Oil Filter Experiment

Phase I

Search for a replacement Spin-on filter

For the 1980-1985 Yamaha XJ Family

Of

Motorcycles

Done By : Ross Presta 19 Oct 03
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Oil Filter Experiment

Phase I

Introduction

Oil filters are used every day but not very well understood. Whether you use a spin on filter or a cartridge type filter , more than likely , the OEM or an aftermarket filter is purchased and used. Why is a particular filter chosen for a specific application?

What I actually started out to do , was to come up with a spin-on filter design to replace a cartridge style design for the 1980-1985 Yamaha XJ650/750 family of motorcycles.

The adapter plate design was very easily done by measuring the filter attachment point on an 1983 XJ650 but should I just pick any filter that would attach ? I realized that I didn't really understand the various factors associated with a filter design. Some research on the web and discussion with fellow bikers led me to realize that flow / pressure characteristics of the original Yamaha cartridge filter design would need to be characterized. Factors such as media material density, number of pleats and physical size of the filter all played an important role in the flow/pressure characteristics of an oil filter.

I obtained some FRAM filters and dissected them and significant variation in pleat number and size was observed from filters that were approx the same shape and size.

The analysis of the pleats construction while interesting was not going to help me pick the proper replacement oil filter. After some discussion with Dwayne Verhey (Fellow biker and mechanic extraordinaire) convinced me that some sort of test fixture would need to be constructed that would measure the flow / pressure characteristics directly without worrying about pleat design and construction. In other words , if I could find a spin-on filter that had the same flow/pressure characteristics as the original Yamaha

design , then I would assume that it could be used without adversely affecting the operation of the lubrication system of the bike.

The Basic Test Fixture

The basic test fixture is made up of a positive displacement pump drawing oil from a resevoir thru a test plate that can accommodate different modular adapters that the filter will attach to and then discharging the oil back to the resevoir. The fixture has a pressure gage on the inlet side of the filter and one on the outlet side of the filter. This setup is not unlike the situation with a real oil pump in the motorcyle drawing oil from the sump, thru the filter and then back to the sump. The inlet and outlet pressure gages would allow the calculation of pressure drop across the filter and would also allow the calibration of the outlet pressure gage to indicate flow rates.

Refer to APP I for a drawing of the test fixture and APP II for a photograph.

Some Related Math

Before we review the results of the experiment, it is necessary to understand some basic hydraulic principles and math. Some of this is very obvious but is stated for clarity.

(1) Pressure drop across the filter is defined as :

P-diff = Pinlet – Poutlet ; units of PSI

(2) Flow (Q) is defined as :

Q= K * (P-diff)^0.5 , since P-diff in this case is being measured across the outlet tube , P-diff in this case is Poutlet since the pressure at the end of the outlet tube is zero so therefore

Q=K*(Poutlet)^0.5 ; has the units “litres/minute”

The expression (XXX)^0.5 means square root of

(3) The outlet pressure gage is calibrated for flow by measuring the time it takes to fill up a 2 litre container. This was done with 3 different oil filters in place and then the values were averaged to get a K factor of 1.444.
(4) Once the pressure / flow values were measured for a given filter , how could we put sense to it all ? Would it not be convenient to devise a flow rating value to each filter to aid analysis ? This value could be analogous to "inverse of resistance" for electrical circuits.The formula for this is defined as :

Flow Rating = Q/P-diff ; the higher the number , the better the pressure/flow characteristics. I.E. Higher flow at lower pressure drop across the filter

Summary and Discussion of Results

The results can be found in APP III but in short :

(1) The original Yamaha cartridge filter has a flow rating of 2.2
(2) The other tested spin-on filters have flow rating values as follows :

(a) Yamaha 5JW-13440-000 (for FJR1300) = 1.753
(b) Fram PH30 = 2.024
(c) Fram 3593A = 1.769
(d) Fram 7317 (FJR1300 EQ) = 1.345
(e) Fram 6811 = 1.5
(f) Fram 5343 = 1.4
(g) Bosch 72179 (FJR1300 EQ) = 2.008
(h) Fram 3675 = 1.91

