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The Gasoline-Diesel Hybrid: The Future of America and Automobiles

Introduction

The United States economy has been in a recession for the last several years and a major factor is the struggling domestic car market. Companies such as Chrysler and GMC went bankrupt and had to be bailed out by the government, while other companies such as Saturn and Hummer went out of business completely. New York Times reports that “By November, G.M. had lost more than $18 billion for the year (2008)” (Bowmer 2011). This statistic is only a glimpse into one of the hardest times to date for United States automotive companies. The former glory of American automobiles and the flourishing economy that accompanied it have been lost.

If the United States was able to capture the next revolutionary automotive advancement, then maybe this former economic greatness could be restored. This revitalization would be a unifying action for the entire country. At the same time, the current issues regarding environmental conservation would take a step in the right direction by decreasing hazardous gas emissions and lowering oil consumption. The communities of both American-car enthusiasts and environmental conservationists would be strengthened by these advancements in engine technology. This technology does exist and is closely approaching its debut. New evolutions in car engines, such as HCCI, RCCI, and MSCI, are currently being designed and are quickly approaching readiness for mass-production and consumer purchase. If these new engines succeed in increasing fuel economy, lowering harmful emissions, while maintaining affordability then the country could see arise of manufacturing and economic growth that could potentially parallel the Industrial Revolution, while also contributing to solving the current environmental crisis.

The State of the Industry

The car industry is at a critical point as well, with ever growing demands for fuel economy and environmental friendliness. Automobile makers are still recovering from one of the biggest collapses in American automobile history in 2008. Michael Wayland, an automotive reporter in Michigan, reports that, "U.S. auto sales, which are on pace to end the year at about 14.5 million vehicles, up from 12.8 million last year, haven't been this high since the government-backed "Cash for Clunkers" program in 2010" (Wayland 2012). These numbers are promising for the future of the industry, but a new and innovative solution is needed in order for a complete recovery.

For the last few years hybrid and electric vehicles were thought to have been the solution to these various issues that the field of automotives is facing. The focus has now shifted to an entirely new innovation, gasoline-diesel hybridization. If successful, this innovation will improve the fuel economy of a vehicle without sacrificing emissions standards. While this strategy may not claim to end all dependence on oil in the ways that electric and solar powered cars do, it is a step in the right direction.

Gasoline engines have been around longer than diesel engines and succeed in having a relatively low cost of production, clean emissions, and horsepower production. The main disadvantage of the traditional gasoline engines is a lack of efficiency in terms of fuel consumption. Diesel engines improve upon efficiency, often rivalling the efficiency of hybrid cars (such as the Toyota Prius), but are plagued by emission related issues. While diesel motors have improved upon their emission related issues through the years, they still face difficulties achieving efficiency and emission standards within a marketable price range, especially during a time when the automotive industry has been receding (Dinesh 2009). In theory, if both the low cost and cleanliness of gasoline powered engines could be combined with the efficiency of a diesel engine the result would be a major breakthrough for mechanical engineers, the field of automotives, and environmental conservation. This theory is now in motion and researchers have developed several strategies to combine both diesel and gasoline engines. The most significant of these strategies are: HCCI, (Homogeneous Charge Compression Ignition), RCCI, (Reactivity Controlled Compression Ignition), and the most recent form that is being researched at the nationally renowned Argonne National Laboratory, MSCI (Multizone Stratified Compression Ignition) (Ciatta 2012).

The Engines

The three designs that researchers are currently analyzing are HCCI, RCCI, and MSCI. These three systems are similar, but are characterized by unique advantages. All three engines answer the demands of the public and government, but face a set of unique challenges at the same time. Regardless of how effective this new technology is, it is equally important that the general public is aware and interested in purchasing the new vehicles. HCCI in particular even has a market outside of the automobile industry; it could appeal to manufacturing plants that are looking to upgrade machines, or anyone who is looking to improve on a process that is powered by some kind of engine.

HCCI (Homogeneous Charge Compression Ignition)

HCCI is the most well known engine prototype and the furthest along its development. The engine is powered by a fuel mixture that ignites automatically under the right conditions without a spark, just like a diesel engine (Song 2007). This ignition style is significantly more efficient than the spark ignition style of a gasoline engine. This design is a significant improvement upon traditional diesel engines because the emissions are cleaner. Since this process is cleaner the expensive exhaust components that are currently required on diesels can be done away with, making it more affordable for consumers (Lerner 2011).Another advantage is HCCI's versatility .Salvador M. Aceves, Daniel L. Flowers, Joel Martinez-Frias, and Francisco Espinosa-Loza of Lawrence Livermore National Laboratory, alongside Robert Dibble of University of California Berkeley, performed research regarding HCCI and reported that, "HCCI is potentially applicable to both automotive and heavy truck engines. In fact, it could be scaled to virtually every size-class of transportation engines from small motorcycle to large ship engines."(Aceves et al. 2008). Since this engine has such a wide range of potential uses, it could improve upon every aspect of the automobile industry, not just the midsize sedan and coupe.

