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Economical comparison of pipeline cleaning methods

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Economical comparison

In order to demonstrate HAPP™s' economical competitiveness compared to other pipeline cleaning technologies today on the market, the following business case has been elaborated.

1 Application range

It is important to note that a HAPP™ is not designed for standard pipeline cleaning jobs. A standard pipeline cleaning job in this context means cleaning of pipelines affected by thin wax layers that can easily be removed with a standard scraper pig in one cleaning run. Typically those layers have thicknesses of less than 2 mm, depending on the pipeline diameter. In such cases pipeline operators usually run their own pipeline pigs to remove the deposits.

Pipeline cleaning service providers are called in once the pipeline operators' staff and equipment can not safely handle the cleaning anymore. This is the case once the wax layer built up to such a thickness that the cleaning pig would accumulate too much debris in front of it and get stuck. Thus several cleaning runs with increasing pig diameters are required to avoid blocking. Generally pipeline operators do not own the multi-diameter cleaning pig sets required for this kind of operation.

To remove extensive wax deposits from the oil pipelines operators and service providers can choose out of the following range of pipeline cleaning methods:

- Mechanical cleaning
  - Full diameter scraper pigs (mandrel, foam, solid cast, spherical, brush)
  - Partial diameter (by-pass equipped) scraper pigs (types as above)
  - Hydraulically activated power pigs (HAPP™)
  - Dependent Hydraulic Jet Pigs
- Chemical cleaning

Thereof Dependent Hydraulic Jet Pigs only have a limited operation reach as they need to be connected to external pumps via hoses. Chemical cleaning requiring a minimum retention time usually applies only for lines out of service.

Provided that the cleaning method should allow the pipeline to remain in operation and continuous operation is required, the choice of cleaning methods confines to scraper pigs and the HAPP™ technology. Therefore this study limits to the comparison of the HAPP™ technology with full or partial diameter scraper pigs.

2 Assumptions

In order to ensure a fair comparison, a pipeline with the following features has been chosen:

2.1 Pipeline

- Pipeline length:..... 15 km
- Pipeline diameter:..... 20 inch
- Thickness of wax layer:..... 10 mm

From these data the following can be calculated:

1. The total wax volume in the pipeline is 118,5 m³!
2. The length of a wax cylinder entirely filling the pipeline diameter is 585m!

Such large wax amounts can not be cleaned away with a scraper pig in only one single run as the plug building up in front of it rapidly becomes to large to be pushed forward by the line

pressure. Scraper pig runs carrying out 5 m³ of wax at a time are already close to the blockage limit. For this study we assumed a volume of 5 m³ of wax to be removable with one scraper pig run so that the number of runs required to remove the above listed total amount of wax calculates to 24.

2.2 Product

- Oil price:..... 90 US$/barrel
- Product velocity: ..... 2 m/s
- Exchange rate: ..... 1,45 US$/€

This lead to the following:

- The pipeline transports 220.000 barrel oil per day.
- Stopping pipeline operations would result in a production loss of 826.000 US$ / hour (570.000 € / hour).

2.3 Further assumptions

N°	Item	Scraper pigs			HAPP™
		full	by-pass equipped		
1.	**By-pass volume**	**0%**	**25%**	**50%**	**100%**
2.	Equipment	same cost for all technologies			
3.	Operating personnel (10 hours per day) n° of operators rate	 2 180 €/h			
4.	Transportion (equipment & operating personnel)	same cost for all technologies			
5.	Living expenses (hotel, daily allowance for meals)	130 €/operator/day			
6.	Blockage risk per pig run	1,00%	0,75%	0,50%	0,10%
7.	Blockage duration	4 days			
8.	Salvage	100.000 € / stuck pig			
9.	Setup time on-site 1. setup > 1. setup	 6 hours 4 hours			 -
10.	n° of cleaning runs	24	24	24	1

Table 2 - Further assumptions

Notes:

N° 1.: Indicated is the percentage of the total product flow by-passing the pig.

N° 2.: Equipment lease rates are assumed to approximately be the same for the contemplated pigs.

N° 3.: Number of specialized operators required to carry out the cleaning job.

