inch



# Challenge 2 – Modify the pumping system - Answers

## Option 2 – Resize the Control Valve 8 inch to 6 inch



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# Challenge 2 – Modify the pumping system - Answers

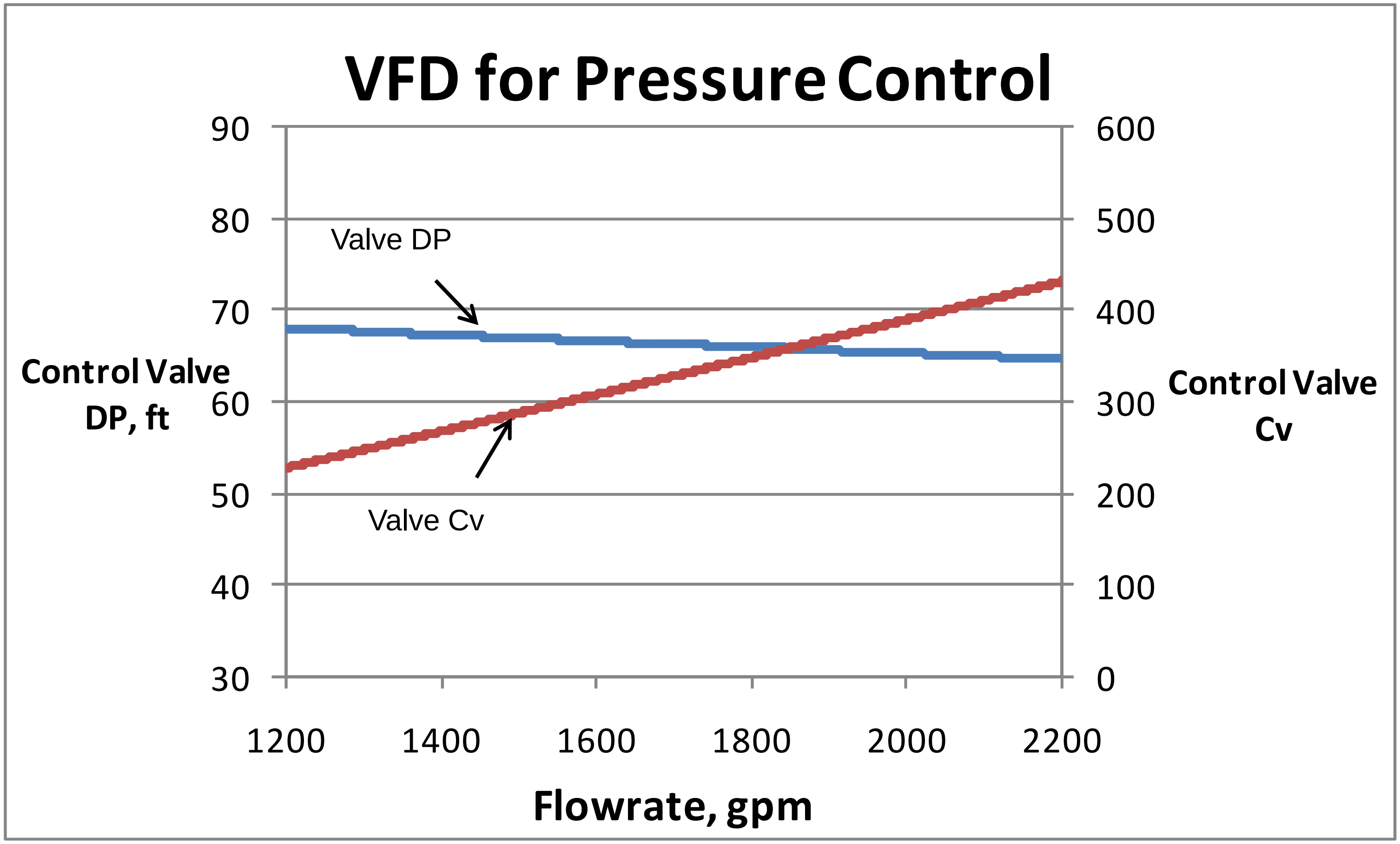
## Option 3 – Install a VFD to control Blend Chest pump discharge pressure

Maintaining a constant pump discharge pressure seems like a good idea. First, the pump speed will decrease (especially at lower production rates), reducing power consumption. Second, the pressure drop across the control valve will be relatively constant. The impact of a constant valve pressure drop on control performance is not obvious - especially where an equal percentage valve is being used. If the control valve is oversized for the application, the valve will operate over a narrow range the slope of the Cv curve will relatively constant – effectively the valve will have a ‘linear’ characteristic. If the valve is correctly sized and operating over a wide range (say 50 to 80%) then the process gain will tend to increase as the valve opens. The flanging coefficient might also affect the process gain – particularly at high valve positions.

