ASPHALTENE ALLEY – IMPROVING RUN LIFE IN A CO2 FLOOD

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ABSTRACT

Between 1995 and 1997 Oxy's South Wasson Clearfork Unit had experienced severe asphaltene plugging and some significant gas cycling from CO_2 flooding. An area of the field became known as Asphaltene Alley due to the high amounts of asphaltene plugging. With an aggressive program of chemical treating and paraffin cutting, failure frequency moved from 1 to .5 during this period. In 1997, due to the industries economics, the CO_2 flooding was reduced from 25 mcf to 5 mcf for the 98 producers in this field.

As economics improved Oxy planned to resume CO_2 flooding in the second quarter of 2001. Oxy also planned to infill drill in an area of this CO_2 flood that had already accumulated unrelieved CO_2 build up. Oxy anticipated continued severe asphaltene plugging and gas cycling in this area. Oxy teamed up with strategic partners to proactively improve run times to be closer to the company average of .19.

The method selected was to run large volume compression pump designs internally coated with Teflon. The large volume vane openings were to help pass larger asphaltene solids and larger volume gas slugs. The Teflon would provide a "slicker", lower friction coefficient, to avoid accumulating asphaltenes and to provide some additional throughput efficiency. The efficiency difference was measured by testing bare stages then retesting the same stages coated with Teflon.

Oxy has run 20 subs with this method. The earliest unit was run 12/15/00. The infill drilling, unrelieved CO_2 pressure, and asphaltene production were realized in 2001, however the new CO_2 flood has been postponed. No units have failed due to asphaltenes or gas cycling yet. There were two failures not related to asphaltenes or gas cycling that gave favorable indication of the effectiveness of the coating.

Further results will be presented as this project continues.

LOCATION DESCRIPTION

Oxy Permian's South Wasson Clearfork Unit, SWCU, is located in West Texas, less than a mile South of the town of Denver City. It is in the Southern section of a group of fields operated by Oxy Permian known as the Wasson Clearfork Area, WCF. See Figures 1 and 2. The WCF currently operates 91 submersible pumps. The SWCU operates 41 submersible pumps. See figure 3.

The SWCU production is commingled from three separate zones. These zones are the Upper Clearfork, Middle Clearfork, and Lower Clearfork. See Figure 4. Typically, the submersibles are set between the Middle and Lower Clearfork, about 6,900 Ft. However, if a desander is run below the motor then the submersible is set above the top perforation of the Upper Clearfork. The reservoir lithology and characteristics are detailed in table 1.

HISTORY

This field began experiencing asphaltene plugging failures in 1991. Failures due to asphaltene increased to a peak of 10 failures in 1995. Between 1993 and 1997 this area saw severe asphaltene plugging and some significant gas cycling from CO_2 flooding. This area became known as Asphaltene Alley due to the high amounts of asphaltene. See figure **6.**

During this time period a number of tactics were used to deal with the asphaltenes. Prior to 1997 chemical feed lines were run along side the power cable or under the cable armor. This proved to be of little improvement and also impractical due to problems with plugging, splice reliability, surface equipment, and other complications. Running feed lines has been discontinued. In 1997 steel or fiberglass shrouds were run in an effort to better circulate chemical as well as alleviate gas cycling, with limited success. Due to the limited success shrouds are now rarely run.

An aggressive program of chemical treating and paraffin cutting were also employed. Based on a wells known history it was chemical treated with Xylene and paraffin solvents by chemical tanker truck. The most severe wells would be treated as much as three times per week including continuous treatment with a slipstream. Paraffin cutting was performed from one to three times per week depending on how deep paraffin was tagged in the well.

From 1995 to 1997 overall failure frequency moved from 1 to .5. In 1997, due to the industries economics, the C02 flooding was reduced from 25 mcf to 5 mcf for the 98 producers in this field.