This test Phase I , did not yield a filter that could be used as a replacement to the original design. The Fram PH 30 was within 10% of the original but on the wrong side of caution. It would have been better if a filter with a flow rating on 2.2 to 2.4 could be found.Also the Fram PH30 is a larger format and fits between the exhaust pipes of the "Maxims" but not the "Seca's". So this filter is not a good candidate for a universal fit. The Fram 3675 and Bosch 72179 might also be a resonable replacement. AAAdditional work would need to be done to be absolutely sure.

Also what is intersting that the WWW.Micapeak.com webpage for the FJR1300 reports the Fram 7317 filter as a suitable replacement for the 5JW-13440-00 original filter. In light

of the values measured , I would not use this filter as a replacement. The Fram 3675

might be an OK replacement if it is concave enough to seal.

I will continue to test and search for a replacement filter to the original Yamaha filter.

I look forward to issuing Phase II of this report , with additional filters tested.

Acknowledgements

(1) Kimon Styropolous for making the adapter plates for me

(2) Dwayne Verhey for interesting discussion, good advice, help with measurements and use of the pump.

Obligatory Disclaimers

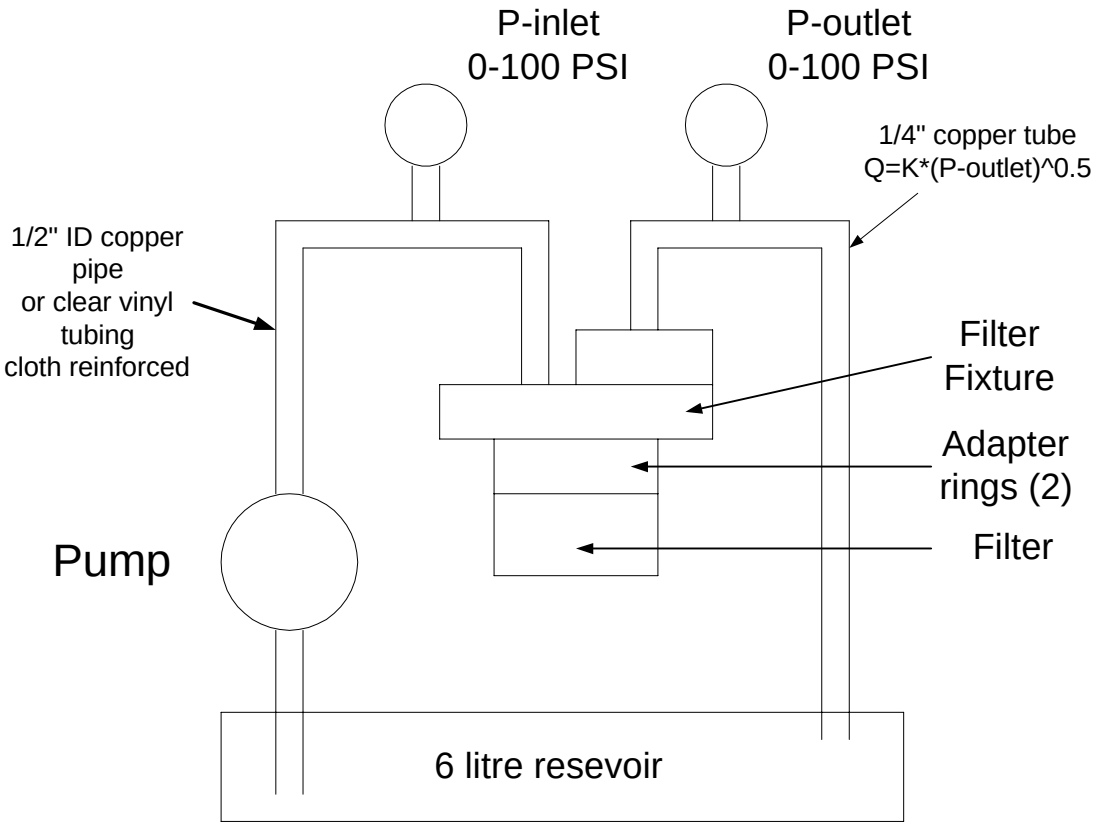
My background is in the High Voltage Equipment and Test Engineering business. Being a curious sort (with lots of time on my hands) , I have endeavored to employ sound engineering principles to the design of this experiment. However , I am not infallable and may have made mistakes. I look forward to receiving comments and/or suggestions for further work.

