Objectives

In May of 2018, to independently validate the new 2-7/8 AMP, InFocus conducted 3rd party dyno testing of the power sections at a third party provider in Red Deer, AB. The objective was to demonstrate repeatable high torque and extended run time performance of InFocus' 2-7/8" AMP (ALL METAL POWER) sections.

This test was successful and well received by all parties present. This testing provided valuable 3rd party data on the performance, durability and wear characteristics of the power sections. Dyno test data was provided by the third party provider.

Test Procedure

1. Initial runs were done with no brake load to confirm operating parameters and establish the no load RPMs at different flow rates. This established the No Load Bit Speed range of 251 – 524 RPM, with corresponding flow rates of 68 – 144 GPM.

2. 1st Load run – 100 GPM Flow Rate

   (a) This started at a flow rate of 65 GPM, and a diff pressure of 800 psi. Produced a stable torque of 375 lb-ft and was held for 15 minutes before increasing flow rate to 100 GPM.

   (b) 100 GPM: the brake load was gradually increased over 25 minutes, with steadily increasing torque values 740 lb-ft at a diff pressure of 1,570 psi.

3. 2nd Load run – 66 GPM flow rate

   (a) This test was started at a flow rate of 100 GPM, and the motor was held at 765 lb-ft for 10 minutes. Flow rate was then dropped to 80 GPM.

   (b) The stable load was 410 lb-ft at a diff pressure of 900 psi. This was steadily increased over 25 minutes until a torque of 890 lb-ft was reached at a diff pressure of 1,950 psi.

   (c) This 890 lb-ft load was held for over 30 minutes at a speed of just under 100 RPM with no drop in performance or change in diff pressure.

Tests were very successful and proved the AMP power section can operate at a variety of load conditions, and can transition easily between loading conditions, all while putting out very high torque for it's size in a sustained (>30min) high load test. Data from the 2nd load run, where maximum torque of 890 lb-ft was achieved and sustained, is plotted in Figure 1.

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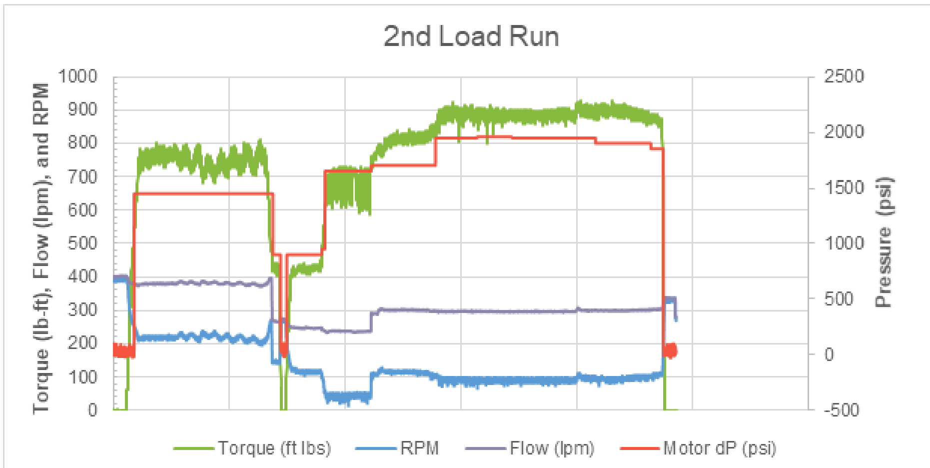

Figure 1 - Graphical results of 2nd Load Run

Post-Run Dimensional Inspection

Aside from testing the performance of the power section, the second goal of these dyno tests were to see the dimensional change of the of the 2-7/8" AMP power section after a sustained high-torque run. This was done with a combination of visual inspection and laser scan comparison before and after dyno testing.

Visual Evaluation of Rotor Profile

Contact appears to have occurred along one side of the profile of the rotor lobe, and in some locations extended to the rotor lobe tip. This is the side where the rotor rolls into the stator. This contact patch does not appear to have any divots or dents or even a step change in lobe thickness. The rotor profile still feels smooth and looks like the contact is more of a polish than any appreciable wear.

NOTE: The rotor was manufactured to a milled finish, resembling "snake skin". The scaling seen is from the manufacturing process and not from dyno testing.

Figure 2 - Closeup of rotor contact patch

Figure 3 - Alternate view of rotor contact patch

Visual Evaluation of Stator Profile

The stator was evaluated via visual inspection with a borescope, as well as tactile evaluation.

Contact appears to be on the flanks on either side of the stator minors, where the rotor makes rolling contact with the stator. The contact patches are smooth, and free of divots and dents. The edges of the contact patches are gradual and no step changes or indents are visible. This wear pattern is consistent through most of the stator. As seen on the rotor, this contact appears to be mostly polish rather than any appreciable wear.

Figure 4 - Post-run borescope of stator

Laser Scans

To quantify the contact and dimensional change seen in the visual inspection, laser scan data was used to evaluate profile change caused by testing.

Laser scans were taken at 2 points in the life of the rotor. Sequence of events follows:

1. Rotor was manufactured
2. 1st laser scan taken to verify geometry
3. Rotor was sent for treatment (adds approximately 0.002" to the entire profile)
4. Motor was assembled, and dyno tested
5. 2nd laser scan taken to evaluate change after dyno testing
6. Laser scan data from both scans was imported into SOLIDWORKS, converted from mesh to solid geometry, and compared to nominal profile.

