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The FloWell Pipeline Solution

Before discussing any project application, it is always better to understand the root of the problem, the cause of the problem and the solution to the problem. Once you have a grasp of the first two elements then the solution becomes almost self-explanatory. So, each of these elements will be explained in turn followed finally by the project application methodology.

The root of the problem

The root of the problem is the ability for paraffin, as temperature drops, to create a semisolid construction that is able to attract and entrain solids in the crude oil stream. The semisolid construction itself can be likened to petroleum jelly which as we know is extremely sticky and perfect for the support of solids attaching to it.

Whereas the semisolid construction itself is relatively easy to remove the fact that it attracts the solids within the crude oil stream creating a much more rigid structure and due to the pressure found within pipelines is compressed into the solid that is found in pipelines that have been abandoned because of this problem. Although at touch and feel it is a solid, in truth the only solidification comes from the entrained solids. The actual binding structure itself is still in a semisolid state.

If it were not for this problem of attracting solids then the removal from pipelines is a very simple operation. Run the pig down the line, or in the environment of production tubing it can be scraped out. That would be a wonderful solution but for the fact of the entrained solids. The solids give it a density that is much more difficult and so pigging and scraping becomes a major exercise instead of a minor application.

Many solutions have been tried, PPD's, xylene, DRA's, providing some relief but eventually they are overcome by the magnitude of the problem and gradually production has lost because the pipeline is getting smaller in capacity. Pigging becomes extremely risky and even though they use sacrificial pigs which are designed to disintegrate if they become stuck, they themselves present another problem.

Scraping production tubing is often a mammoth exercise because of the equipment required and the time it takes. However, scraping does not remove all the precipitation and therefore there is a platform of existing precipitation remaining in the production tubing for precipitation to rapidly accumulate again.

The cause of the problem

The cause of the problem begins at molecular level. As the temperature decreases the paraffin molecules begin attaching to each other creating long chain molecules which then themselves create a crystalline structure ending in the precipitation we see that looks like petroleum jelly.

Heat causes these long chain molecules to separate (melting) but because of various issues heating the pipeline is a hugely expensive exercise not only in the energy used but the cost of installation in the first place.

PPDs and xylene are often used and they themselves have their own problems. They are generally solvents and as anybody knows solvents, if given the opportunity, will leach out of the environment they are in. You only have to open a tin of paint and leave it open to the atmosphere to see this effect in action.

It does not take long for the solvents to leach out and you get a skin on the top of the paint. Leave it open for too long and you will get a solid lump. So even after they are injected, the solvents will work on the paraffin precipitation but will also want to leach out which returns the problem.

DRA's (drag reducing agents) are intended to reduce the amount of drag in the flow to enhance the velocity of the flow. However, they do nothing to prevent or reduce the precipitation of paraffin. We know this to be a fact because on a relatively recent project on a pipeline DRA was being applied but flows were steadily decreasing.

DRA's also require laminar flow and as anyone with knowledge of pipeline flows this only occurs in straight pipelines. The moment there is any deflection in the pipeline there is turbulence. The steeper the direction changes the more turbulence and so DRA's have to be reapplied on extremely long pipelines.

The solution to the problem

Because the problem is caused by long chains of molecules creating a crystalline structure then the best solution would be to find a way to break up these long chain molecules into single units which has the effect of turning the paraffin precipitation back into liquid.

This is exactly how FloWell operates. By working at molecular level breaking up these long chains with the specific compounds that are blended into the FloWell solution, these long chain molecules are broken up but what is more significant is that they are then isolated and prevented from creating long chain molecules.

It is not understood how it does this but it has been proven that paraffin after treatment from the FloWell solution and subjected to temperatures below freezing (-5° C) the paraffin did not solidify. The paraffin became a similar consistency to melting snow. Once the paraffin was subjected to positive temperatures the slushy paraffin became a liquid again. The process was repeated and the results were the same. This was positive proof that not only did the paraffin return to liquid state it was prevented from precipitating even at extreme temperatures.

FloWell was then applied to a pipeline by injection into the oil stream prior to the export pumps. This pipeline had been suffering from paraffin precipitation for over 10 years. The flow capability of the pipeline was reducing to a point where it was making the oil well an uneconomic proposition.

Every one of the above potential remedies have been tried with the final proposal being a DRA. Although it reduced the magnitude of the decline, the decline continued. The FloWell solution

was applied together with the DRA (we were unaware of this at the time) and the situation did not change.

Upon identifying that DRA was still being applied we asked for it to be discontinued. The moment it stopped the magic began.

The decline immediately halted, it hesitated for a while, then all of a sudden, the increase in flow began at an exponential rate. Over a period of 10 days, the flowrate that was lost over 100 days was recovered. This was due to bottlenecks being cleared initially, the primary bottleneck being a flexible catenary connecting the floating platform to the sea-bed pipeline.

After this point the recovery rate levelled at around 1 to 2 barrels per hour, sometimes the recovery was neutral but it never declined. It was later identified that it was the slow release of heavily compressed contamination that caused the slowdown in recovery but this was always followed by a regular hourly increase.

From this project we identified that turbulence is an essential component in the FloWell treatment of wells and pipelines. It is essential to ensure that the FloWell solution is distributed evenly throughout the flow so the maximum engagement with the paraffin content was affected. This prevented any new precipitation from forming and now the FloWell solution was able to attack the existing precipitation in the pipeline.

Flow dynamics indicates that the point of maximum velocity is in the centre of any flow. Following a parabolic curve, the velocity decreased the further from the centre of the flow until it reached a point of zero velocity at contact with the pipeline walls.

This presented a new theory on how the FloWell solution was able to attack the precipitation on the pipe walls producing a slow gradual return in flow instead of a rapid one. If the FloWell solution was working on the inner wall of the precipitation then overall length of 25 km (the length of the treated pipeline) then even at micro-millimetre reduction per hour the volume increase would be enormous.

This was not the case and further analysis indicated that the precipitation was being attacked end on. The theory supporting this is that turbulence appears when there is a change of direction. Going from a large bore to a much smaller bore is indeed a change of direction and the swirling effect created was washing end-on the existing precipitation returning the paraffin to liquid phase and releasing the contaminants.

Although the bore was providing a restriction through the whole length, the increasing production was related to the increase in bore by the removal of the precipitation and solids. So, for every barrel of oil increasing production the equivalent of one barrel by volume of precipitation and solids was being removed from the pipe wall, just like making a small tunnel bigger except that in this case the spoils go through the smaller tunnel instead of being removed through the larger tunnel.

The shortening of the precipitation was the shortening of the distance the crude oil had to pass through the smaller bore. This made a project predictable. Volume (pipeline capacity), viscosity and pressure are the elements controlling velocity. This in turn is the volume of flow through the pipe which is measured in cubic metres per day or barrels of oil produced per day. To increase flow in a fixed capacity you need an increasing pressure.

Knowing the original flowrate through an uncontaminated pipeline and comparing it to the flowrate of the existing pipeline provides data to enable the prediction of the period of time it takes to clear the pipeline.

However, what has to be considered is the third element that is involved which restricts the flow, viscosity. Paraffin precipitating creates an increase in viscosity. So, although the return to the original flowrate through an uncontaminated pipeline can be projected, it was based originally on a highly viscous crude oil flow.

By preventing paraffin precipitation and reducing the viscosity pro rata the original flowrate could now be exceeded. This means that if production was increased beyond the original flowrate because of the FloWell solution, the reduction in viscosity meant that this pipeline could handle marginally higher volumes. This together with the reduced pumping pressure which is still available meant that a much higher magnitude of oil flow can be handled.