Various studies have achieved a variety of results regarding how much more efficient HCCI is than regular engines, but, “according to GM, an HCCI engine, when combined with other advanced technologies, provides up to 15 percent greater fuel economy than a comparable, non-HCCI engine” (Roy 2011). The majority of studies have similar results, with variation being caused by certain factors such as the compression of the engine and different fuel types.

HCCI does have limitations that are currently being faced by researchers. At UCLA Berkley researchers performed a study on “the most important problems associated with HCCI engine operation: control, startability, emissions of hydrocarbon and carbon monoxide, power density, and transition to other modes of operation” (Aceves et al. 2008). Since HCCI is powered by fuel mixture that auto ignites, it is difficult for engineers to find a way to allow the engine to respond to abrupt actions from a driver, such as slamming the gas pedal. Other engineers, such as Lund University researcher Thomas Johansson, have begun to propose ways of solving these weaknesses. Johannson’s research shows that by placing a turbocharger onto an HCCI, the power density issue can be minimized and practically fixed (Johansson et al.2009).

RCCI (Reactivity Controlled Compression Ignition)

RCCI is the second most well-known engine design of the future led by engineer Rolf Reitz. Kami Buchholz is a writer for SAE who follows Reitz and his work on RCCI. In an article about Reitz Buchholz describes Reitz’s various accolades such as “22 years of his more than 30 years in engine research at the U of W-Madison. His resume also includes six years at the General Motors Research Lab in Warren, MI, and a stint as ERC director” (Buchholz 2011). Reitz and his team have designed RCCI to operate almost identically to that of HCCI, by mixing gasoline and fuel in order to have an engine that will ignite without any spark or flame. The separating factor of RCCI is its potential to run off of various fuel sources. Reitz and the rest of the Engine Research Center are "engaged with research projects on the use of alternative fuels, including bio-fuels, ethanol, and natural gas, he said." (Buchholz 2011). The ethanol and diesel mixture is the short term solution to efficiency needs, while bio-fuels and other fuels are what Reitz hopes to be the solution to efficiency and emissions needs in the automotive industry for decades to come.

RCCI's data is similar to that of HCCI, reported as ">15% improved diesel engine fuel efficiency (lower CO2) + meet emission mandates in-cylinder" (Reitz 2011). RCCI is very similar to that of HCCI in the aspect of overall function, with differences coming mainly in the way that RCCI is built to run off of multiple fuel types. The weaknesses of RCCI are not as prominent as those of HCCI, due to the fact that it is not as far along in the engineering process.

MSCI (Multizone Stratified Compression Ignition)

MSCI is the most recent of the gasoline-diesel engines. This project is headed by Steve Ciatta at the Argonne Laboratory in Illinois, which is associated directly with the U.S. Department of Energy (Lerner 2011). Information on MSCI is limited because it is still in the early stages of design. Even though it is not far along developmentally, it is drawing significant attention from major car companies and even *Mechanical Engineering Magazine* (Ciatta 2012). Majority of the information that the public has on MSCI comes firsthand from what Steve Ciatta and other personnel who are closely involved in the process. This engine design operates in a way that is similar to HCCI as well, but strives to improve upon HCCI. Engineers behind the project have created this system to “operate at higher compression ratios than other low-temperate combustion engines” (Ciatta 2012).This engine is designed to “inject fuel two or three times during each compression cycle, starting early in the stroke” (Ciatta 2012). The fuel mixture is inserted into the engine frequently so that a stable fuel is created that can be controlled more easily, and this stable fuel mixture requires higher compressions in order to ignite (Ciatta 2012). This is the factor that gives MSCI a great deal of potential to be an improvement upon HCCI engines.

MSCI appears to have the greatest increase in efficiency. Steve Ciatta, the head mechanical engineer reported, “our work to date shows near-zero particulate matter emissions and 66 to 80 percent reductions in NOx compared with conventional diesels” (Ciatta 2012). These numbers are impressive, but just like HCCI, MSCI has a challenge involved with power. Ciatta describes these limitations in the same report when he says, “when we use exhaust gas to lower combustion temperatures, we reduce the violence of our combustion reactions. As a result, peak power drops roughly 25 percent” (Ciatta 2012). MSCI has not progressed as far as HCCI in the creation phase, so it is possible for more issues to arise.