At a pump discharge pressure of 30 psig, the average power consumption is 52 HP and the average speed is 1025 rpm. The average power savings is approximately 20 HP – which translates into an annual power cost reduction of $10000. In this example the valve is one size too big and the control valve operates over a narrow range (45 to 60% open). Even with a relatively constant pressure drop (28 psi), the process gain is almost constant at 62 gpm/%OP. This will improve Machine chest level control performance. Moreover, the control valve will not cavitate at any flow condition due to the reduce d valve DP and this will reduce maintenance costs. This option does not address the effects of backlash and stiction in the control valve – and the process gain is high!

# Challenge 2 – Modify the pumping system - Answers

## Install a VFD to control Blend Chest pump discharge pressure



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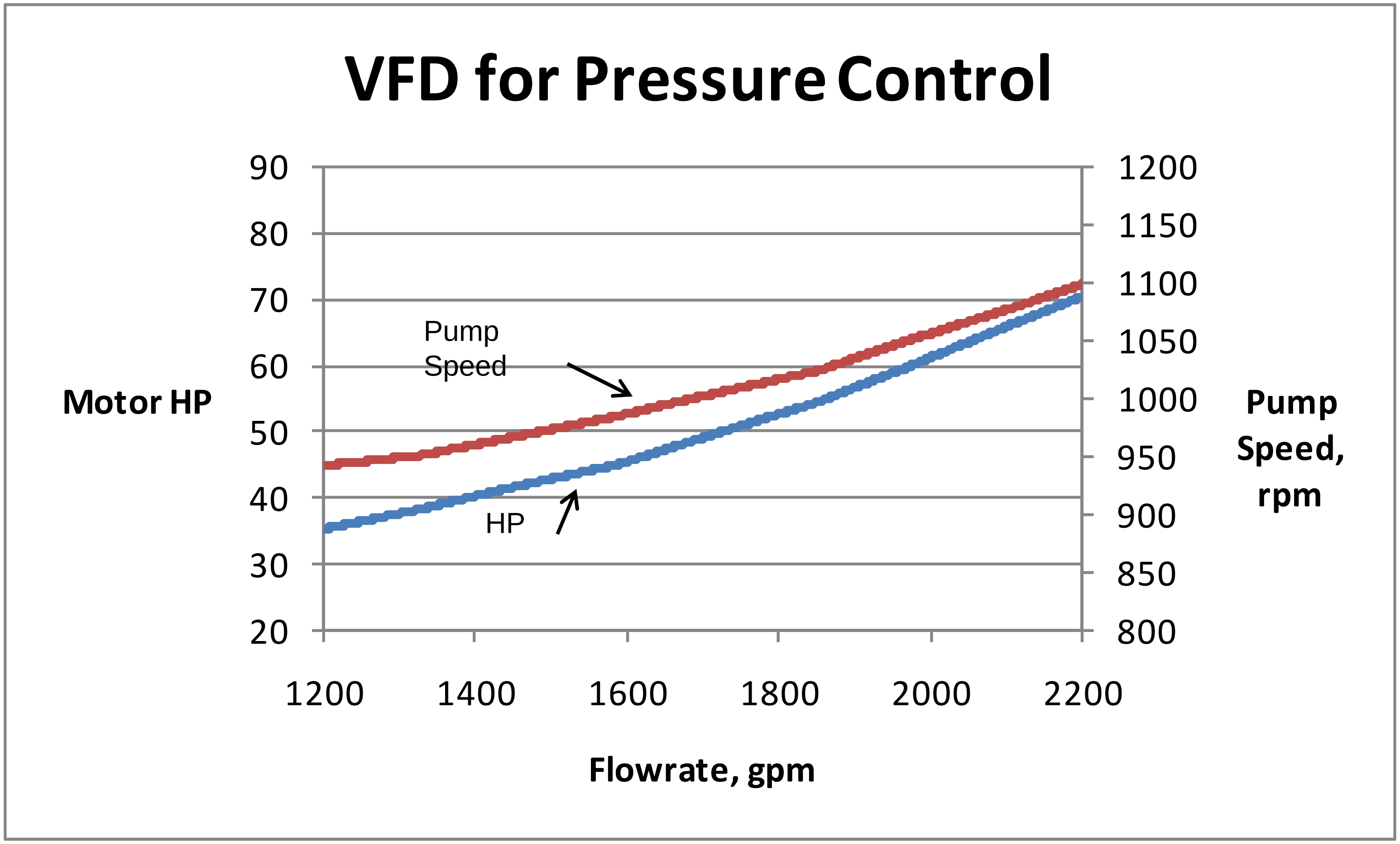
# Challenge 2 – Modify the pumping system - Answers

