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AMMONIA THERMOCHEMICAL ENERGY TRANSFER DEMONSTRATION

Final Report
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INSTITUTE OF ADVANCED STUDIES

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1. Introduction.

This report is "final" only in the sense that it marks the end of a period of substantial funding by NERDDC. With the passing of this period, there still remains the basic support of the ANU which should enable the project to continue until the objectives have been achieved. A regrettable feature of the project has been the inconsistency of its development apparent by the end of 1981. While a great deal of effort had been devoted to the major components of the system, areas such as instrumentation and control were not in an equally advanced state. During 1982 to the present the available effort has been directed towards correcting this situation. This partly explains the slowness of progress but the inadequacy and piecemeal nature of funding, the need to make many instruments and auxiliary components in-house because of their unavailability in the market, the shift to a new laboratory, and bad luck are also offered as explanations.

Despite these difficulties a great deal has been achieved and the project is now poised for further progress.

2. Objectives.

Originally the primary objective was to construct a small pilot plant to demonstrate thermochemical energy transfer using the reversible ammonia reaction. The heat source was to be electrically powered. Under Dr.Williams' management the objective was widened to include in the experimental programme the design of solar absorbers and hydrocarbon liquid - liquid chemical reactions.

Since Dr.Williams' departure the project has been returned to the original objective. The reader is referred to previous annual reports for detailed discussions of the objectives of the project and the methods proposed for achieving them.

3. Course of project

The project was initiated by the author in 1974. There followed a period of assessment of the concepts involved both within the group and by bodies external to it. The most notable external assessments were a review by the Department of Science (ref. 2)and the feasibility study of Davy Pacific Pty. Ltd., (ref. 4). As a result of these assessments NERDDC commenced funding the project in 1979.

Dr.O.Williams joined in 1975 and in 1980 obtained a three year appointment as Research Fellow. He brought considerable enthusiasm and energy and had a marked influence on its course both as a result of his part in determining the detailed design of several major components: the dissociator, synthesisor and flow net work; and his successful bid for leadership.

3.1 Management.

During the course of the project there were two changes of management. The first change, viz. from management by the author to management by Dr.Williams was prompted by the author's heavy involvement in another NERDDC project related to a method of manufacturing paraboloidal mirrors, upon which, at that time, depended the White Cliffs solar power project. The second change in management was brought about by Dr. Williams' resignation from the project. He had felt that he had been placed under great stress by the deadlines either imposed by NERDDC or implicit in his non-tenured appointment.

3.2 Accident.

During Dr.Williams' period of management an innovative method of handling liquid ammonia led to the accidental explosion of an ammonia shipping cylinder. Fortunately no-one was hurt although the event caused some material damage to the building. The explosition had an enormous effect on morale and caused many months delay for the project.

3.3 Major Components

All major components of the system are now complete having been designed and constructed in-house as planned. They include: dissociator, synthesiser, accumulators,separator, two 20 litre high pressure storage vessels, liquid circulating pump, liquid compressor and gas circulating pump. Of these the most complex component is the synthesiser described fully in ref. 3. It comprises a hot wall pressure vessel with cold flanges each end and internal groups of 3 m.m. diameter tubing for heat exchanging with the catalyst bed contained within the pressure vessel.

3.4 Auxiliary Components.

These include pneumatic motors for driving the liquid compressor and circulating pumps, electric motors and controllers for alternative pump drives and a liquid nitrogen compressor and vaporisor (designed and constructed in-house) for the supply of high pressure clean nitrogen gas used for testing, flushing and accumulator backing. (ref 8).

3.5 Flow network.

All components are interconnected by a comprehensive network of high pressure piping and valves. The network also includes filters, provision for evacuation of any section, and provision for drainage of any section, to a special shower cabinet in which traces of ammonia are washed out from the waste gases before their release to the atmosphere.

3.6 Instrumentation.

The flow network contains several pressure gauges and pressure transducers. Thermocouples are used to monitor the temperatures in the dissociator and synthesiser. Flow of liquid ammonia is measured by a turbo meter designed and built in-house. Ref. 1. Differential pressure gauges and orifices are available for monitoring gas and liquid flow. Data logging is accomplished by means of a computer coupled to a digital volt meter and multiplexer.

A pressure vessel and automatic balance have been designed and constructed in-house. Known as a balancing separator (ref. 6) this combination is to be used for the absolute measurement of rates of dissociation and synthesis, the determination of nitrogen-hydrogen ratio in the synthesis gas and finally as the means of sensing the difference in rates of dissociation and synthesis in the demonstration of energy transfer by means of an automatically controlled fluid loop.

3.7 Control System.

The major components are: the balancing separator referred to above; a motor driven flow control valve designed and constructed in-house and presently being coupled to an electronic circuit and differential pressure gauge for the automatic control of gas flow; a constant flow liquid regulating valve constructed in-house; and an automatic pressure regulating system not yet completed.

The current plans for instrumentation and control have been discussed in ref. 7.

4. Current Status.

Current staffing comprises the author and Mr.R.E.Whelan, head technical officer, part-time. The most pressing difficulty is the shortage of additional staff. The project desperately needs a young technician with at least three years tenure so that the wasteful cycle experienced so often of "train and lose" , may be broken. Given the need for a thorough training in safe handling procedures and in techniques that are specific to the project it is not feasible to operate by employing the occasional assistant for periods as little as six months as has been the case in the immediate past.

The labours of the past 18 months have gone a long way to correcting the imbalance that had existed between the provision of major hardware components and the components for instrumentation and control. Consequently, the project is about to enter an experimental phase with the dissociator, from which it is hoped to obtain the first comprehensive set of data on its performance. The next major task after that will be to commission the synthesiser. It is anticipated that this will present many challenges especially with respect to thermal stability (ref. 5) and the design of an appropriate heat rejection system. There are many potential sources of trouble that need nullifying such as overheating of the hot wall of the vessel and the soldered internal tube joints. Moreover calorimetry is not easy to effect and the synthesiser has still to be suitably housed on the roof of the laboratory.

Once the pilot plant has been commissioned successfully many important new areas of research will be opened up for experimental study. The control of the energy transfer loop is likely to be one of these since many factors such as the reaction rate, individual phase flow rates, temperatures and pressures interact in a unique way. The challenge is to understand this and devise simple control methods. This work should be applicable to many other thermochemical systems.

Again the optomisation of output configurations for work production is a particularly important area that awaits study. The theoretical work of the group has laid an excellent thermodynamics foundation for this. Catalyst studies are particularly important: there is a need to study the characteristics of existing catalysts under the new optimum conditions that prevail in thermochemical loops as well as to assess new types of catalysts. It might be expected that experimental work along these lines would give us new insights which would lead to the more rational design of specific components such as solar absorbers.

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