28, and in those portions where the catalyst 24 is absent, a delay in the onset of reforming for reactants flowing through the bottom of the header 28.

In addition, the reforming panel 22 is heated by combustion gases and thus is hotter than the temperature of the partially reformed hot mixture leaving the prereformer 18 which contains the incoming reactants for the reformer panel. As a result, the incoming reactants heat as the mixture progresses down the header with the highest maximum temperatures occurring at the bottom of the header. It is the bottom of this header on the first reformer panel that is one of the most critical locations for carbon deposition. However, as is shown in the preferred embodiment of the present invention, a catalyst strip 24 is placed within the header 28, thus the reforming begins within the header 28. The extent of reforming occurring in the header 28 is typically negligible at the top of the header 28 but becomes greater toward the bottom of the header 28.

The inclusion of this reforming reaction helps to cool the inlet header and introduces more hydrogen into the flow of material within the header which in turn which increases the gas volume, and reduces the residence time of the fuel within the delivery device and increases the hydrogen partial pressure. This in turn also helps to suppress carbon formation. Detailed views of these features are shown in FIG. 5(*b*).

In the present preferred embodiment of the invention, the reformer system is a 7.5 kWe scale reformer system in which fuel is delivered by a $1/16^{th}$ inch tube into a 0.028 inch OD (~0.013-inch ID) hypodermic needle. Preferably, the needle is positioned with the tip of the needle located within the center of a steam flow chamber that is undergoing an expansion from $1/8^{th}$-inch tube to ¼-in tube. While these features and descriptions of the preferred design of the invention are described above it is to be distinctly understood that the invention is not limited thereto but may be various otherwise embodied according to the needs and necessities of the user.

For increased efficiency of the system the selection of a reforming catalyst that does not itself promote carbon formation is preferred. The selection of a particular catalyst should be made with this issue clearly in the mind of the user. Such a selection is an appropriate determination that can be made by a party of skill in the art; however the inclusion or exclusion of any particular catalyst is not a limiting factor upon the scope of the present invention.

The reduction of carbon deposition can be further enhanced by utilizing materials that are not conducive to the formation of carbon deposits. In the present preferred embodiment of the invention, all of the surfaces to which unreformed fuel may be exposed are fabricated from Inconel 625, with the exception of the injection needle which is made from stainless steel. In addition to excellent high temperature properties, Inconel 625 contains minor component additives of Niobium plus Tantalum (3.15-4.15%) and Molybdenum (8-10%). These materials are believed to also further the resistance of the present invention to forming carbon deposits. While the present preferred embodiment of the invention is described as being utilized and made from these materials it is to be distinctly understood that the invention is not limited thereto but that a variety of other types of materials may also be utilized according to the needs and necessities of the user.

In some prior art fuel reforming systems, recuperators that preheat incoming reactants using reformate product from a reformer have been utilized to attempt to increase efficiency. However one problem that exists in such a circumstance is that while such a reheating device maintains an appropriate temperature for reactions, (about 650 to 800^{i} C) heating to too high a temperature without initiating reforming can lead to formation of carbon deposits. This phenomenon has been observed particularly as reformate temperatures approach 800 C. These carbon deposits build up on a variety of areas in particular near the inlet of a fuel cell reformer, and the outlet of a recuperator if the particular embodiment utilizes such a device.

In the present embodiment, this problem has been significantly reduced by placing reforming catalyst into the recuperator to form a prereformer 18. These catalysts initiate a reforming reaction at a lower temperature than the main reformer, using heat extracted from the hot reformate. The presence of these catalysts provides several functions including: providing cooling to the recuperator which reduces the maximum temperature that the steam and fuel will reach before entering the reformer panels to a range of approximately 570° C. to 600° C.; and reforming 5 to 10% of the hydrocarbon feed to produce ~3.4 to 8% hydrogen in the feed stream. This range is believed to reduce carbon deposit formation, and is substantially different from other methods and systems. This process also increases the velocity of the gas within the system, as compared to many other systems due to an increase in molar flow which shortens the residence time of the fuel in the header of the inlet reformer panel.

One additional feature of the preferred embodiment of the present invention is that the methane (in this instance a non-desired by product) concentration was very low (<0.28%) while the typical equilibrium methane content for reforming at these temperatures is quite high. The reason for this is believed to be that early in the reaction process the level of fuel conversion is low so that the steam concentration is high relative to CO and H_2, which pushes the equilibrium for the reaction $CO+3H_2 \rightarrow CH_4+H_2O$ away from the formation of methane. This is another feature that demonstrates the increased efficiencies of the present preferred embodiment over other systems and devices that exist in the prior art.

While various preferred embodiments of the invention have been shown and described, it is to be distinctly understood that this invention is not limited thereto but may be variously embodied to practice within the scope of the following claims. From the foregoing description, it will be apparent that various changes to the application may be made without departing from the spirit and scope of the invention as defined by these claims.

What is claimed is:

1. A system for reducing carbon deposition in a steam reforming assembly for hydrocarbon fuels, said system comprising:

a steam source, said steam source configured to produce a steady flow of steam;

a mixing tube extending between said steam source and a prerefomer, said mixing tube having an opening configured to receive fuel into a flow of steam passing through said mixing tube and to deliver a thoroughly mixed uniform mixture to a recuperative prereformer;

said recuperative prereformer operatively connected to said mixing tube and configured to receive said mixture within said prereformer and to treat a portion of said mixture with at least one catalyst; and

a reformer operatively connected to said prereformer downstream, said reformer having an inlet operatively connected to a header said header containing at least one catalyst.

2. The system of claim 1 further comprising a superheater operatively connected between said steam source and said mixing tube whereby steam from said steam source is transferred to said superheater, and said superheater, super heats the steam from said steam source.