The experimental results found in this document do not reflect the actual pressure/ flow values found in the actual running engine of the mortorcycle. This experiment reflects relative pressure /flow characteristics at one operating condition , namely flow of approx 5 litres/min. However , I feel that it enables the user to maker judgements between different filters tested in terms of “better / worse “.

As always , **USE AT YOUR OWN RISK !!**

Appendix I

Drawing of Test Fixture


P-inlet
0-100 PSI
P-outlet
0-100 PSI
1/4" copper tube
Q=K*(P-outlet)^0.5
1/2" ID copper
pipe
or clear vinyl
tubing
cloth reinforced
Filter
Fixture
Adapter
rings (2)
Filter
Pump
6 litre resevoir

Appendix II

Photo of Test Fixture


GREENFIELD
CANADA
Tap/Drill Chart
LETTER DRILL

Appendix III

Experimental Results

oil=10W30

Date/Time	Oil Temp (degC)	Filter	P-inlet (PSI)	P-outlet (PSI)	P-diff (PSI)	Flow L/Min	K	Filter Flow Factor	Filter Old/New
17-Oct-03 1800 Hrs	10	XJ650 original	20	14.25	5.75	5.45	1.4444	2.274	Old
18-Oct-03 1000 Hrs	8	Yamaha 5JW-13440-00	23.5	14	9.5	5.40	1.4444	1.753	Old
18-Oct-03 1400 Hrs	10	Fram PH30	20	13.25	6.75	5.26	1.4444	2.024	New
18-Oct-03 1109 Hrs	12	Fram 3593A	25	15	10	5.59	1.4444	1.769	new
18-Oct-03 1313 Hrs	12	Fram 7317	30.5 28	14.5 13	16 15	5.50	1.4444 1.4444	1.375 1.345	new
18-Oct-03 1330 Hrs	12	Fram 6811	27	14	13	5.40	1.4444	1.499	new
18-Oct-03 1345 Hrs	12	Fram 5343	29.5	14.25	15.25	5.45	1.4444	1.396	new
18-Oct-03 1244 Hrs	11	Bosch 72179	22	14.5	7.5	5.50	1.4444	2.008	old
19-Oct-03 1445 Hrs	11	Fram 3675	22	14	8	5.40	1.4444	1.911	new

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Oil Filter Experiment

Phase II

Introduction

This phase of the testing involved the following :

(a) repeat the testing of the first phase with more accurate pressure gauges. The original were general purpose 2" dia , 0 – 100 PSI models with unknown accuracy. This time 4" gauges , 0-30 PSI models with 2 % accuracy were used so that the readings were within the middle of the dial.

(b) Another test was set up using the oil cooler installed as per on the motorcycle and then checking the pressure readings with the same type of filters. The Bosch filter was not available as it had been replaced on the owners motorcycle.This test used a 4" gauge , 0-60 PSI on the inlet and a 4" , 0-30 PSI gauge on the outlet. All the gauges used in this test were checked against one another on a manifold and exhibited readings with 0.25 PSI of each other.

Discussion of the Results and Conclusions

The repeat test showed that the readings were a little different than those of the original test ,but the ranking of the filters remained unchanged. These results can be seen in app I

The interesting part of the test, was when the oil cooler was installed and the filters retested. The difference between them were not as large as before. The inlet pressure was also much higher indicating that the oil cooler was very restrictive on its own. The oil cooler lines have a measured inside diameter of 5 mm.