PLAN

As economics improved Oxy planned to resume C02 flooding in the second quarter of 2001. They planned to increase C02 injection volumes to 40 to 45 mcf/day. Oxy also planned to infill drill in an area that had already accumulated unrelieved C02 build up. They planned to drill 7 infill wells, 3 on 20 acre spacing and 4 on 10 acre spacing. Oxy anticipated continued severe asphaltene plugging and gas cycling in this area. Oxy teamed up with their strategic partners to proactively improve run times to be closer to the company average of .19. The team could not identify significant additional improvements in the chemical program over what is already being done. Focus was turned to sub pump designs and specialty coatings.

METHOD

The method selected was to run large volume compression pump designs internally coated with Teflon. The large volume vane openings were to help pass larger asphaltene solids and larger volume gas slugs. The compression design would allow lower production volumes without downthrust damage when aspaltenes and gas are less prevalent. The Teflon would provide a “slicker”, lower friction coefficient, to avoid accumulating asphaltenes and to provide some additional throughput efficiency.

An evaluation of lift requirements indicated a majority of the production to be in the 1,000 to 1,200 BFPD range. Most wells being 5 ½ inch casing with some 7 inch. Existing gas volumes have been adequately handled by a conventional rotary gas separator. In anticipation of the new C02 flood, down hole gas calculations would only be speculative in trying to account for gas break through volumes to select pump stage models. It was decided that any larger vane volume selected would assist in handling excessive gas. Advanced Gas Handlers and other devices could be used if it became necessary.

A number of pump stage models were evaluated to identify for standardization. It became obvious that radial stages had more angularity in their flow paths and smaller vane openings. By contrast a mixed flow stage had a considerably smoother flow path and larger vane openings. See figures 7 and **8.**

The 400 series 1750 BEP compression model mixed flow stage was selected for standardization. **A** 400 series 4300 BEP compression model mixed flow stage was also selected for a couple wells with anticipated rates of about 2,000 BFPD.

Teflon coating is smoother and has a smaller friction coefficient than the niresist stage cast and machined surfaces. This could be seen indirectly by increased pump efficiency of the coated stages. Increased pump efficiency would also help offset some efficiency loss from operating the larger vane pump in a less efficient area of its pump curve.

The efficiency difference was measured by testing uncoated stages then retesting the same stages coated with Teflon. The following special procedures were used to help ensure test result consistency. During initial assembly the stages were numbered, in order, with an engraving pen. The uncoated pump test was repeated until there was less than 2% difference between tests. This eliminates inconsistency from wearing in new stages and thrust washers. The uncoated pump was disassembled. These stages, including pump head and base, were then Teflon coated. The engraved numbers could be recognized through the coating. The pump was then reassembled with the stages in the same order as the original assembly. The coated pump test was also repeated until there was less than 2% difference between tests. Using the same pump and stage order minimized potential construction inconsistencies of testing two different pumps or of the reassembly of the same pump with the stages in a different order. Besides the 400 Series 1750 BEP mixed flow stage this type of testing was also done with a 400 series 800 BEP radial stage and a 538 series 2600 BEP mixed flow stage. In most cases the pumps were only tested a maximum of 4 times and in most cases there was less than 1% difference in the last tests.

There are very obvious efficiency gains of the Teflon coated stages over the non-coated stages. The efficiency gains varied by pump volume and across the recommend range of each pump. The results indicate a trend of greater efficiency gains for greater pump volumes. The efficiency results are detailed in table 2. See figure 9

In actual application designs all internally wetted parts are Teflon coated including the I.D.'s of the gas separator, heads, bases, and discharge head. API pump test criteria are specific to the vendors recommended range. This design method purposely operates outside of the recommended range. Due to uncontrolled pump manufacturing variables outside of the recommended range the vendor could assure that all pumps would meet API test criteria, through the recommended range, although may not adhere to the same API tolerances outside of the recommended range. For this reason a test point is taken at the rate of application design to verify pump performance. Pump stages or motor horsepower could be added to enhance pump performance at that specific design point if necessary, although that has not been required yet.