## Install a VFD to control Blend Chest pump discharge pressure



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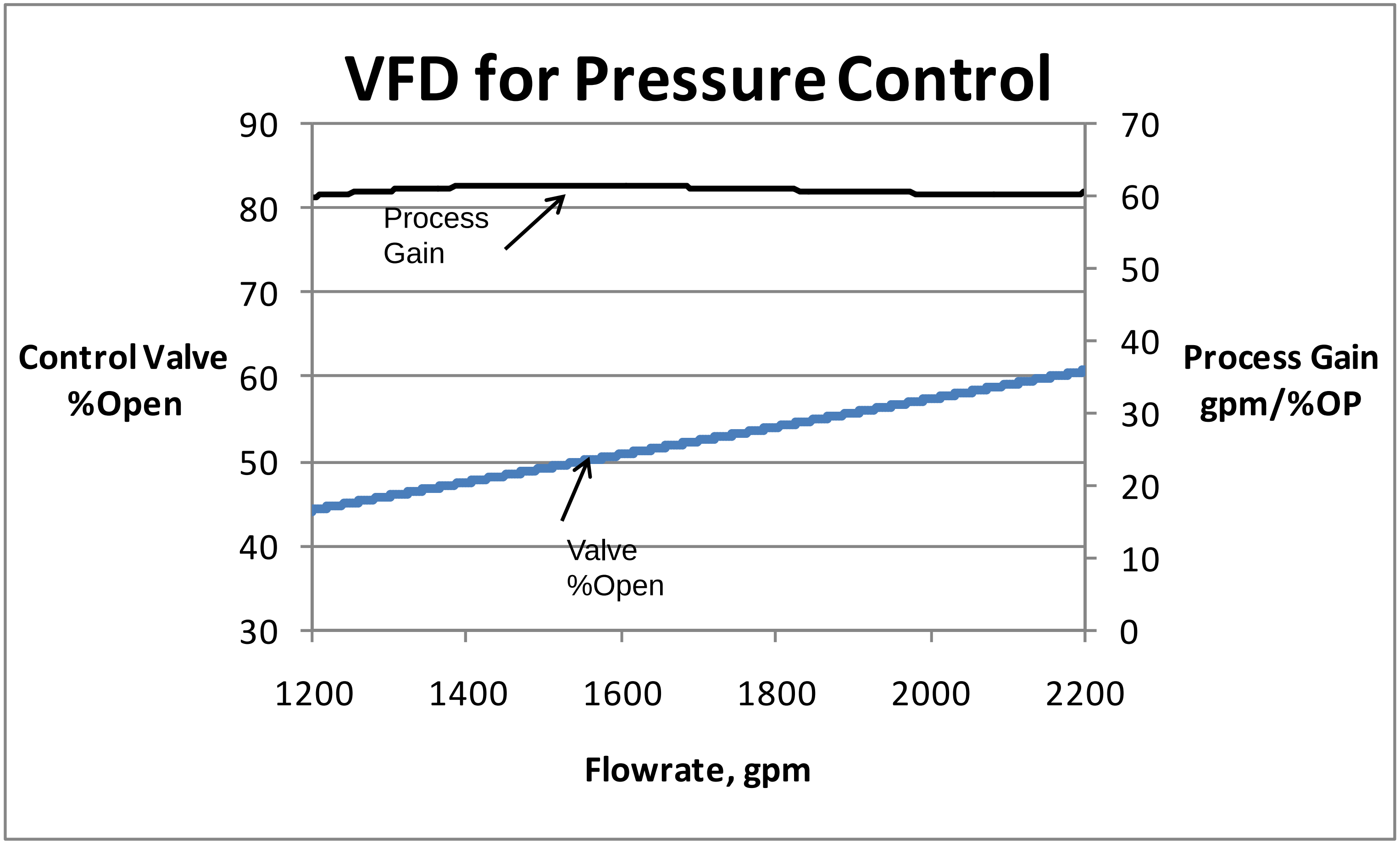
# Challenge 2 – Modify the pumping system - Answers

