Оглавление

Вступление

Техническое предложение по испытаниям метода смешивания дизельного топлива № 2 с водой в различных пропорциях между дизельным топливом и водой.

Пропорции смешивания в идеальном варианте должны составить 50% воды на 50% дизельного топлива.

Испытания целесообразно проводить, начиная с 10% воды на 90% дизельного топлива, постепенно увеличивая количество воды шаг за шагом на 5%, соответственно уменьшая шаг за шагом количество дизельного топлива в смеси на 5%.

Для приготовления смеси дизельного топлива №2 с водой предполагается применять обычную водопроводную воду, без предварительной обработки или фильтрации. Подобная практика была испытана в Ливонии (Детройт) при общей минерализации воды не выше 200 миллиграмм на литр.

Ввиду наличия у нашей компании соответствующих базовых технических решений, на последующих стадиях испытаний предлагается применять ту же водопроводную воду, у которой в электрохимическом реакторе (изобретение нашей компании) будет увеличен уровень щёлочности до 11 единиц.

Учитывая важность именно проверки качества горения полученной смеси дизельного топлива и воды, а также анализа уровня загрязнения выхлопных газов окислами азота и сажей, предлагаем испытания полученной при смешивании эмульсии начать с испытаний при применении этой эмульсии в бойлере (с рабочими характеристиками, указанными в ответах на наши вопросы).

Наша компания располагает устройствами для комплексного смешивания и активирования топливных смесей с рабочим диаметром 25 миллиметров, с производительностью:

- максимальная 7.5 галлонов в час
- минимальная 2.5 галлонов в час

Для обеспечения намного меньших уровней производительности, требуемых предложенным для испытаний бойлером, специалисты нашей компании предлагают на имеющемся приспособлении применить систему отвода излишней эмульсии в дополнительный бак или ёмкость.

Для определения характера процесса и технологии и полученной эмульсии будет необходим тот же комплекс оборудования и приспособлений, включая и измерительные приборы и инструменты.

Очень важным является измерение температуры пламени при сгорании эмульсии, что обязательно необходимо предусмотреть.

В случае согласия с предложенным порядком проведения испытаний, наша компания предложит и согласует с вами протокол испытаний и детальный рабочий дизайн испытательного оборудования или испытательного стенда.

Общая характеристика эмульсий, которые могут быть получены при помощи устройства для динамического смешивания и гидродинамического активирования жидкостей в развитом турбулентном потоке

Характеристика эмульсий, которые могут быть получены при помощи устройства для динамического смешивания и гидродинамического активирования жидкостей в развитом турбулентном потоке

Эмульсии могут быть получены в динамически активном потоке одной из жидкостей, входящих в эмульсию. Для изготовления эмульсии нет необходимости применять технологические ёмкости, устройство для приготовления эмульсии является частью трубопровода.

Для приготовления эмульсии нет необходимости применять высокое и сверхвысокое давление, а также нет необходимости в применении ультразвуковых технологий.

Время приготовления эмульсии не превышает долей секунды. Параметры эмульсии, в том числе и размеры частиц её компонентов определяются геометрией соответствующих секций и деталей устройства для динамического активирования жидкостей в развитом турбулентном потоке.

Процесс приготовления эмульсии происходит в одно и то же время с гомогенизацией не только по размерам частиц компонентов эмульсии, но и по уровню турбулентности потока.

Общие свойства эмульсий, в которых содержание органических компонентов превышает содержание неорганических компонентов и которые получены при помощи устройства для динамического активирования жидкостей в развитом турбулентном потоке:

1. Общие свойства эмульсий, в которых содержание органических компонентов меньше, чем содержание неорганических компонентов, и которые получены при помощи устройства для динамического активирования жидкостей в развитом турбулентном потоке
2. Общие свойства эмульсий, в которых содержание органических и биологических компонентов превышает содержание неорганических компонентов, и которые получены при помощи устройства для динамического активирования жидкостей в развитом турбулентном потоке
3. Общие свойства эмульсий, в которых содержание органических и

биологических компонентов меньше, чем содержание неорганических компонентов, и которые получены при помощи устройства для динамического активирования жидкостей в развитом турбулентном потоке.