RESULTS

Oxy has run 20 subs with this method. The earliest unit was run 12/15/00. The infill drilling, unrelieved CO_2 pressure, and asphaltene production were realized in 2001. The new CO_2 flood has been postponed. To date none of the new units have failed due to asphaltenes or gas cycling. There were two pulls not related to asphaltenes or gas cycling that gave favorable preliminary indication of the effectiveness of the coating.

The first pull, SWCU 8548, was a twisted shaft due to operations. This was a new infill drill well. This unit was pulled after only 60 days. There were considerable asphaltenes on the exterior surfaces such as housings and tubing. Internally there were traces of asphaltenes. The stages were easily cleaned up. These stages were later reused in another well.

The second pull, SWCU 8527 was a scheduled conversion to an injector. This well has been lifted by submersible since 1987. Historically, this well has failed for reasons other than asphaltenes such as scale and corrosion. This last unit had run 197 days. There were significant asphaltenes present on exterior surfaces such as housings and tubing. The lower pump was torn down without flushing or testing to evaluate the condition of the Teflon coating. There was a very thin film of asphaltenes evenly spread on all the diffusers and impellers. This thin film did not adhere to the stage surfaces. It would easily smear off with a light touch of the finger. It would more readily stick to anything else that touched it. These stages were easily cleaned and the pump was reassembled. All three pumps and the rest of the equipment from this well all tested within API. These pumps were later installed in another SWCU well. See figures 10 and 11.

CONCLUSIONS

So far there have not been any negative results from utilizing this method. Initial observations of two short run units are encouraging. Oxy still plans on restarting their CO_2 flooding in the future. Currently, the submersible pump failure rates of SWCU are at .20. Oxy plans to run these coated large vane compression pump systems in 95% of the SWCU wells, including new wells, conversions, and replacements.

Oxy will continue to evaluate this project and plans to report further results in the future.

Table 1

General	
Discovery	Dec-40
Structure	Struc/Strat
Average Depth (ft)	6600
Proven Productive Acres	4720
Primary Producing Mechanism	solution gas drive
Secondary Producing Mechanism	waterflood
Tertiary Producing Mechanism	CO_2 aug wtrflod '85 CO_2 miscible '89
Unitized Acreage	4960
Pattern size/type	40 acre 5 spot
Well spacing	20 acre*
	* some 10 acre producers
Fluid Data	
Crude Gravity, °API	35
Reservoir Temp, °F	120
Original Reservoir Pressure, PSIG	2600
Res. pressure @ wtrflood, PSIG	500
Current Reservoir Pressure, PSIG	
Original Sol. GOR, scf/stb	- 250
Original B_o / Current B_o	1.25 / 1.20
Crude Viscosity, at Original Pr	1.25
Water Viscosity	0.60
Formation Characteristics	
Lithology	dolomite
Average gross pay thickness, ft	1500
Average net pay thickness, ft	251
Net/Gross Ratio	0.17
Porosity, %	6.4
Permeability, md	1.7
Current Status	
Wells, Producing beam/ESP	55/34
Wells, Injecting	52/17 (CO2/wtr)
Wells, Shut in	
Wells, PxA	
BOPD (OFM)	3952
BWPD (OFM)	30142
MCFD (OFM)	4109
BWIPD (OFM)	39087
CO_2 Injection, MCFD	0
Avg oil / producer	44
Avg water/injector	566
Avg oil cut	12%
WOR	7.63
GOR	1.04
Decline rate	2.86 %/yr nom exp

Table 2

Pump BEP	Test Point	Uncoated % Efficiency	Coated % Efficiency	Gain % Efficiency	% Difference
2600	Min	58.05	58.73	0 68	117%
2600	BEP	63 19	70 57	7 38	11 68%
2600	Max	47 65	57 41	9 76	20 48%
1750	Min	58.45	60.31	1.86	3.19%
1750	BEP	64.21	68.52	4.31	6.72%
1750	Max	63.15	66.50	3.35	5 30%
800	Min	47.26	46.69	-0.57	-1.21%
800	BEP	54.46	56.31	1.85	3.40%
800	Max	48.00	51.33	3.33	6.94%