## Install a VFD to control Blend Chest pump discharge pressure



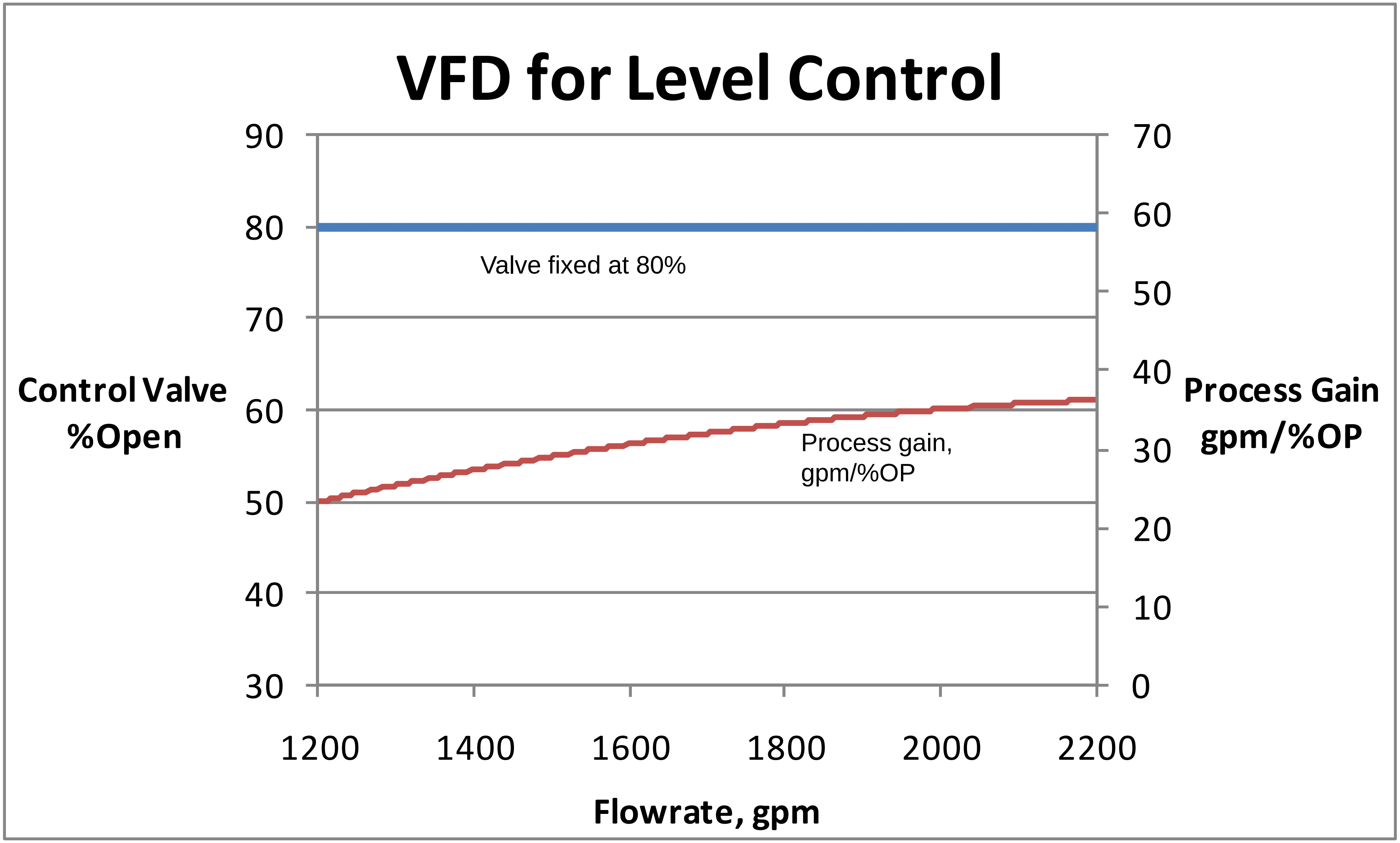
# Challenge 2 – Modify the pumping system - Answers