Future of Gasoline Diesel Hybrids

Each engine design has the potential to be an innovation that shapes the future of automobiles. HCCI, RCCI, and MSCI each have unique advantages that could improve upon current automobiles. HCCI is the leading innovator, currently being tested in various prototypes (Roy 2009). It excels in being versatile and could improve upon other areas than automobiles as well. RCCI is being designed in a way that will allow it to burn various fuels, opening the door to alternative energy types for the future. MSCI improves upon efficiency more than both HCCI and RCCI, without making any sacrifices, such as cost or clean emissions. Each system would be a significant improvement to efficiency and a crucial step in the right direction.

Return of the Revolution

The automobile industry is only one contributor in the current and unprecedented technological revolution. New technologies such as smart phones, computers, and wireless routers have connected the world in a way unlike ever before, and this connectivity has the potential to be the heartbeat of another Industrial Revolution. Author and Editor Chris Anderson shares a similar view regarding the coming of an industrial resurgence (Anderson 2012). In a 2012 presentation he explains his ideas that this revitalization will occur due to the effects of social media and source sharing (Anderson 2012). These may be the driving forces behind motivating consumers, which in turn will create the jobs needed to stimulate the current economy; however these three engines could be the backbone of a recovering economy. These gasoline-diesel hybrid engines are also being driven through development by the recent passing of new Corporate Average Fuel Economy (CAFE) standards.

Obama Administration and CAFE

The new fuel economy standards state that new cars must be able to achieve 54.5 miles per gallon of gasoline on average. This number is likely unrealistic, even for the much improved gasoline-diesels. All hope is not lost, however, because the CAFÉ required 54.5 mpg is not the same miles per gallon that consumers are accustomed to. Forbes writer Micheline Maynard reports that, “the numbers obscure the fact that your 2025 car probably won’t get anything like 54.5 mpg (unless you own a hybrid or an electric vehicle). Your average will probably be more like 40 mpg” (Maynard 2012). This 40 mile per gallon goal is well within the reach for HCCI, RCCI, and especially MSCI. Later in the article, Maynard describes why this discrepancy exists, stating that the unrealistically high numbers are a direct result of not taking realistic driving conditions into consideration (Maynard 2012). This misleading statistic has resulted in a significant amount of disapproval from the general public towards the Obama Administration and the new fuel standards.

Regardless of the difficulty of achieving these new standards, it is undisputable that the new regulations are a job creator. A report released by the National Resource Defence Council reports that “By 2020, the U.S. job gain relative to 2008 could be as little as 49,000 or more than 150,000” (Baum and Luria 2010). This is quite a large range of possible jobs being created, but the results of the last two years have been encouraging, not to mention that these stats do not take the government’s new regulations for 2025 into consideration.

Effects Outside of the Automobile Industry

The success of Gasoline-diesel engines will be mostly on the consumer sales of the mass produced vehicles, but there are two additional areas where the impact may be even greater: Manufacturing and large trucks. Manufacturing jobs will be created in order to produce the new vehicles and their accompanying upgrade and replacement parts. This rise in manufacturing could have an effect similar to that of the Industrial Revolution in the late 18th century, not necessarily in the paradigm shifting advancements, but in the way that the focus will turn to new manufacturing jobs and especially a rise of the middle class.

Manufacturing Revolution

Manufacturing will see a rise due to the demand for production of these engiens, and as the car industry recovers the lost jobs will return. Manufacturing will also benefit from the improvement of efficiency during the manufacturing process. Specifically, manufacturing and industry related jobs will benefit from gasoline-diesel hybrids because the engines needed to operate heavy machinery can also be improved upon with these three engines, in particular, HCCI, which was designed with versatility in mind. If companies are able to save expense by using more efficient machinery then it will contribute to the companies success and potential growth which would lead to more job creation.

This rise of the middle class due to manufacturing jobs lines up perfectly with the economic policies and plans of the current president, Barrack Obama. His economic policies are based around strengthening the middle class, and creating equal opportunities. This is exactly what happened during the Industrial revolution, which was characterized by the steam engine and other mechanical advancements (Wyatt 2009). These three engines, along with the jobs that will accompany them, are being developed at the opportune time with the connection of the world through social media and the government making efforts to re-establish the strong middle class that has been the backbone of America for the past several decades.

There is one requirement that will be an important factor in this possibility for a revolution and that is skilled workers. All of the jobs that will be created by manufacturing will require a skilled employee in order to maximize efficiency. Mark Crawford, a writer for Area Development Online, reports in a recent article that, "Although advanced manufacturing is ready to surge ahead, it needs 600,000 qualified workers to do so" (Crawford 2012). He continues mention how this is an issue because the jobs that are opening are struggling to find qualified employees (Crawford 2012). This is another problem that has a constructive solution, it opens up a fairly reliable job market for students who are looking to enter into specialized schooling and training after high school; it also creates a way for adults to go back to school to either find a job or to advance to a more satisfying career choice.