Figure 1

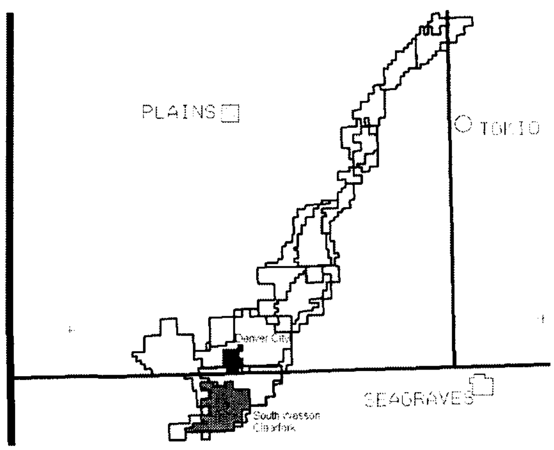
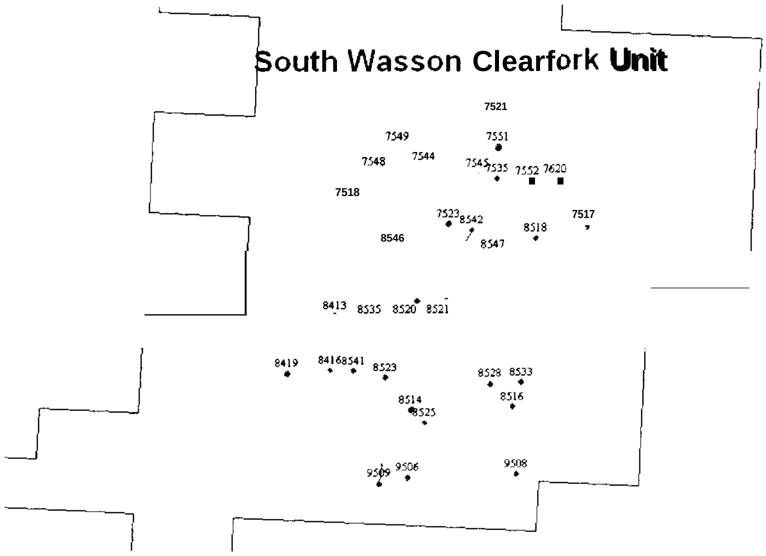


Figure 2



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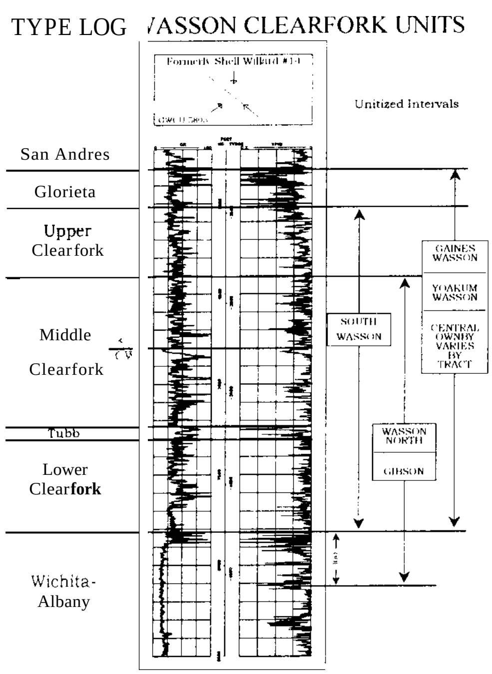
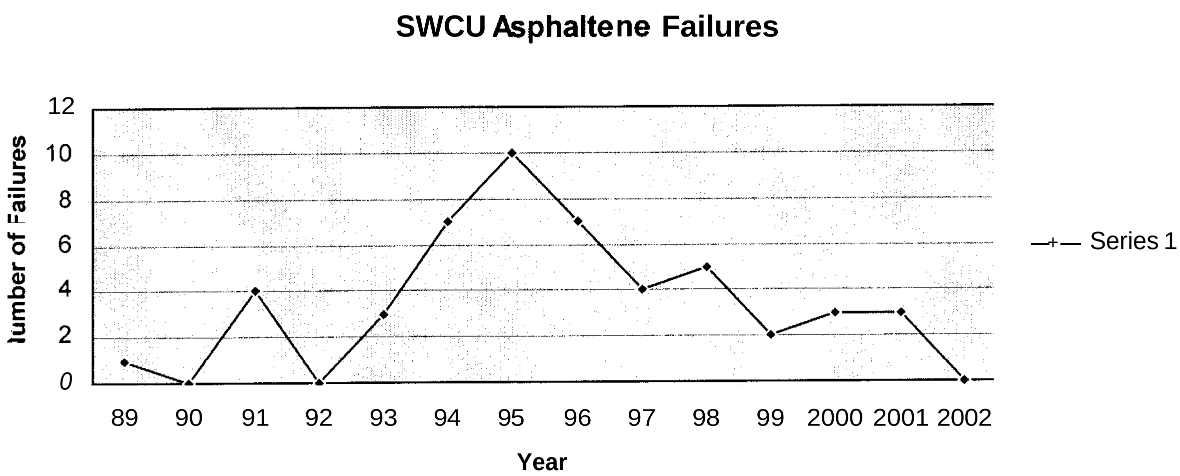