## Option 4 – Install a VFD to control Machine Chest Level

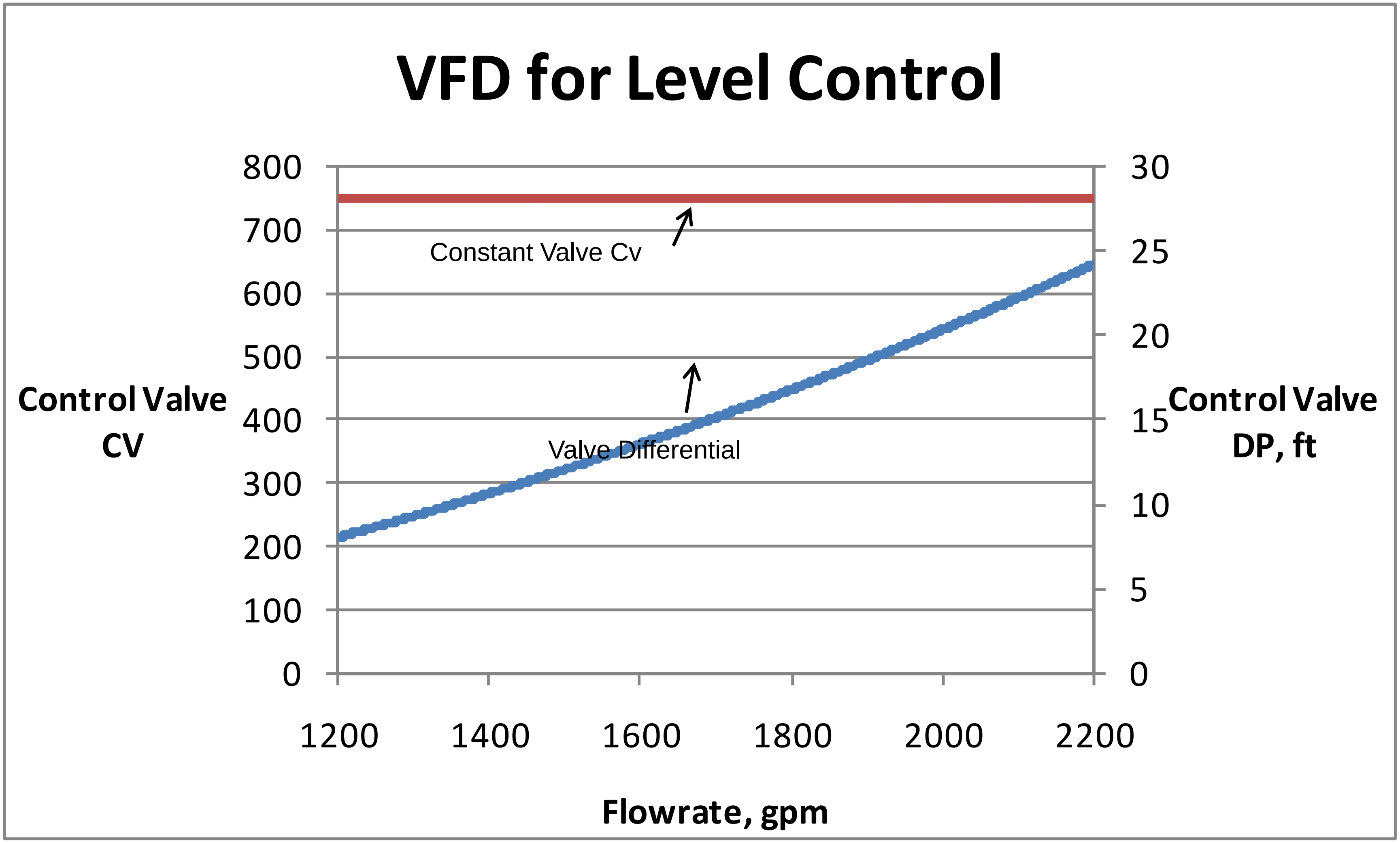
There are 2 keys advantages to this option. First, it has the highest potential for power savings – since the loss across the control valve will be minimized. Second, the negative effects of control valve backlash and stiction have been eliminated since the control valve is no longer the final control element. The process gain is expected to be relatively linear – at least if friction head dominates the system curve.