The flow rate was checked again but remained unchanged from before.

These results are shown in app II

A comparison between the 3 tests are tabulated in app III to show at a glance the results of all the testing. The alternate spin-on filter candidates is still the PH30 but now the original Yamaha filter for the FJR looks like a good candidate. I assume that if the Bosch filter was available for testing , the it would be the best choice.

Appendix I

oil=10W30 with 4" 0-30 PSI gauges both sides

Date/Time	Oil Temp (degC)	Filter	P-inlet (PSI)	P-outlet (PSI)	P-diff (PSI)	Flow L/Min	K	Filter Flow Factor	Filter used/New
23-Oct-03 1700 Hrs	9	XJ650 original	15.5	12	3.5	5.00	1.4444	2.675	used
23-Oct-03 1700 Hrs	9	Yamaha 5JW-13440-00	19	12.5	6.5	5.11	1.4444	2.003	used
23-Oct-03 1700 Hrs	9	Fram PH30	17	12.25	4.75	5.06	1.4444	2.320	New
23-Oct-03 1700 Hrs	9	Fram 3593A	19.25	12	7.25	5.00	1.4444	1.858	new
23-Oct-03 1700 Hrs	9	Fram 7317	24.5	12	12.5	5.00	1.4444	1.415	new
23-Oct-03 1700 Hrs	9	Fram 6811	21.5	12	9.5	5.00	1.4444	1.623	new
23-Oct-03 1700 Hrs	9	Fram 5343	24	12	12	5.00	1.4444	1.444	new
23-Oct-03 1700 Hrs	9	Bosch 72179			0		#DIV/0!	#DIV/0!	used
23-Oct-03 1700 Hrs	9	Fram 3675	18.25	12	6.25	5.00	1.4444	2.001	new

Appendix II

oil=10W30 with 4" 0-30 PSI gauge on outlet - 4" 0-60 PSI on inlet - with oil cooler attached

Date/Time	Oil Temp (degC)	Filter	P-inlet (PSI)	P-outlet (PSI)	P-diff (PSI)	Flow L/Min	K	Filter Flow Factor	Filter used/New
24-Oct-03 1600 Hrs	12	XJ650 original	52	12.5	39.5	5.11	1.4444	0.813	used
24-Oct-03 1600 Hrs	12	Yamaha 5JW-13440-00	55	12.5	42.5	5.11	1.4444	0.783	used
24-Oct-03 1600 Hrs	12	Fram PH30	53	12.5	40.5	5.11	1.4444	0.802	New
24-Oct-03 1600 Hrs	12	Fram 3593A	57	12.5	44.5	5.11	1.4444	0.766	new
23-Oct-03 1800 Hrs	12	Fram 7317	63	12.5	50.5	5.11	1.4444	0.719	new
24-Oct-03 1600 Hrs	12	Fram 6811	60	12.5	47.5	5.11	1.4444	0.741	new
24-Oct-03 1600 Hrs	12	Fram 5343	63	12.5	50.5	5.11	1.4444	0.719	new

24-Oct-03 1600 Hrs	12	Bosch 72179			0		#DIV/0!	#DIV/0!	used
24-Oct-03 1600 Hrs	12	Fram 3675	58.5	12.5	46	5.11	1.4444	0.753	new

Appendix III

oil=10W30

Filter	2" gauges	4" gauges	4" with oil cooler
XJ650 original	2.274	2.675	0.813
Yamaha 5JW-13440-00	1.753	2.003	0.783
Fram PH30	2.024	2.32	0.802
Fram 3593A	1.769	1.858	0.766
Fram 7317	1.345	1.415	0.719
Fram 6811	1.5	1.623	0.714
Fram 5343	1.4	1.444	0.719
Bosch 72179	2.008	xxx	Xxx
Fram 3675	1.911	2.001	0.753