N° 4.: Transportation costs for shipping of material and transport of personnel to/from the site are assumed to be the same for the contemplated technologies.

N° 5.: Living expenses such as for hotel and for meals are assumed to be 130 € per operator & day.

N° 6.: The blockage risk per pig run is given in percentages. I.e. a risk of 1% equals one blockage per 100 pig runs. With the by-pass flow increasing the blockage risk due to a plug accumulating in front of the pig decreases respectively. Thus a 50% bypass flow reduces the blockage risk of a full diameter pig to 50% of the original (full diameter pig) risk. Even though a HAPP™ is bypassed by 100% of the product flow, a "safety" risk factor of 0,1% has been assumed.

N° 7.: For the case of a pig getting stuck and blocking a line, the duration required for the salvage (location and freeing) of the pig has been assumed to be 4 days. During this period the line is shut-down.

N° 8.: The cost for the salvage of a stuck pig have been estimated to be 100.000 €.

N° 9.: The set-up time for a pig to be ready for a cleaning run has been estimated to be 6 hours at the first time and 4 hours for all further runs.

N° 10.: For the given pipeline conditions, the required number of cleaning runs with a scraper pig is 24 (see 2.1).

3 Calculations

3.1 Pre-calculations

With the assumptions given above the following can be calculated:

N°	Item	Scraper pigs			HAPP™
		full	by-pass equipped		
1.	By-pass volume	0%	25%	50%	100%
2.	Pig run time	2:05 h	3:07 h	4:10 h	31:15 h
3.	Total cleaning job duration	15 days	18 days	20 days	4 days

Table 1 - Calculation of pig run time and cleaning job duration

Notes:

N° 2.: The pig run time is the time the cleaning pig needs to travel through the 15 km pipeline. A full diameter scraper pig is assumed to travel with product flow speed. By-pass equipped pigs travel slower respectively. I.e. a 50% bypass flow cuts the pigs travel speed down to 50% of the original (full diameter pig) speed.
HAPP™s' travel speed has been assumed to be 15 times slower than the product speed.

N° 3.: The total job duration takes into account the set-up time as well as the pig run time per cleaning run.

3.2 Cost comparison

The above assumption and pre-calculations allow developing a cost comparison for the four cleaning methods. It is to note that not all cost positions are quantified. Cost positions being assumed to be equal for all four methods are not compared as they do not contribute any cost differences.

The following table shows the calculated results:

Economical comparison

N°	Item	Scraper pigs			HAPP™
		full	by-pass equipped		
1.	**By-pass volume**	**0%**	**25%**	**50%**	**100%**
2.	+ Equipment	same cost for all technologies			
3.	+ Operating personal	54.000 €	64.800 €	72.000 €	14.400 €
4.	+ Transport	same cost for all technologies			
5.	+ Living expenses	3.900 €	4.680 €	5.200 €	1.040 €
6.	**Subtotal Cleaning service only**	**57.900 €**	**69.480 €**	**77.200 €**	**15.440 €**
7.	+ Production loss	792.988 €	594.741 €	396.494 €	79.299 €
8.	+ Salvage	1.000 €	750 €	500 €	100 €
9.	**Subtotal Production loss & salvage**	**793.988 €**	**595.491 €**	**396.994 €**	**79.399 €**
10.	**Total cleaning job cost** (6. + 9.)	**851.888 €**	**664.971 €**	**474.194 €**	**94.839 €**

Table 2 - Calculation of total cleaning costs per job (none differing cost positions not included!)

Notes:

N° 3.: Costs for operating personnel include job duration and the hourly rate at 10 hours/day.

N° 5.: Living expenses consider job duration and daily allowance.

N° 7.: The production loss is the product of blockage duration, blockage risk and the production loss per day.

N° 8.: Salvage costs are calculated as the product of blockage risk and salvage costs per stuck pig.