In this example the 8 inch control valve is fixed at 80% open to increase line resistance. The high control valve Cv means that the control valve power consumption will be low. The average power consumption is 25 HP – a savings of 47 HP versus the original design. The annual savings of $23500 is enough to justify the cost of the VFD. There will be a reduction in pump/valve maintenance costs. The reduction in machine chest level and consistency variation will improve product quality and reduce raw material costs - benefits that will likely have a greater economic return than the pump power savings.

# Challenge 2 – Modify the pumping system - Answers



# Challenge 2 – Modify the pumping system - Answers



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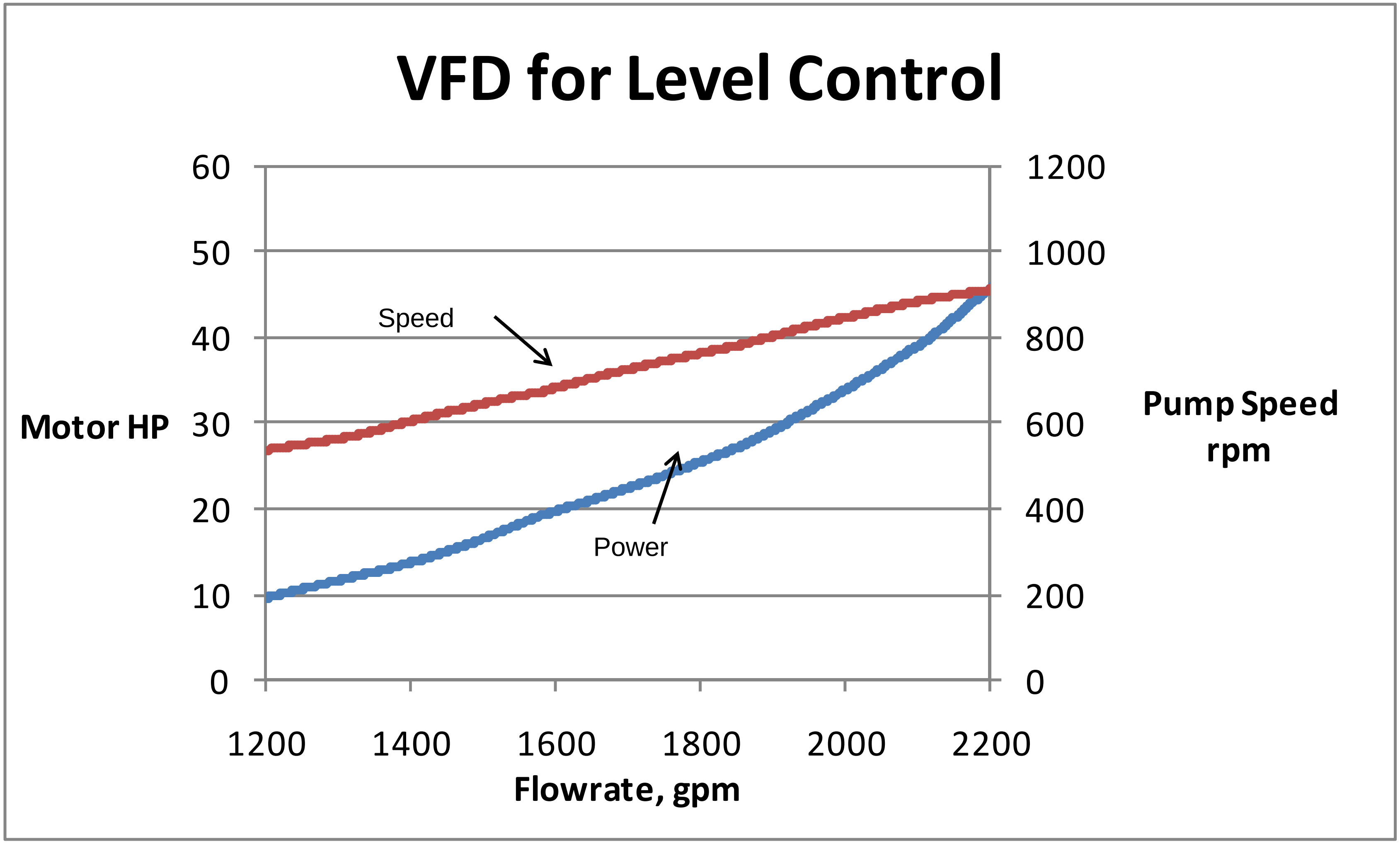
# Challenge 2 – Modify the pumping system - Answers



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