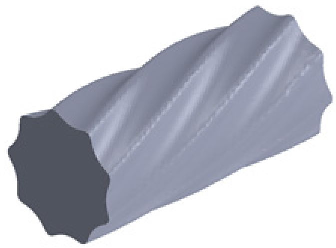

Figure 5 - Example of laser scan data import in SOLIDWORKS

Post Test Data Analysis

For both laser scans, a 4-6" representative section of the rotor was scanned, then imported into SOLIDWORKS, converted from mesh to solid, and then cross sections were taken and compared to the nominal profile.

NOTE: It is important to note that the points are imported as a polygon mesh from the laser scan data, so there is some rounding error as the curvature of the tips are connected straight line segments rather than true, clean arcs.

The initial laser scan, taken directly after manufacturing, showed the minors to be exactly on size, and the majors very slightly under the maximum nominal dimension. This was consistent across most of the lobes and fell within the acceptable tolerance.

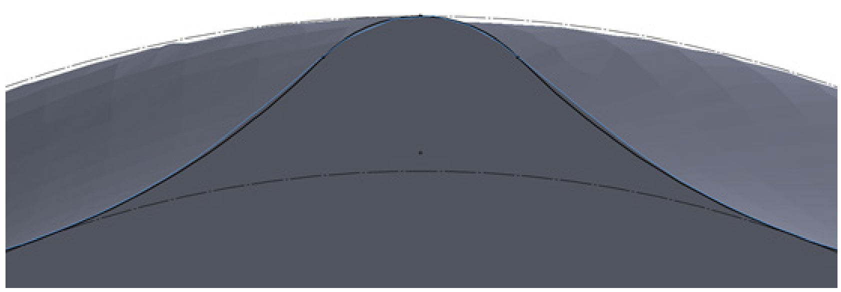

Figure 6 - Sample lobe profile after manufacturing

The post-dyno laser scans help quantify what was seen in the visual rotor inspection. The minors and the flanks saw no wear, and scans show them to be approximately 0.002" thicker than in the first scan. This is consistent with the expected growth due to rotor treatment. The dimensional change on the majors varied between lobe and profile location, but was generally between 0.001 – 0.002". On most lobes this contact was preferential to one side of the major, which again lines up with the visual inspection and the side of the major that would roll into the stator.

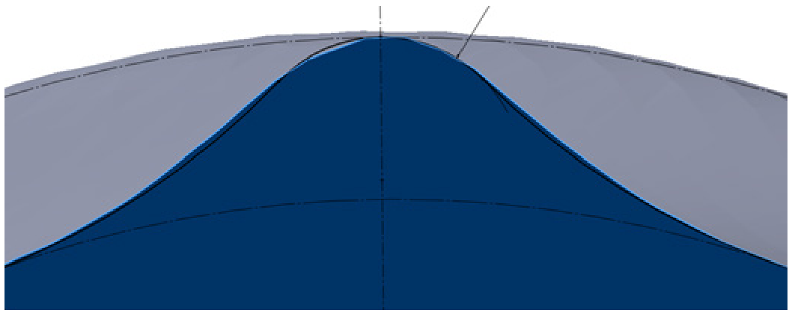

Figure 7 - Sample lobe profile after dyno testing

Although 0.001 – 0.002" dimensional change was observed on most majors, it is unlikely that this change would continue to progress at the same rate. In the final dyno test of the day, maximum torque of 890 lb-ft was achieved and held for a period of over 30 minutes without any measurable decrease in performance. This may indicate that observed dimensional change is initial run-in of the rotor and may not lead to performance degradation over time.

Conclusions

The third party dyno testing was very successful and proved the performance capabilities and dimensional characteristics of the 2-7/8" AMP power section. While further analysis continues to be done, some initial conclusions can be drawn from the test data and post-run inspection.

High Torque from Short Power Section

The 2-7/8" AMP power section produced exceptional torque in a very short power section. The torque produced is one of the highest in class for it's diameter, but it does so with just 78" (6.5 ft) of total length. This allows operators to run a shorter BHA without sacrificing power or performance.

890 lb-ft @ 1950 psi from a 78" (6.5 ft) power section.

Minimal Wear & Sustained Performance

In the dyno tests, dimensional change of 0.001" – 0.002" was seen on the majors, mostly on the side where the major rolls into the stator lobe. Initial run-in was expected from this power section, and does not seem to degrade motor performance. In the final load test of the day, after the motor had already seen sustained run time, maximum torque of 890 lb-ft was achieved and sustained for over 30 minutes without any measurable drop in performance.

High Flow Rate @ 0 load

The AMP power section is capable of very high flow rates at low load. This is advantageous when drilling/milling plugs and ports. The higher annular velocity improves cutting removal and milling/drilling efficiency.

The initial No Load dyno runs demonstrated RPM in the range of 251 – 524 RPM, with corresponding flow rates of 260 lpm – 535 lpm (68 – 144 GPM). After data processing and extrapolation, the published No Load Bit Speed of 183 RPM – 550 RPM were established over flow ranges of 189 LPM – 568 LPM (50 - 150 GPM)

Stall Resistant

Looking at the performance curve for the 2-7/8" AMP, it appears that the RPM curve for the AMP power section does not see a dramatic drop-off like is seen in traditional power sections. During the 3rd party dyno testing, the test was run to maximum pump capacity without being able to stall the power section.

References

IDSI-MOT-SPEC-0019 REFLEX 2875_73mm 91038