Рисунок 1. Пример автомобиля, в котором можно использовать описанную технологию

Новая версия технологии приготовления эмульсий вообще и топливных эмульсий в частности

Основное отличие предлагаемой версии получения эмульсии заключается в том, что:

– эмульсия формируется в устройстве для динамического смешивания и активирования жидкостей и газов, в динамичном потоке 60 % одного из компонентов эмульсии в который также в виде динамического потока, вводятся 40% этого же компонента эмульсии и после этого в место соединения 60 и 40 процентов одного из компонентов эмульсии вводится второй компонент эмульсии, также в виде динамического потока;

– потоки 60 и 40 процентов одного из компонентов эмульсии являются коаксиальными и соосными в трёхмерном пространстве, в котором эти фрагменты потоков движутся;

– при этом линейные скорости движения потока из 40% одного из компонентов эмульсии как минимум в 4 раза превышают линейные скорости потока из 60% этого же компонента эмульсии;

– физические условия в месте соединения этих потоков, включая концентрические эффекты Бернулли в каждом из потоков обеспечивают гомогенизацию турбулентности объединённого потока (турбулентную гомогенизацию);

– динамический поток второго компонента эмульсии вводится в зону, в которой осуществлена турбулентная гомогенизация;

– интегрированный поток полученной эмульсии приобретает состояние гомогенизации уровня турбулентности по всему объёму интегрированного потока во всех точках сечения этого потока;

– время этого процесса формирования гомогенизированной по уровню турбулентности эмульсии по расчётам составляет не более 0.1 секунды;

– выход из устройства для динамического смешивания и активирования жидкостей и газов в интегрированном (изобретённом) устройстве напрямую соединён с входом в стандартный насос высокого давления (применяемый на любом современном двигателе внутреннего сгорания как дизельном, так и бензиновом);

– интервал времени, необходимого для перехода первичной эмульсии с гомогенизированным уровнем турбулентности в рабочие цилиндры насоса высокого давления не превышает по расчётам также 0.1 секунды;

– в насосе высокого давления эмульсия с гомогенизированным уровнем турбулентности сжимается до давления более 2000 бар, что позволяет предположить, что, следуя определению нано – эмульсии, при таком уровне сжатия происходит ещё один цикл гомогенизации эмульсии, возникающей при её сжатии в замкнутом объёме, что может квалифицироваться как процесс получения нано эмульсии со всеми свойствами и преимуществами нано эмульсии;

– ввиду того, что от момента возникновения гомогенизации по уровню турбулентности до момента возникновения гомогенизации от сжатия проходит не более 0.2 секунды, с учётом инертности этих процессов в потоке жидкости, можно считать процесс полной гомогенизации полностью однородным;

– указанный интегральный процесс формирования двойной и трёхмерной гомогенизации в непрерываемом динамическом однородно турбулентном потоке смешиваемых в эмульсию жидкостей таким образом можно считать последовательным процессом гомогенизации эмульсии и её переходом в конце процесса в категорию нано эмульсий;

По этому методу нами была в потоке сформирована эмульсия из дизельного топлива и водопроводной воды, которая при сжигании в камере сгорания дизельного двигателя показала необычные показатели, не встречающиеся в публикациях, и не отмеченные в опубликованных результатах научных экспериментов и исследований. Это позволяет предположить, что была получена именно наноэмульсия, что косвенно подтверждается и при анализе фотографий эмульсии под микроскопом.

Интегрированное устройство, состоящее из системы смешивания и гомогенизации уровня турбулентности эмульсии, связанной напрямую с насосом высокого давления как объектом размерной геометрической гомогенизации эмульсии под давлением, за предельно малое время между этапами гомогенизации, при максимальной однородности распределения частиц одного компонента эмульсии в объёме гомогенизированного по уровню турбулентности второго компонента эмульсии, позволяет квалифицировать последовательный процесс формирования эмульсии как новый и позволяющий получить двойную гомогенизацию эмульсии с переходом этой эмульсии в категорию наноэмульсий, но с новыми критериями однородности как по геометрии, так и по уровню турбулентности.

Эти факты говорят о том, что описанный процесс и интегральное устройство для его реализации являются новыми и не очевидными для любого средней квалификации специалиста в этой области.

Что изобретено:

– новый вид наноэмульсии с двойной трёхмерной гомогенизацией в динамическом потоке как по уровню турбулентности, так и по геометрии частиц в её объёме;

– новый вид и конфигурация аппарата для последовательной гомогенизации в развитом динамическом потоке жидкостей – компонентов эмульсии.

Рисунок 2. Пример автомобиля, в котором можно использовать описанную технологию

Эмульсии

Эмульсии, в которых компоненты органического происхождения смешаны с водой. В этих эмульсиях компоненты органического происхождения введены в воду. Компонентами органического происхождения могут быть углеводородные жидкости, жидкости, содержащие высокие концентрации жиров, масла, ароматических углеводородов и т. д.

В эмульсиях этого типа содержание органических компонентов в воде не превышает 50% от веса всей эмульсии, но в большинстве случаев это 10 – 20 % от веса всей эмульсии.

Наиболее важные параметры таких эмульсий:

– размеры частиц или капель жидкости органического происхождения в воде;

– равномерность распределения частиц органического происхождения в воде;

– устойчивость размеров частиц или капель жидкости органического происхождения, повторяемость этих размеров и период времени, в течении которого сохраняется равномерность распределения этих частиц в объёме воды.

