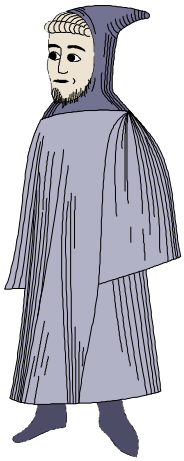
The Saga of PID

An educational tale for those who would understand the concept of PID

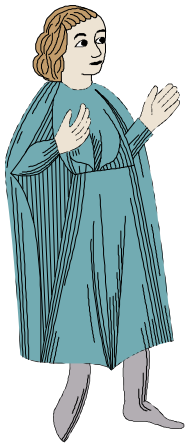
Once upon a time, long ago in a far distant land, there was a council engineer called Emil. He was in charge of the water supply for a fabulous city and was about to retire because of his advanced age.

Of course he had organised his pension, social security and so on. In addition he had been foresighted enough to make an agreement with the council that his successor should be one of his sons:

Peter



Ivan



David

But it had not been decided which one.

Here is their tale:

Job description

Emil, the father, had been responsible for keeping a constant level (actually the aim was to achieve a constant pressure to the consumers) in the council's water tower independent of changes in consumption. This was done by opening or closing the three valves in the water supply line to the tower, depending on the consumption.

It should be noted that this was no easy job, since the consumption varied a lot.

The sons had visited Emil at the tower now and then, but they had never taken the trouble to watch Emil's techniques. They had also followed the development of medieval control technology and considered themselves fully competent to take over.

Just before Emil was to retire, Osquar, a younger relative who had studied control engineering, visited Emil. They discussed control engineering at length and with great vision and agreed that a level control could be built up several different ways, using :

Manual
Electrical
Fluid power
Mechanical
Hydraulic
or
Pneumatic control

Three requirements

In any case the control had to comply with three requirements:

- When the level changes because of an "interference" (change in the consumption), the controller should take action against it as quickly and efficiently as possible to restore the required level.
- The return to the required level has to take place with as few deviations as possible and preferably not periodic.
- The controller has to keep the level within the necessary limits to achieve an even pressure in the supply lines.

The controllers are tested

Emil´s retirement day was getting closer, but so far none of the sons had come up with a method or equipment which complied with the requirements.

The local council discussed the situation and agreed upon making a test where the sons should each show their skills with the father as a supervisor. This was an empirical method to find the best successor.

Ivan is oscillating

Ivan starts off with a methodical approach. When he sees that the water level has dropped 100mm below the ideal level - the set point - he realises that there is a rise in the water consumption. Therefore he starts to open the inlet valve slowly and evenly.

After a while Ivan recognises that the reduction of the level is getting slower and at the end the level starts to rise again. But, still he goes on opening the valve until the level reaches the set point. Then he stops opening.

He recognises that the level goes on rising, but not until it reaches 100mm above the set point does he start closing the valve, which he does in the same methodical, slow and steady way as he opened it.

The level is now drops to the set point but does not stop there. It goes on dropping.

Ivan repeats his actions several times but never gets to the constant level.

What was the problem?

Through the slow oscillations the level exceeds or drops below the set point all the time.

Ivan behaves like an integral action controller where the correction speed is proportional to the deviation between the set point and the controlled variable. If there is a deviation, Ivan goes on adjusting the valve, never reaching a stable level since the control has an integral-action. , see fig.1.above

Peter has a sense of proportion

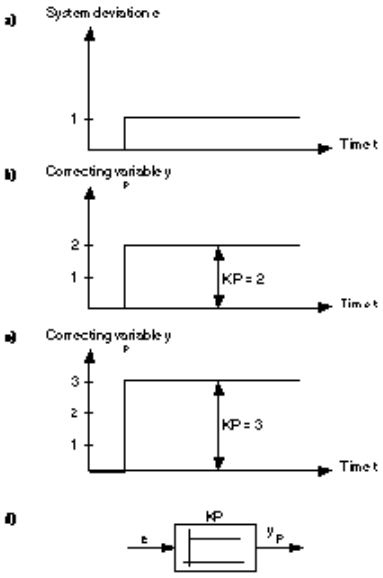
Peter starts his attempt after lunch. As a systematic person he has planned in advance how to do it. It does not take him many seconds to figure out that he has to open the valve 5 turns to balance the level drop of 100mm.

On the other hand he is not too keen about getting the level to the set point. As he assumes that the consumption will lower quite soon, the level will rise again. At first there is no signs he is wrong, but after a while he sees that the level is 50mm too high.

According to his past experience, this level change fits in with 2.5 turns on the valve to be compensated. He then quickly closes the valve 2.5 turns to keep the pressure constant.

At any readable deviation from the set point, he opens or closes the valve as much as he thinks necessary to stabilise the level.

Peter´s operation is proportional to the deviation between the set point and the controlled variable - the same way as a proportional-action controller behaves, see fig.2.

