THE POSSIBILITY TO USE A NUCLEAR REACTOR AS SOURCE OF ENERGY FOR A JET ENGINE

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Abstract. *It had investigated the possibility to use a nuclear reactor for airplanes propulsion. The 2 possible solutions for a nuclear jet engine are: the direct cycle (where the fluid pass through the reactor's core) and the indirect cycle (the fluid is passing through a heat exchanger). Taking in to account the radioprotection problems, the only realistic solution seems to be the indirect cycle, where the energy transfer should be performed by a heat exchanger that must work at very high speed of the fluid. The heat exchanger will replace the classical burning room. It had performed a more precise theoretical study for the nuclear jet engine regarding the performances of the nuclear reactor, of the heat exchanger and of the jet engine. It was taken in to account that in the moment when the burning room is replaced by a heat exchanger, a new model for gaso-dynamic process from the engine must be performed.*

Keywords: *nuclear reactor, propulsion, jet engine.*

1. INTRODUCTION

Interest in atomic energy hit full force following World War II. The scientists who had raced to produce a bomb had also developed theories for a number of possible uses for the atom. Martin Mann lists a number of them in his book, Peacetime Uses of Atomic Energy. Ideas ranged from power generation, to nuclear excavation, to nuclear propulsion for vehicles on land, sea, and in the air. There were proposals for nuclear ships, nuclear locomotives, nuclear automobiles, and nuclear aircraft. It is this last proposal that is the topic for this paper, which will examine the technical and socio-political aspects of the United States Air Force's Aircraft Nuclear Propulsion (ANP) program and associated programs, including the reasons the ANP program was undertaken, and the reasons it was canceled after a decade of work.

2. SHORT HISTORY

The principles behind using atomic energy for the propulsion of aircraft were developed early in the atomic age. As early as 1942 Enrico Fermi and his associates involved with the Manhattan District Project discussed the use of atomic power to propel aircraft [1]. There was the potential for the release of radioactive materials to the atmosphere and the problems of direct radiation during operational use [2]. The requirements for an operational nuclear aircraft were that, even under the most adverse conditions, the aircraft did not add

materially to the general background atmospheric radioactivity and that while in use the aircraft restricted all harmful radiation to within the craft or a pre-designated exclusion area [3].

In 1946 the interest in atomic aircraft developed into a long-lived project knows as NEPA, for Nuclear energy for the Propulsion of Aircraft [4]. The NEPA project, which started in May, was controlled by the United States Air Force (USAF) and was therefore oriented towards developing both an atomic- powered long-range strategic bomber and high-performance aircraft.

Extensive studies were conducted under NEPA from 1946 until 1951, at which time it was replaced by the joint Atomic Energy Commission (AEC) / USAF ANP program. The ANP program set forth the ambitious goal of full-scale development of aircraft reactor and engine systems. One of the factors that led to the creation of the ANP program was a study done at MIT by a group convened by the AEC in 1948 to look at the potential uses of atomic powered flight. "This study group, known as the Lexington

Unfortunately the ANP project was divided into two parts which needed to work closely together, but these two parts were managed by totally separate entities.

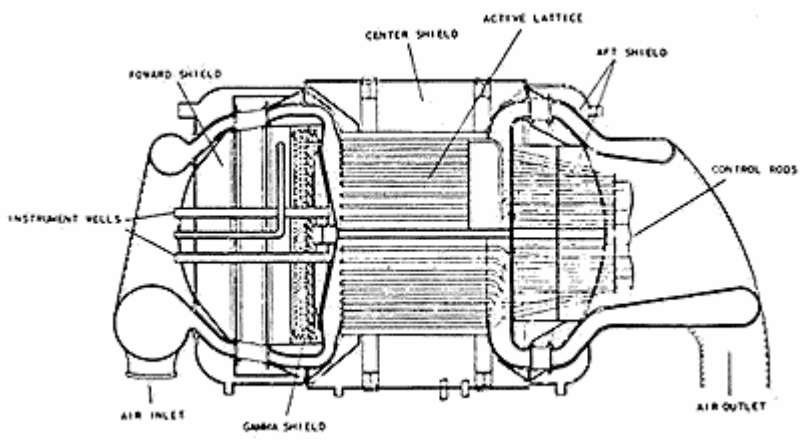

Fig. 1. The direct cycle solution.

Under the ANP program the General Electric Co., at Evendale, Cincinnati was issued a contract to develop a direct-cycle (Fig.1) turbojet, and Pratt & Whitney Aircraft Division of United Aircraft Corp. was authorized to study an indirect cycle (Fig. 2) and work was started at the Connecticut Aircraft Nuclear Engine Laboratory (CANEL) [5]. In the direct air cycle air enters through the compressor stage of one or more turbojets. From there the air passes through a plenum and is directed through the reactor core. The air, acting as the reactor coolant, is rapidly heated as it travels through the core. After passing through the reactor the air passes through another plenum and is directed to the turbine section of the turbojet(s) and from there out through the tailpipe [6]. An indirect system is very similar, except that the air does not pass through the reactor itself. After passing through the compressor the air passes through a heat exchanger. The heat generated by the reactor is carried by a working fluid to this heat exchanger. The air then passes through the turbine and out the tailpipe as above. The working fluid in the indirect cycle is usually a dense fluid, such as a liquid metal, or highly pressurized water. This allows more heat energy to be transfer, thereby increasing the efficiency of the system [7].

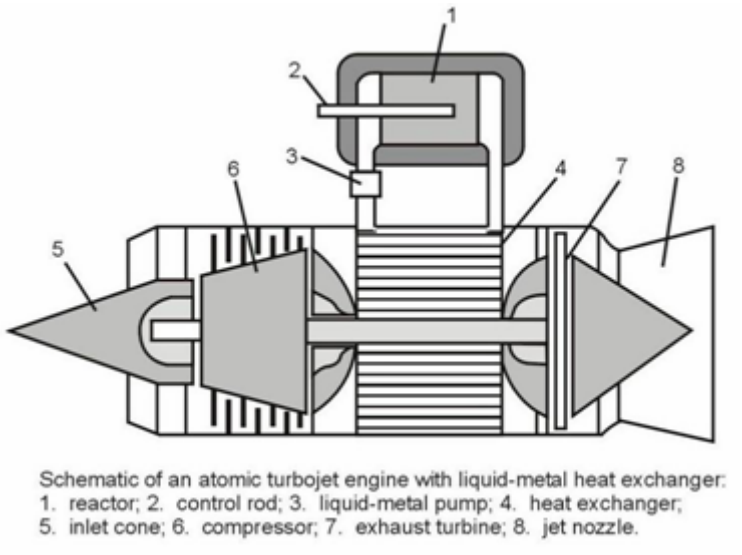

Fig. 2. The indirect cycle solution.

3. THE THERMODYNAMIC CYCLE

The thermodynamic cycle of the nuclear jet engine is characterize in principal by the fact that the working fluid is the air in all engine's sections. The burning room is replaced in the indirect cycle case by a heat exchanger which transfers the energy from the nuclear reactor to the working fluid [7]. The solution proposed for this study is illustrated in Fig. 3.

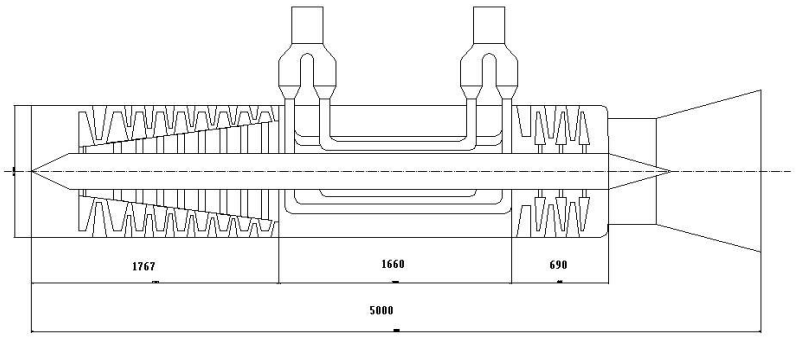

Fig. 3. The nuclear jet engine.

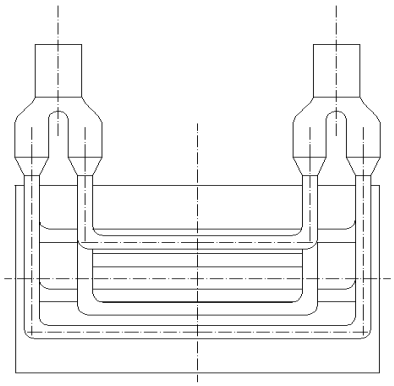

Fig. 4. The heat exchanger.

The thermodynamic cycle [8] of the nuclear jet engine is shown in Fig. 5.

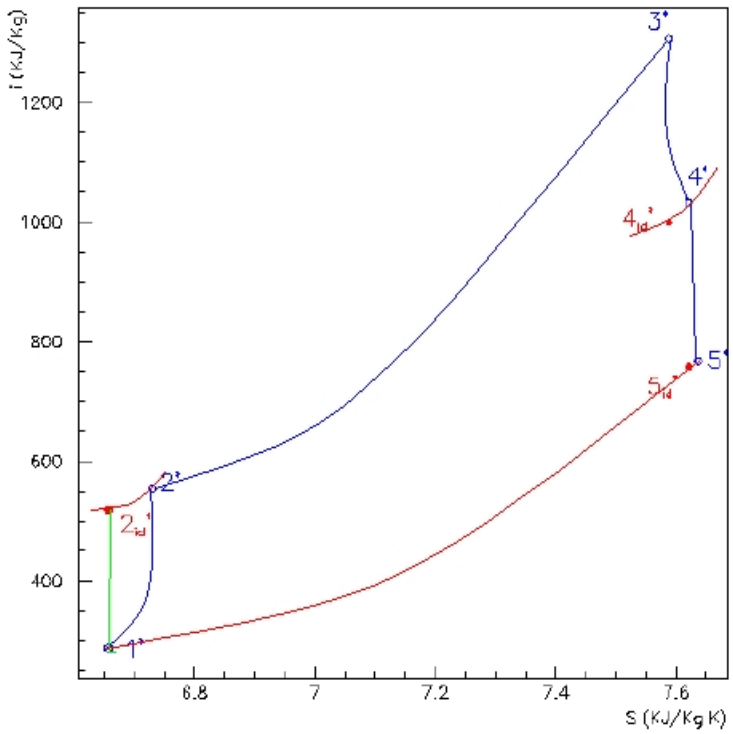

Fig. 5. The thermodynamic cycle of the nuclear jet engine.

The heat exchanger proposed in this case is systems of pipes and fluid is, also air which is used to reduce the temperature of the nuclear reactor. The material of the heat exchanger is a Cr-Ni combination, chose in principal for its very good characteristic in heat transfer. A schematic view of the heat exchanger is shown in Fig. 4.

4. THE NUCLEAR REACTOR

The nuclear reactor proposed for this application is a homogenous one composed by a combination of the nuclear fuel UO_2 (5%) and the moderator material BeO (95%). The reactor [9] is controlled by B_4C tubes which have the mission to stop the neutrons. The schematic view of the nuclear reactor is shown in Fig. 6.

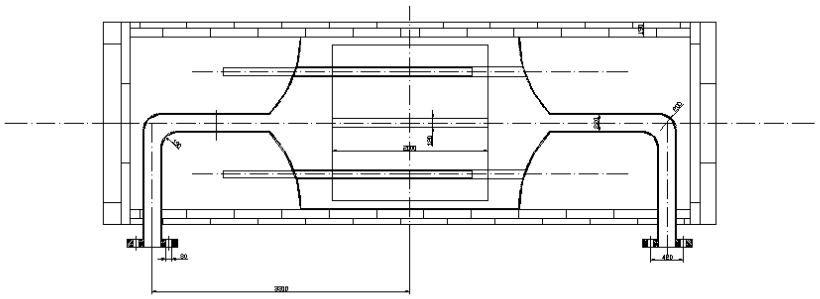

Fig. 6. The nuclear reactor.

The weight of the nuclear reactor (including also the protection shields) is estimated at 5.000 kg. In this condition we can say that the nuclear jet engine is designed in special for transport airplane which can operate on long distances.

5. THE CONTROL OF THE ENGINE

Since the fuel debit could not be use for the engine's control, we must to concern the problem of the manipulation on the geometry of the engine and on the nuclear reactor.

Using the control tubes we can vary the temperature of the reactor and also the temperature in the turbine. This is the most efficient method for the nuclear jet engine's control.

6. CONCLUSIONS

The most important conclusion which can be putted is that the nuclear jet engine's can represent a solution for the airplanes which are designated to long distance flight, in special by the fact that fuel consumption is in principal 0.

A very important problem which must be very well studied is the possibility to release radioactive materials in to the atmosphere, especially in a case of an accident.

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Manuscript received: 30.04.2010
Accepted paper: 01.09.2010
Published online: 04.10.2010