Figure **4**



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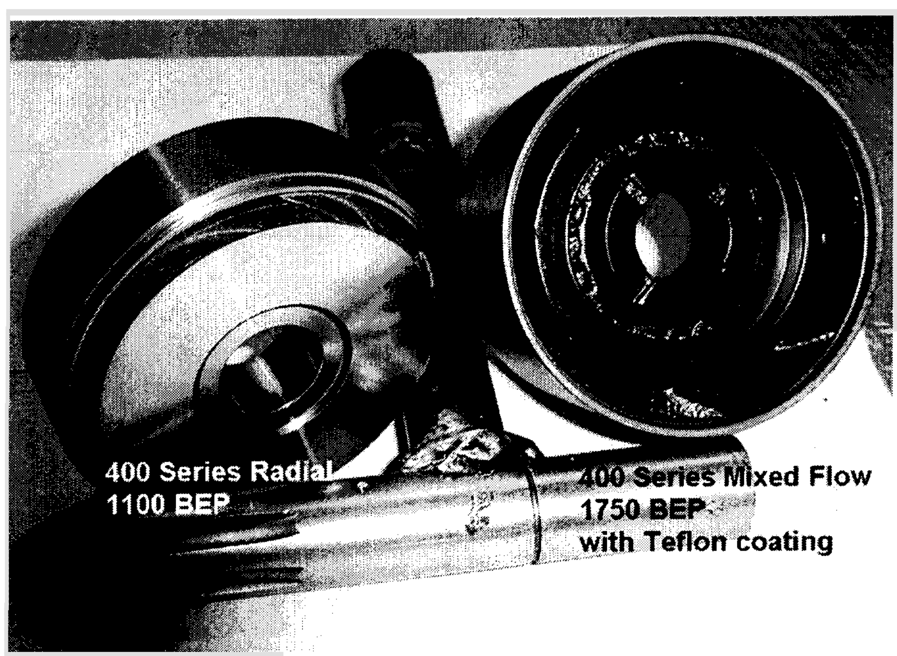