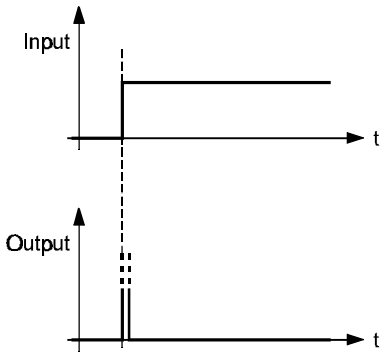


David - always in a hurry

David had been waiting all day for his attempt. The knowledge of his brothers relative failure had made him plan his job carefully. The result was a complicated method with a lot of work.

David studies the speed at which the level drops. If it drops fast, he opens the valve 10 turns as fast as possible and the closes it again just as fast when the level starts to rise again. When he has closed the valve, he notices that the level has deviated from the set point.

David only reacts until a change in the level takes place - the same way as a differential action controller, see fig.3



Emil evaluates his sons

After the tests was finished, Emil discussed his sons´ performances with the deputy chief of the councils technical department. They could not decide who the best solution and should succeed Emil.

Ivan needed far too long to get back to the set point and his way of doing it had resulted in an unsuitable situation. The continuous change in the valve position resulted in fluctuations in the level and he lacked the ability to dampen them.

His only solution was a slow adjustment of valves, but the slower Ivan worked, the longer the citizens would have to wait to get the correct water supply pressure back.

Peter succeeded in avoiding fluctuations in the level and the deviations had not been all too big. On the other hand, he never managed to keep the level to the set point.

David fast quick and powerful reaction made the water supply act like a whiplash. Despite all his efforts, his method was the least attractive one since the level moved increasingly further away from the set point.

PI and PD

As obviously none of the three managed to take over Emil's function all alone, it was decided to make a new test where they should work together.

Technically this was no problem, since there were - as mentioned earlier - three parallel supply lines to the water tower, each with it's own valve.

Unfortunately, as the test was to start, David was sick, so Peter and Ivan had to show what they could achieve together.

They stuck to their earlier methods. If the level dropped 100mm, Peter opened the valve 5 turns immediately and thereby avoided the level drop. Ivan, at the same time worked slowly and determined to get the level back to the set point, and now he did not have to compensate for the rise in consumption. The only work to do was to finish what Peter had started and correct his carelessness caused by rushing. Ivan actually had even less to do, since there were no fluctuations due to wide-open valves.

Together Peter and Ivan acted like a **PI** controller, their co-operation resulted in an immediate restoring of the water level and a first class result because of Ivan's integral way of behaviour. The consumers were all in all satisfied, but still wanted to see what happened with all three working together before they made any decision.

Next time a test was to be made, poor Ivan was ill, so Peter and David had to handle it together.

Just as the test started, the water level dropped to the low level mark.

Peter tried, sticking to his method, to stabilise the level by opening the valve proportional to the level drop.

David immediately opened his valve 10 turns so that the water supply rose to a high flow. He was convinced that Peter was lacking behind and that it was his own quick action which prevented the drop of the level. He was so convinced that he never even checked the deviation compared to the set point.

Peter´s "measuring" method and immediate reaction stabilised the drop.

David, on the other hand, had amplified Peter's influence and avoided a larger deviation from the set point by his "rush" action.

In spite of this they never managed to get to the set point even if they operated with a small deviation.

PID

At last Emil managed to get all three sons together for the last test.

Peter as always opened the valve 5 turns

This time too, the level dropped 100mm below set point when the test started.

Ivan, according to his habit, started to open the valve to get back to the set point.

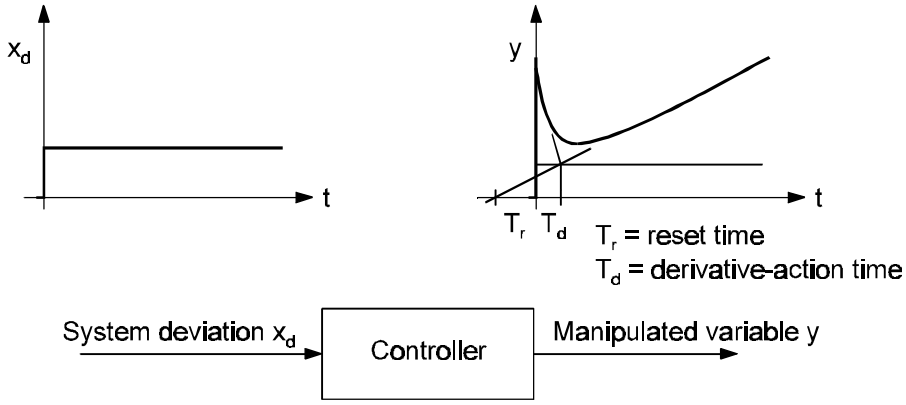
David immediately opened the valve 10 turns.

What happened was this:

David avoided the large deviation by his quick acting.

Peter handled the interference and

Ivan took the deviation away.



Together the three succeeded in finding the ideal solution. The result was that Peter, Ivan and David were employed to take care of father Emil's former job.

All the citizens - except one - were happy with the result. The only person not applauding the solution was the council´s bookkeeper, who not only had to pay Emil's pension, but also had to pay no less than 3 sets of salaries instead of just one.
Everyone else thought it fine that technology should create jobs.

And it is a fine story to tell!

The End