Испытания эмульсий этого типа могут иметь непосредственный характер измерений, при котором эмульсии формируются на Устройстве для формирования эмульсий, и полученная эмульсия исследуется на предмет измерения:

– размеров частиц или капель жидкого компонента органического происхождения в воде;

– равномерности и однородности распределения частиц органического происхождения в воде;

– длительности периода устойчивости размеров частиц или капель жидкости органического происхождения, сохранение геометрической повторяемости этих размеров за определённый период времени, и, период времени, в течении которого сохраняется равномерность распределения этих частиц в объёме воды.

Эмульсии и их отличия в зависимости от размерных факторов

Размеры частиц жидких компонентов эмульсий определяют основные свойства и характеристики эмульсий. Чем меньше размеры частиц, тем выше качество эмульсии. Производство эмульсий по технологии и на устройстве для динамического смешивания, гомогенизации и активирования, позволяет получить минимальные значения размеров частиц. Этот параметр является основным при квалификации эмульсии как миниэмульсия, как микроэмульсия и как нано эмульсия.

При первых испытаниях процесса приготовления эмульсии на устройстве для динамического смешивания, гомогенизации и активирования были получены признаки многоуровневого расположения капсул и автономных частиц компонентов. Этот фактор требует более подробной и детальной проверки при последующих испытаниях.

Эмульсии и их отличия в зависимости от факторов равномерности распределения частиц дополнительного (не доминирующего компонента) в объёме доминирующего компонента.

Эмульсии и их различия в зависимости от метода гомогенизации

В классических технологиях приготовления эмульсий для гомогенизации применяются различные химические реагенты. При применении для приготовления эмульсии устройства для динамического смешивания, гомогенизации и активирования оба этапа гомогенизации осуществляются только за счёт геометрии устройства без каких-либо химических реагентов, при улучшении основных свойств и качества эмульсии.

Эмульсии и их отличия в зависимости от последовательных шагов гомогенизации

В эмульсиях классического типа отсутствует гомогенизация по уровню турбулентности.

В устройстве для динамического смешивания, гомогенизации и активирования как исключительное свойство и преимущество имеется возможность в процессе приготовления эмульсии заодно и осуществить гомогенизацию по уровню турбулентности.

Причины важности гомогенизации по уровню турбулентности

Одним из важнейших свойств в рабочем цикле устройства для динамического смешивания, гомогенизации и активирования является возможность создать в зоне формирования эмульсии однородного фона по турбулентности по всему поперечному сечению потоков компонентов эмульсии.

Кроме того, что однородный фон турбулентности формирует однородный размерный фон частиц, одинаковые гидродинамические условия в зоне приготовления эмульсии позволяют снизить время необходимое для полного приготовления эмульсии, что очень важно при формировании эмульсии в динамическом потоке её компонентов.

Причины важности гомогенизации при помощи высокого давления

Возможность последовательной работы устройства для динамического смешивания, гомогенизации и активирования с насосом высокого давления позволяет создать исключительные равномерные условия для гомогенизации под воздействием высокого давления, так как в насос высокого давления поступает эмульсия с однородным фоном турбулентности по всему объёму.

Важность минимизации временной паузы между последовательными циклами гомогенизации

Временная пауза между процессом гомогенизации турбулентности и гомогенизации под давлением, благодаря свойствам устройства для динамического смешивания, гомогенизации и активирования, составляет не более 10 миллисекунд

Такой малый временной интервал позволяет считать последовательный процесс гомогенизации непрерывным и обеспечивает стабильность и качество процесса двойной гомогенизации.

Важность мультипликации скорости движения или давления в потоке между последовательными циклами гомогенизации

Как показали первые испытания устройства для динамического смешивания, гомогенизации и активирования при формировании эмульсии, ввод в канал, по которому эмульсия выводится из устройства для динамического смешивания, гомогенизации и активирования, стимулятора гидравлического сопротивления, позволяет интенсифицировать процесс приготовления эмульсии.

Технико-экономическое обоснование концепций тестирования

Новое изобретение: Интегрированная система для получения нанотопливной эмульсии из бензина и этанола на автозаправочной станции.

На рисунке 3 представлен концептуальный вариант использования системы производства топливной наноэмульсии на: автозаправочной станции или заводе по производству топлива.