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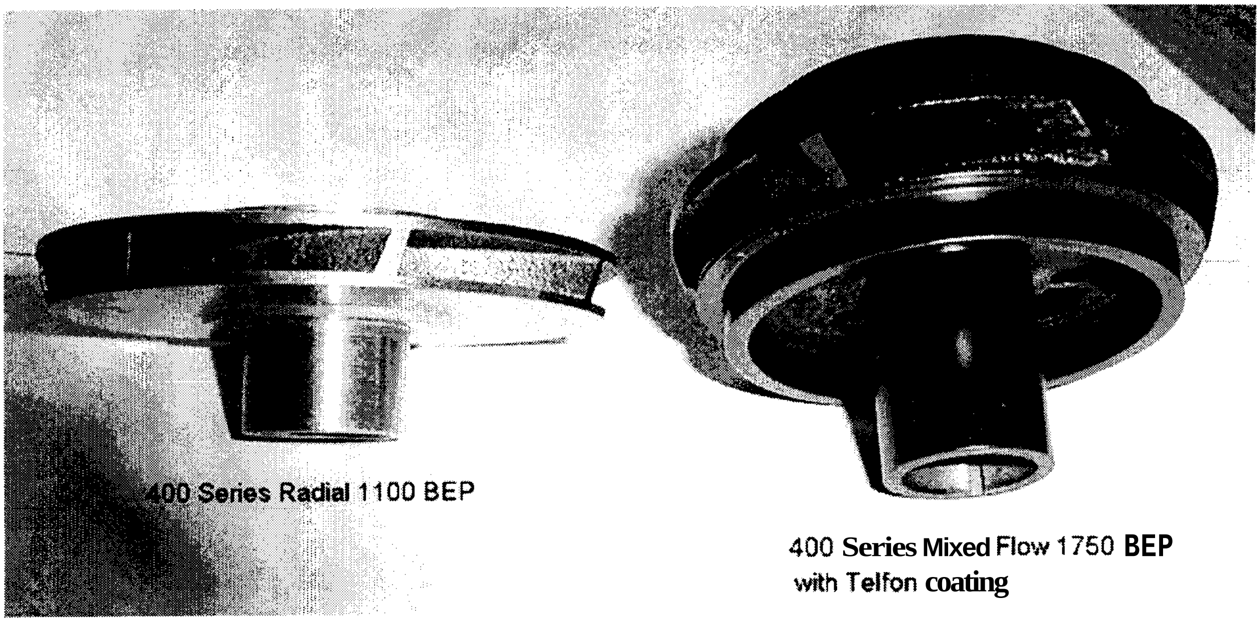

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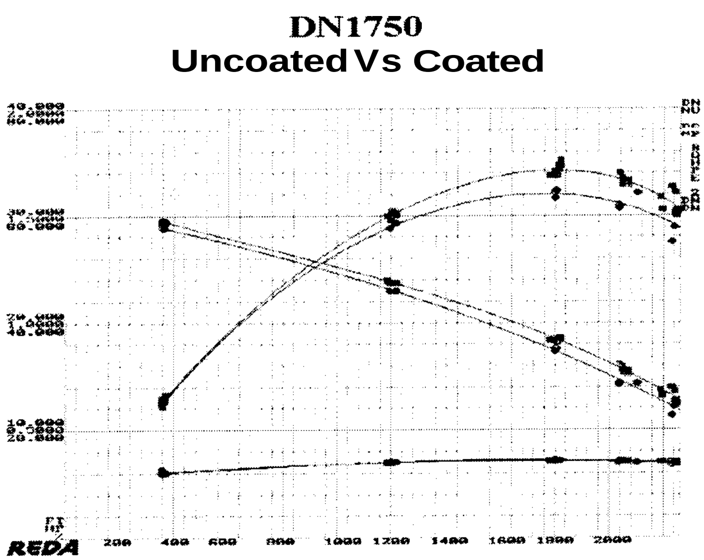

