A Green Engine Concept—Need Of the Hour

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I. Introduction


The Real Problems

If One Tries To Define The Problem In Short It Would Be: Affordable Clean, Green Mobility And Also Affordable Clean Energy. Affordable Would Necessarily Mean That The Common Man Should Be Able To Utilize The Means Of Transportation. The Means Should Be Clean—I.E. Should Not Emit Any Harmful Products. In Energy Production And / Or Utilization Some By-Products Are Generated Which Are Damaging For The Flora And Fauna. Thus The Affordable Green Mobility Should—If At All—Emit Environment-Friendly By-Product. For Example A Hydrogen Based Engine Would Produce Water As By-Product Which Is Environment-Friendly And Not Harmful. However, A Hydrogen Based Mobility Solution Is Not Affordable—At Least As Of Now. At Present The Available Clean Energy Sources Are Not Convenient And Efficient. Solar Energy Is Practically Free But Tapping It For Day-To-Day Use Is Not Convenient. Electrical Energy Is Plagued With Storage Problem. Therefore, Even If We Manage To Produce Electricity In Environmentally Clean Manner Storage Becomes A Hindrance As We Are Experiencing In Electric Cars. Charging Batteries Takes A Long Time And The Range That An Electric Car Can Travel In A Single Charge Is Limited. All These Difficulties Warrant A Fresh Look At How Clean Energy Can Be Tapped Which Would Be Also Useful For Mobility.

Why Combustion?


Some Dissociation Chemical Reactions

One Of The Simplest Dissociation Reactions Is Dissociation Or Decomposition Of Calcium Carbonate Into Calcium Oxide And Carbon Dioxide:

\[ \text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2 \]

This Reaction Produces Lime And Carbon Dioxide Gas After Dissociation. This Is An Endothermic Reaction—Meaning It Needs Energy For Dissociation. Obviously Such A Reaction Is Not Going To Be Useful For An Engine.

Any Electrovalent Compound Ionizes In An Aqueous Solution And Dissociates In Positive And Negative Ions Such As:

\[ \text{NaCl (Solid)} \rightarrow \text{Na}^+(\text{Aqueous}) + \text{Cl}^-(\text{Aqueous}) \]

These Reactions May Be Endothermic Or Exothermic. However They Too Are Not Useful For Consideration With Respect To An Engine.
Some Ammonium Compounds Do Dissociate And Are Interesting To Study.

\[ \text{NH}_3\text{Cl} \rightarrow \text{NH}_4 + \text{HCl} \]

This Is A Decomposition Reaction Which Is Reversible But Endothermic. It Also Produces Hydrochloric Acid Which Is Corrosive And Harmful.

\[ (\text{NH}_4)_2\text{CO}_3 \rightarrow 2\text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O} \]

This Reaction Is Endothermic And Produces A Harmful Gas—Ammonia. However Ammonium Nitrite (NH_4NO_2) At 100°C Decomposes Thus:

\[ \text{NH}_4\text{NO}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O} \]

In This Exothermic Reaction It Releases Nitrogen And Water Vapour. It Produces Energy Equivalent To 224 KJ Per Mole Of Ammonium Nitrite. However, Ammonium Nitrite Is Highly Unstable. Therefore, Although The Reaction Produces Harmless Gases This Substance Cannot Be Considered For An Engine.

Ammonium Nitrate, On The Other Hand Offers A Number Of Decomposition Reactions.  
1. \[ \text{NH}_4\text{O}_3 \rightarrow \text{N}_2\text{O} + 2\text{H}_2\text{O}(-36\text{KJ/Mole}) \]
2. \[ \text{NH}_4\text{NO}_3 \rightarrow \text{NH}_3 + \text{HNO}_3(176\text{KJ/Mole}) \]
3. \[ \text{NH}_4\text{NO}_3 \rightarrow \text{N}_2 + 2\text{H}_2\text{O} + 1/2\text{O}_2(-602\text{KJ Mole}^{-1}) \]


Decomposition Of Ammonium Nitrate Into Nitrogen, Water Vapour And Oxygen Is The Most Suitable To Run A Complete Green Engine. This Reaction Normally Takes Place Above 250°C.

**Comparison Of Energy Content Of Various Substances**

If We Compare The Energy Content Of Various Traditional Fuels With That Of Ammonium Nitrate It Is Noticed That The Latter Is The Lowest In Table 1 Given Below.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Energy Content KJ/Gm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>34</td>
</tr>
<tr>
<td>Petrol (Gasoline)</td>
<td>48</td>
</tr>
<tr>
<td>Diesel</td>
<td>45</td>
</tr>
<tr>
<td>Black Coal</td>
<td>34</td>
</tr>
<tr>
<td>Brown Coal</td>
<td>16</td>
</tr>
<tr>
<td>Ammonium Nitrate</td>
<td>7.53</td>
</tr>
</tbody>
</table>

Though The Enthalpy Of Ammonium Nitrate Is Low It Is Nearer To Brown Coal. The Question Is Whether This Energy Content Is Sufficient To Run And Sustain An Engine.