4 Analysis of results

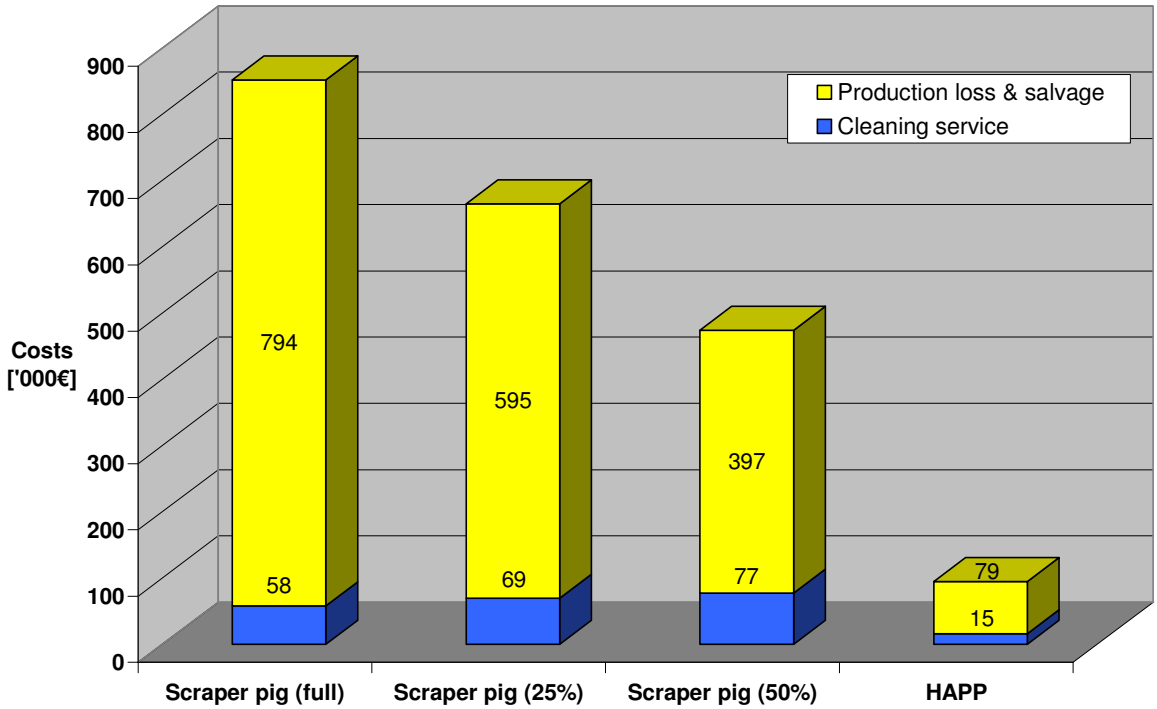

Chart 1 - Comparison of total cleaning project costs (none differing cost positions not included!)

The findings reveal that:

1. The total project costs are dominated by the averaged production loss and salvage costs as they represent more than 90% of it. Thus significant cost advantages arise for pigs equipped with by-passes, most for hydraulically activated power pigs (HAPP™).
2. Production loss and salvage costs averaged with the blockage risk still are the most important cost position for pipeline cleaning jobs.
3. The high number of cleaning runs required makes cleaning with scraper pigs significantly more expansive than cleaning with a HAPP™ which requires only one cleaning run.
4. Production loss and salvage costs are directly related to the blockage risk so that cost advantages become more important with larger by-passes. A HAPP™ by-passed by the entire product flow causes the least costs at this position.
5. Cleaning with by-pass equipped scraper pigs is most expensive if only the cleaning service itself is considered. This is due to the slower pig travel speed during the cleaning run.

5 Conclusion

The economic comparison of different pipeline cleaning methods has been carried out for a 15km long 20”-oil pipeline. The wax layer thickness has been assumed to be 10mm.

Costs for the cleaning service are proportional to the job duration allowing for significant cost advantages for pigs with larger by-pass capacities. Hence a HAPP™ job comes least expensive as with only one cleaning run required, the time on site is reduced to a minimum.

Production loss and salvage costs have been considered by assuming probability factors for a pig getting stuck. Again, larger by-pass capacities lower the pipeline blockage risk due to debris plug formation in front of the pig. With the averaged production loss and salvage costs accounting for more than 90% of the total project costs, a HAPP™ cleaning job comes out to be far less expensive than all other cleaning methods.

The high cleaning efficiency and its large by-pass capacity make a HAPP™ the first choice for pipeline cleaning while a pipeline needs to be kept in operation.