RED CURVE 4 DN1750, 125 STAGE PUMP w/ COATED STAGES

BLUE CURVE 1 DN1750, 125 STAGE PUMP w/ UNCOATED STAGES

Figure 9

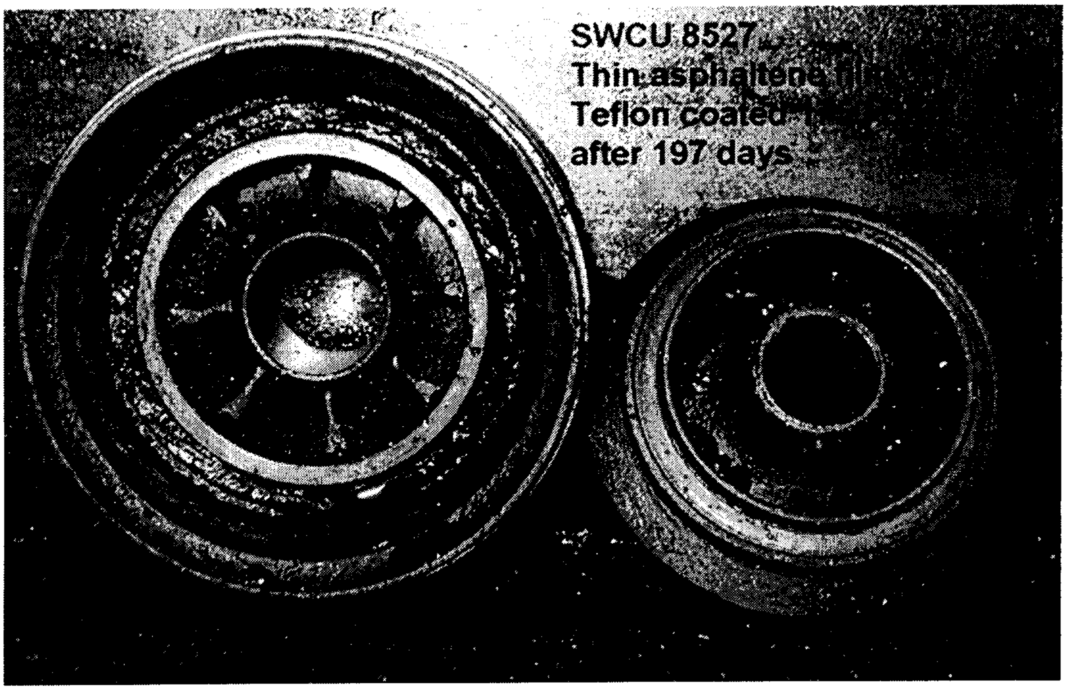

Figure 10

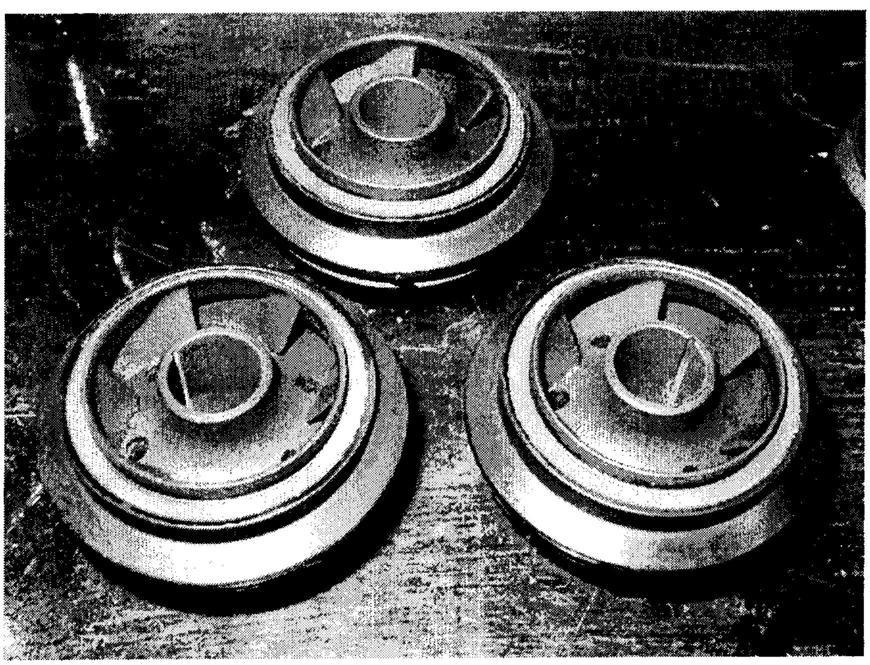

Figure 11