**Engine Power**


<table>
<thead>
<tr>
<th>Sr</th>
<th>Reaction</th>
<th>Heat (Cal/G)</th>
<th>Gas Volume (ML/G)</th>
<th>Temp °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(\text{NH}_4\text{O}_3 \rightarrow \text{N}_2\text{O} + 2\text{H}_2\text{O} )</td>
<td>-521</td>
<td>840</td>
<td>320</td>
</tr>
<tr>
<td>2</td>
<td>(\text{NH}_4\text{O}_3 \rightarrow \text{N}_2\text{O} + 2\text{H}_2\text{O} )</td>
<td>108</td>
<td>910</td>
<td>860</td>
</tr>
<tr>
<td>3</td>
<td>(\text{NH}_2\text{O}_3 \rightarrow 3/4\text{N}_2\text{O} + 1/2\text{N}_2\text{O}_4 + 2\text{H}_2\text{O} )</td>
<td>316</td>
<td>980</td>
<td>950</td>
</tr>
<tr>
<td>4</td>
<td>(\text{NH}_2\text{O}_3 \rightarrow \text{N}_2\text{O}_4 + 2\text{H}_2\text{O} + 1/2\text{O}_2 )</td>
<td>354</td>
<td>945</td>
<td>560</td>
</tr>
<tr>
<td>5</td>
<td>(8\text{NH}_2\text{O}_3 \rightarrow 5\text{N}_2 + 4\text{NO} + 2\text{NO}_2 + 16\text{H}_2\text{O} )</td>
<td>201</td>
<td>980</td>
<td>260</td>
</tr>
<tr>
<td>6</td>
<td>(\text{NH}_2\text{O}_3 \rightarrow 1/2\text{N}_2\text{O}_4 + \text{NO} + 2\text{H}_2\text{O} )</td>
<td>36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Large Volume Of Gases Produced By Decomposition Can Certainly Offer Sustainable Mechanical Power. For Continuous Decomposition Reaction A Temperature Level Above 250°C Needs To Be Maintained. Initial Heating Can Be Facilitated By A Battery Powered Heater. As The Decomposition Reaction Itself Is Exothermic It Will Not Be Difficult To Maintain The Temperature Level Once The Reaction Has Been Initiated.

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Green Engine Concept

A Conceptual Design Of Ammonium Nitrate Engine May Consist Of A Feeder Unit To For Continuous Supply Of Ammonium Nitrate. Ammonium Nitrate May Have To Be A Mixture With Some Additives For Safer Handling. The Nitrate Would Enter A Reaction Chamber Where The Decomposition Will Take Place. As Has Been Mentioned Above, The Chamber Will Need Heating Initially To Facilitate The Complete Decomposition To Nitrogen, Oxygen And Water Vapour Which Takes Place At 250°C. Later The Temperature Would Be Sustained Because Of The Exothermic Nature Of The Reaction. See Fig.1.

It Must Be Noted Here That It Is Very Essential To Maintain The Temperature Above 250°C Because At Lower Temperatures The Decomposition May Result In Unwanted Noxious And Corrosive Gases Like Nitrous And Nitric Oxides As Well As Nitric Acid. A Safety Feature Will Have To Be Incorporated In The Design Of The Engine To Ensure That The Reaction Stops As Soon As The Temperature Goes Below 250°C.

A Continuous Decomposition Resulting From Uninterrupted Supply Of Ammonium Nitrate Would Build A Large Volume Of Nitrogen, Oxygen And Water Vapour Mixture. Water Vapour May Be Condensed To Water Which Can Be Used To Cool Parts Other Than The Reaction Chamber. The Remaining Gases Would Be Stored In A Sealed Reservoir To Build Pressure. Valves Would Be Fitted To The Reservoir To Control The Pressure. A Stream Of Gas Under Pressure Would Be Released To Rotate A Turbine. This Rotation Would Provide The Mechanical Drive. Obviously The Mechanical Power Can Be Used To Drive Vehicles As Well As Electricity Generators And Pumps.

Fig. 1 - Concept Diagram of an Ammonium Nitrate Engine

Challenges

The Reaction Looks Very Simple But It Will Need A Great Effort, Investment And Time Before Ammonium Nitrate Engine Can See The Light Of The Day. The Challenges In Taking This Concept To Reality Have Many Aspects. These May Be Listed As Follows:


c. Availability Of Ammonium Nitrate: This Should Not Be A Great Challenge Since Ammonium Nitrate Is Used As A Fertilizer Too. For Making It Available As An Engine Fuel Would Need Some Kind Of Regulation.

d. Prototype: There Could Be Several Types Of Engines Based On The Principle Of This Concept. Even A Reciprocating Type Of Engine Can Be Built Which May One Day Open The Possibilities Of Converting Existing Fossil Fuel Engines Into Ammonium Nitrate Engines. To Build A Prototype, However, May Take Years And A Lot Of Financial Investment.

e. Materials: Reaction Chamber Needs To Be Maintained At A Temperature Above 250°C And If The Exothermic Reaction Heats Up The Gases The Materials For Reaction Chamber And Turbine / Reservoir
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Need To Be Resistant To Heat To Those Levels. Materials For Engine Construction Also Need To Be Corrosion Resistant To Nitrates.

II. Conclusion


References: