**Proof of Principal Test to Feed and Meter
Granular Coal into 450 psig Gas Pressure.**

2nd Quarterly Technical Progress Report

Period: 1st April 1999 - 30th June 1999

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Issued: July 1999.

Project # DE-FG26-98FT40330--02

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Abstract

The objective of this project is to demonstrate proof of principal to feed and meter granular coal into 450 psig gas pressure for use with pressurized fluidized bed combustors. This report summarizes work undertaken in the second quarter of 1999 in support of that objective.

Testing has been carried out on a small scale pump, but provided inconsistent data for correlation with performance predictions based on material properties. The problems were due to the inability of the test rig to maintain a steady state condition, compounded by a limitation of the available drive to overcome a gas pressure in excess of 50 psi.

In order to obtain sufficient data to enable the requirements for the 450 psi pump to be adequately defined, another series of tests was required on an intermediate pump. This pump was installed and tested in the test rig that will be used for the final high pressure tests, and enabled data to be obtained under steady state conditions up to 175 psi gas pressure.

This data has enabled the high pressure pump design to be finalized and implementation of the changes needed is underway.

The extra testing carried out has resulted in considerable delays in the project timescale, so a 6 month no-cost extension has been requested. The final high pressure testing is now scheduled to commence in late September 1999.

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Introduction

This is the second quarterly report by STAMET INC. describing the progress of their work toward the successful proof of principal test to feed & meter granular coal into 450 psig gas pressure.

The work reported in this document covers further modifications to existing experimental pumps and test rigs, and a series of additional testing carried out on a second pump at intermediate pressures up to 175 psi to provide additional experimental data. This provided improved correlation between predictions and experimental results that was deemed necessary before committing to the final design to be tested at the target 450 psi.

This series of tests has now been completed and the final design modifications to the SBIR pump to enable the 450 psi testing program to commence are now underway.

Executive Summary

As previously reported, facilities have been provided to measure the relevant properties of bulk materials necessary to attempt predictions of Stamet pump performance, and a small scale pump tested to provide data for comparison with predictions. Further work was recommended to test and refine the performance predictions over a wider range of conditions before implementation of the results to define the geometry to be tested for the final high pressure pump.

In this quarter some further small scale pump testing has been carried out to extend the experimental data available for comparison. However, correlation of these results with the material data information proved to be difficult. Several inconsistencies were found in the pump data obtained, increasing the level of uncertainty regarding the validity of the data correlation. The inability of the test rig to maintain a steady state condition and the limitation of pressure capacity to 50psi were identified as the major problems causing these inconsistencies. Since this test information is to be used to define the geometry for modifications to the pump for the final 450 psi test program, a complete review of available options to improve the data was made. This resulted in a decision to carry out an additional testing program on a second pump, at an intermediate pressure level and under steady state conditions, before committing to the final high pressure pump geometry for the 450psi tests. The higher level of confidence this provides in the final design justifies the significant extension of the project timescale. A no-cost 6 month extension has been requested for the project to allow time for this additional work to take place.

Testing has now been carried out on this pump, and the data obtained used to refine the pump performance prediction capabilities. This has resulted in the final geometry to be used for the 450 psi pump tests being defined. The internal modifications to the pump are now partially complete and the rest of the changes are in progress.

At this time, testing on the high pressure pump is scheduled to commence in late September.

Experimental

As stated a second series of pump tests has been undertaken to extend the data available and improve the confidence level that the final high pressure test program will ultimately be successful.

An existing Stamet pump, designated 0230, has been modified to handle fine coal and provided with an outlet geometry designed to provide a controlled seal at up to 175 psi of gas pressure. The pump modifications provided improved internal sealing and a controlled venting system. A particle pressure sensor was also included in the outlet horn to monitor particle pressure on the wall at that location to provide additional data on the actual conditions at the pump exit.

Based on the small scale pump results and available theoretical analysis, the outlet was reconfigured to adequately seal the selected coal, while applying minimal outlet restriction and hence HP requirements.

The most significant limitations of the small pump test arrangement were the 50 psi pressure limit and the inability to maintain a steady load condition. These shortcomings were overcome in the arrangement used for these tests, enabling steady state conditions to be measured at pressures up to 175 psi. The test rig arrangement and instrumentation used for this series of tests is the same as that which will be used with the high pressure pump for the final 450 psi tests, so this provided the added benefit of checking out these systems before the final program is started.

A series of tests of this modified 0230 pump and installation was then conducted, leading to the successful pumping of the coal into 175psi gas control of gas and coal leakage.

Results & Discussion

A series of tests of the modified 0230 pump was conducted, starting with no gas pressure and gradually increasing, ultimately leading to the successful pumping of the coal into 175psi gas with minimal gas or coal leakage.

The testing identified low volumetric efficiency for the pump, so the potential material flowrate was not achieved. Investigations determined the causes to be on the supply and inlet side of the pump.

Testing was therefore carried out to determine the supply capacity of the existing hopper and supply pipe. These tests determined that the existing arrangement could not deliver

the coal being used to the inlet of the pump at the required rate. The hopper and supply pipe were therefore modified and re-tested until an arrangement was found to be capable of delivering coal at a rate well in excess of the pump capacity.

The testing also showed that the effectiveness of the venting system was limited. An additional vent was installed to allow migrating gas to escape without interfering with the material inlet flow. Additional venting was also added to the inlet side of the pump to help to de-aerate the material entering the pump duct.

Further testing with the modified arrangement showed a significant increase in the pump throughput. Full capacity (100% volumetric efficiency) was achieved at approximately 60% of full speed with no gas load applied. Further modifications to the inlet pipe were incorporated but we were still unable to maintain full capacity when running the pump at full speed. The remaining problem area was identified as the transition from the supply pipe into the duct.

A program of testing to investigate and improve the flow characteristics of this transition has been implemented. The results of this program will be of use in final commercial machine designs, but will not have any significant bearing on the progress of the final high pressure testing planned under this grant.

The data from the 0230 pump tests has been used to correlate with the materials data and improved agreement obtained. This data was then used to confirm the modifications to be incorporated into the pump for the final high pressure testing program to 450 psi.

These modifications are now underway. Despite the above work resulting in a significant extension to the timescale of the program, the quality of the data now available as input to the final design modifications to be tested to 450 psi has been much improved, greatly enhancing the chances of success.

At this point in time the program is running considerably behind the original planned schedule and a 6 month no-cost extension has been requested. As stated, the delay is due to the considerable increase in the amount of testing carried out to provide more accurate data to finalize the high pressure design. This delay is justified since it will allowed the incorporation of the latest information and knowledge in the final SBIR pump design. This will improve the final product and increase the chances of successfully achieving the target pressure.

Conclusion

- 1) Correlation of the results from initial testing on a small scale pump with data obtained from facilities provided to test those properties affecting performance in the Stamet pump proved difficult.
- 2) The main problems were the inability of the small scale test rig to maintain a steady state condition and the pressure limitation of 50psi.
- 3) A further test program on an intermediate pressure pump capable of 175psi installed in the test rig to be used for the final high pressure tests was undertaken and provided improved data to define the final high pressure arrangement to be tested.
- 4) These final changes required to the SBIR pump and test rig have now been defined and implementation is under way. Testing and reporting of final results is expected to be complete within the 6 month time extension requested.