Effect on the Trucking Industry

The trucking industry could benefit the most from these new engines and is a potential good starting position for the implementation of these gasoline-diesel hybrids (US Department of Energy 2001). Tractor trailers are notorious for harmful emissions and poor fuel economy, but these new engines will improve upon trucking more than ever before. The fuel efficiency increase of these new engines will save the tractor trailer drivers a significant amount of money on gas prices, emissions regulation equipment, and inspection fees. This cost effective solution to the trucking industry could potentially lower the cost of shipping for businesses and people, which is a small yet important step in a process towards economic recovery.

The issues with controlling the reactions in the combustion process are not as big of a factor for large trucks because the majority of the time the engine will operate at constant conditions along the highway. Since the new hybrids operate without the violent spark combustions of a traditional gasoline engine and don't require the expensive exhaust components of a traditional diesel, then an engine designed for a large truck will have great gas mileage, longevity due to the controlled, non violent reactions that control the engines, low initial cost because of the expense saved on expensive diesel exhaust components, and low cost of operation since the engines are currently being designed to run on low grade 65 octane gasoline (Hanley 2010). This 65 octane gas would be remarkably cheaper than the current gasoline which is 85 octane or higher. In the same article Thomas Wallner, a researcher at Argonne National Laboratory (the same laboratory that MSCI is being developed in) reveals that aside from passenger vehicles they are also working on, “ways to increase the efficiency of commercial diesel trucks, which are heavy users of diesel fuel, and there's the expectation that the work will result in a new truck sitting in Washington, D.C., in three to five years” (Hanley 2010). This article was released in 2010, so this deadline isn’t far away but all indicators suggest that this technology is on the brink of unveil anytime within the next couple of years. The benefits to the large trucking industry is obvious but one group of potential beneficiaries often goes unnoticed when talking about gasoline-diesel engines, the environmental conservationists.

The Green Movement

It is easy to only look at government regulations on car emissions standards as a money trap that limits potentially useful systems, such as the diesel motor, but the reality is that they serve a good purpose. There is a vast community of car enthusiasts and environmental conservationists alike that have proven to be a reliable market for efficient and clean vehicles. Vehicles such as the Chevrolet Volt, Nissan Leaf, and Toyota Prius all have been established as popular cars because of their high standards for fuel economy and minimal pollution to the environment. If these new engines reach even higher standards without compromising their "green" qualities then the market needed to be successful already has a foundation to grow on.

The environmental conservation community can play a pivotal role in the success of the HCCI, RCCI, and MSCI. Majority of people practically unaware of these systems completely, while even those that are familiar can probably tell you little more than the basic concept of a gasoline-diesel hybrid. The community of green car enthusiasts have the ability to change this, if they became informed and interested in the innovative technology. This community has continued to grow with the increasing trend of environmental friendliness over the last several years, and endorsement from this community would go a long way in marketing HCCI, RCCI, and MSCI to the public.

The Bigger Picture

These new motors are only one factor in the bigger picture of restoration of America. The auto industry isn't the sole cause of the economic recession that occurred in 2008, but it was part of the perfect storm that left such a strong community of American car enthusiasts with little to be excited about. In the way that environmental conservation is trending, so too is the hope that the American auto industry will return to former glory, not only to stabilize and improve the economy, but also to unify domestic car enthusiasts once again. This technology is becoming rapidly available, now the next step is to get informed. Regardless of what kind of improvements are available, if majority of consumers are uninformed then it will be almost impossible for such an innovation to succeed. It is time for the people of the United States to respond; the opportunities are opening up and it's time to take action.

Conclusion

The issues that the United States faces with the economy, a weak middle class, machines that are harmful to the environment, and fragmented communities can all benefit from advancements in the realm of mechanical engineering, especially by engine developments such as HCCI, RCCI, and MSCI. The solution starts at the level of community and works it way and solving the more overwhelming issues of national debt and global friendliness. If these systems can provide hope for people, bringing back that pride in American made automobiles, then automobile companies will hopefully gain the confidence to invest more time and money into research and development for engines like HCCI, RCCI, and MSCI. This time and money will be used to develop an engine that not only will save the consumer money, but will also help protect the environment from harmful gaseous emission. This investment will create the multitude of jobs needed to support a strong middle class, which coincides perfectly with President Obama's plan to economic recovery. This is much easier said than done, and may very well be a stretch, but one thing is for certain; the road to recovery for this nation runs straight through Detroit, Michigan.

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