METHOD OF FABRICATING A ROCKET ENGINE COMBUSTION CHAMBER

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ABSTRACT

A process for making a combustion chamber for a rocket engine wherein a copper alloy in particle form is injected into a stream of heated carrier gas in plasma form which is then projected onto the inner surface of a hollow metal jacket having the configuration of a rocket engine combustion chamber. The particles are in the plasma stream for a sufficient length of time to heat the particles to a temperature such that the particles will flatten and adhere to previously deposited particles but will not spatter or vaporize. After a layer is formed, cooling channels are cut in the layer, than the channels are filled with a temporary filler and another layer of particles is deposited.
Fig. 6
METHOD OF FABRICATING A ROCKET ENGINE COMBUSTION CHAMBER

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 86-568 (72 Stat. 435; 42 U.S.C. 2457)

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to methods of making liquid rocket engine combustion chambers.

2. Prior art

It is known to make a rocket engine combustion chamber by casting a liner and then forging it into the desired hourglass shape. Cooling channels are then cut in the outer surface of the liner, followed by filling the cooling channels with wax. A thin layer of copper is then electrodeposited over the filled channels and a thicker layer of nickel is electrodeposited over the copper layer. The wax is then removed from the channels to leave them clear and a multi-part clamshell jacket is fitted around the liner and the entire assembly is welded together to form a combustion chamber.

A major disadvantage of this process is that there are numerous welds which cannot be inspected. Failure of one of the welds can result in a catastrophic failure of a space shuttle being lifted into orbit by the rocket motor.

Another disadvantage of this conventional process is that it is very expensive and time consuming, the electrodeposition of the copper and nickel layers alone requiring thousands of man hours and great expense.

SUMMARY OF THE INVENTION

A process for making a combustion chamber for a rocket engine wherein a copper alloy in particle form is injected into a stream of a heated carrier gas in plasma form which is projected onto the inner surface of a cast, hollow metal jacket having the configuration of a rocket engine combustion chamber. The particles are in the plasma stream for a sufficient length of time to heat the particles to a temperature such that the particles will flatten and adhere to previously deposited particles but will not spatter or vaporize. After a layer of the alloy has been built up, cooling channels are cut in the layer. The cooling channels are filled with a filler material and a second layer of alloy is then applied to cover the cooling channels. The filler material is then removed from the cooling channels to leave open cooling channels through which a cooling liquid can be circulated.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional view of a cast metal jacket which serves as a form for making the combustion chamber.

FIG. 2 is a cross sectional view of the jacket of FIG. 1 after a first layer of an alloy liner has been applied to the inner surface of the jacket.

FIG. 3 is an enlarged fragmentary view taken on line 3—3 of FIG. 2 showing cooling channels which have been cut in the first layer of the alloy liner and then filled with a filler material.

FIG. 4 is a cross sectional view of the apparatus of FIG. 2 after a second layer of alloy liner has been applied.

FIG. 5 is a greatly enlarged fragmentary view taken on line 5—5 of FIG. 4 showing the completed cooling channels after the filler has been removed from them.

FIG. 6 is an enlarged fragmentary view showing the vacuum plasma spray nozzle positioned to spray the heated alloy particles onto the inner surface of the jacket.

FIG. 7 is a schematic view showing the structure used with the vacuum plasma spray nozzle to form the combustion chamber.

DETAILED DESCRIPTION OF THE INVENTION

Referring now in detail to the drawings, there is shown in FIG. 1 a one-piece, cast metal jacket 11 inside of which a liner is to be formed to make the combustion chamber for a liquid rocket engine. The jacket 11 is cast from a suitable metal, with the preferred metal being one of several alloys, Inconel 718, stainless steel 347 or JBK-75. These alloys have the following compositions:

<table>
<thead>
<tr>
<th>Inconel 718</th>
<th>Stainless 347</th>
<th>JBK-75</th>
</tr>
</thead>
<tbody>
<tr>
<td>nickel</td>
<td>50-55%</td>
<td>9-13%</td>
</tr>
<tr>
<td>chromium</td>
<td>17-21%</td>
<td>17-15%</td>
</tr>
<tr>
<td>niobium</td>
<td>7-10.5%</td>
<td>0.8%</td>
</tr>
<tr>
<td>molybdenum</td>
<td>2.8-3.3%</td>
<td>0%</td>
</tr>
<tr>
<td>titanium</td>
<td>0.85-1.15%</td>
<td>0%</td>
</tr>
<tr>
<td>aluminum</td>
<td>0.2-0.8%</td>
<td>0%</td>
</tr>
<tr>
<td>iron</td>
<td>balance</td>
<td>balance</td>
</tr>
</tbody>
</table>

While the above alloys are preferred, other metals and alloys can be used provided that the metal or alloy can withstand the high temperatures encountered in vacuum plasma spraying (described below) and has properties suitable for use in a liquid rocket combustion chamber.

FIG. 2 shows the jacket of FIG. 1 after a layer of a copper alloy forming a liner 12 has been applied to the inner surface of the jacket. This liner is applied by a vacuum plasma spray system wherein an alloy in particle form is heated and projected at a high velocity into impact with the inner surface of the jacket 11 under vacuum or low pressure conditions, i.e., 40 to 200 torr.

FIG. 6 shows a cross sectional view of the spray head 15 used to form the liner 12. The head 15 includes a tungsten cathode 18 and a copper anode 19, the anode 19 being surrounded by a water jacket 22 for cooling the anode. A DC voltage of 40 to 70 volts from a supply 23 is applied across the cathode and anode to cause a current flow of 800 to 1,200 amps between the cathode and the anode.

A carrier gas of about 80%-100% argon and up to 20% helium or hydrogen from a supply 24 is passed through the head 15 and toward the jet of Mach 2 to Mach 3. A metal alloy in powder form from a supply 27 is injected through ports 28 into the gas stream. The DC current flowing in the form of an arc from the cathode 18 to the anode 19 heats the gas to a high temperature, i.e., 5,000 to 20,000 Kelvin and ionizes it to form a plasma.

The metal alloy is preferably an alloy of 3.2 to 3.7 weight percent silver with the balance being copper or an alloy of 2.75 to 3.25 weight percent silver, 0.3 to 0.7
weight percent zirconium with the balance being copper. The alloy is in powder form with a particle diameter within the range of 5 to 45 microns.

The method of claim 1 wherein the alloy is selected from the group consisting of (a) an alloy of 3.2 to 3.7 weight percent silver and 96.3 to 96.8 weight percent copper and (b) 2.75 to 3.25 weight percent silver, 0.30 to 0.7 weight percent zirconium with the balance being copper.
7. The method of claim 6 wherein the jacket is made from an alloy selected from the group consisting of (a) 50–55 weight percent nickel, 17–21 weight percent chromium, 4.75–5.5 weight percent niobium–tantalum, 2.8–3.3 weight percent molybdenum, 0.85–1.15 weight percent titanium, 0.2–0.8 weight percent aluminum with the balance being iron, (b) 9–13 weight percent nickel, 17–19 weight percent chromium, 0.8 weight percent niobium–tantalum with the balance being iron and (c) 29–31 weight percent nickel, 14–16 weight percent chromium, 1–1.5 weight percent molybdenum, 2.1–2.5 weight percent titanium, 0.1 to 0.35 weight percent aluminum with the balance being iron.

8. The process of claim 6 wherein the gas is 80–100% argon with up to 20% of helium or hydrogen.