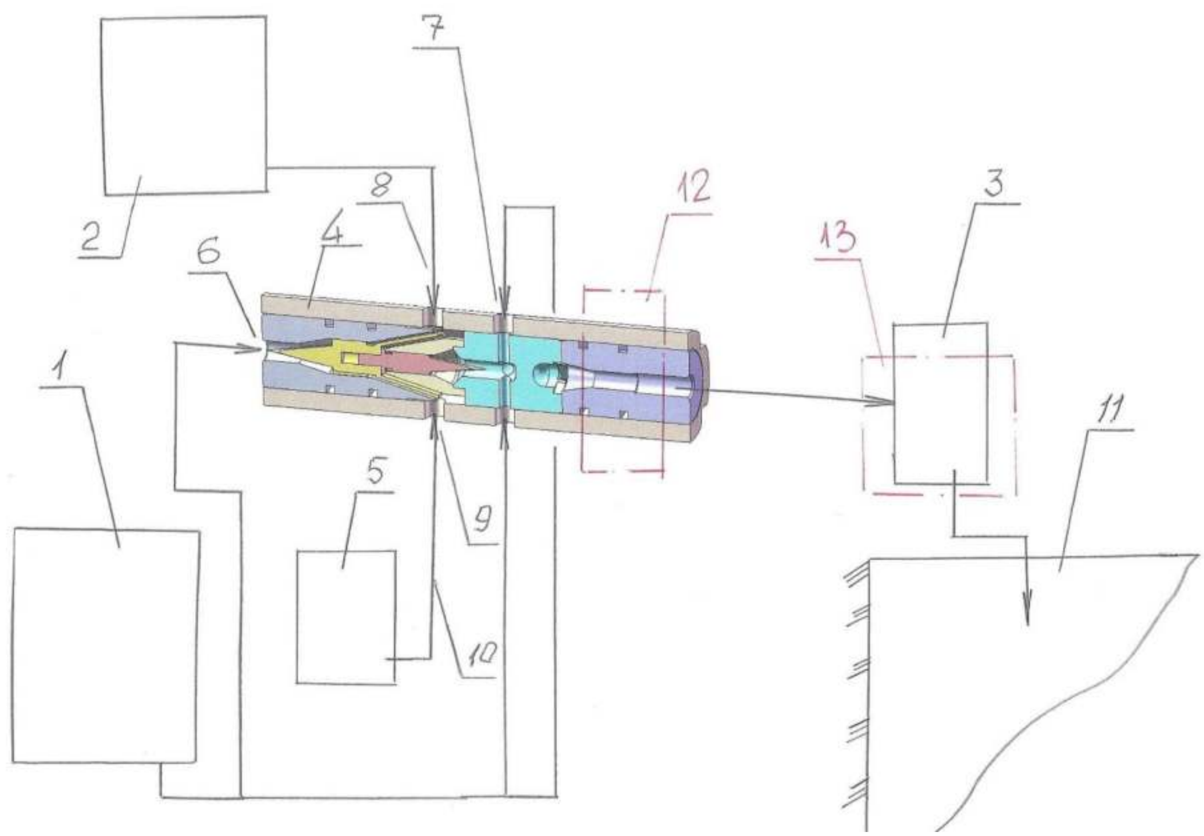


Рисунок 3. Концептуальный вариант использования системы производства топливной наноэмульсии

1 – бак для бензина или дизельного топлива

2 – резервуар для этанола (или метанола с водой, или этанола с водой)

3 – насос высокого давления (от обычного дизельного двигателя)

Устройство для смешивания и активации топлива 4 – TEI (текущий прототип, диаметр 25 мм)

5 – дополнительно, - резервуар для воды

6 – основной ввод бензина или дизельного топлива в устройство для смешивания и активации топлива

7 – вторая группа (4) входов для устройства смешивания и активации топлива

8 – ввод этанола (или метанола, или смеси этанол-метанол с водой, или воды)

9 – опция ввода воды

10 – водопровод (опционально)

11 – заправочный бак для бензина/дизельного топлива со смесью этанола (метанола или воды)

12 – первая стадия гомогенизации топливной смеси, - гомогенизация на турбулентном уровне (новая операция)

13 – вторая стадия гомогенизации топливной смеси (микроэмульсии) под высоким давлением и получения наноэмульсии (новая операция)

Преимущества технологии:

– результат работы – нанотопливная эмульсия, которая имеет более высокое октановое число, низкий уровень детонации, низкие выбросы и расчетную экономию топлива

– простое и не дорогое оборудование для осуществления операции

– оборудование может быть адаптировано к существующим заправочным станциям или оборудованию производственного предприятия без каких-либо модификаций существующего оборудования

– для производства наноэмульсии не требуется эксплуатационный бак, - все операции производятся в динамических условиях потока топлива в трубе

Конфигурация в соответствии с рисункм 1 может быть использована в качестве технико-экономического обоснования и демонстрационной тестовой установки.

Рисунок 4 демонстрирует второй вариант изобретения с подачей наноэмульсии непосредственно в бак автомобиля (на обычной заправочной станции) или в горелку котла.

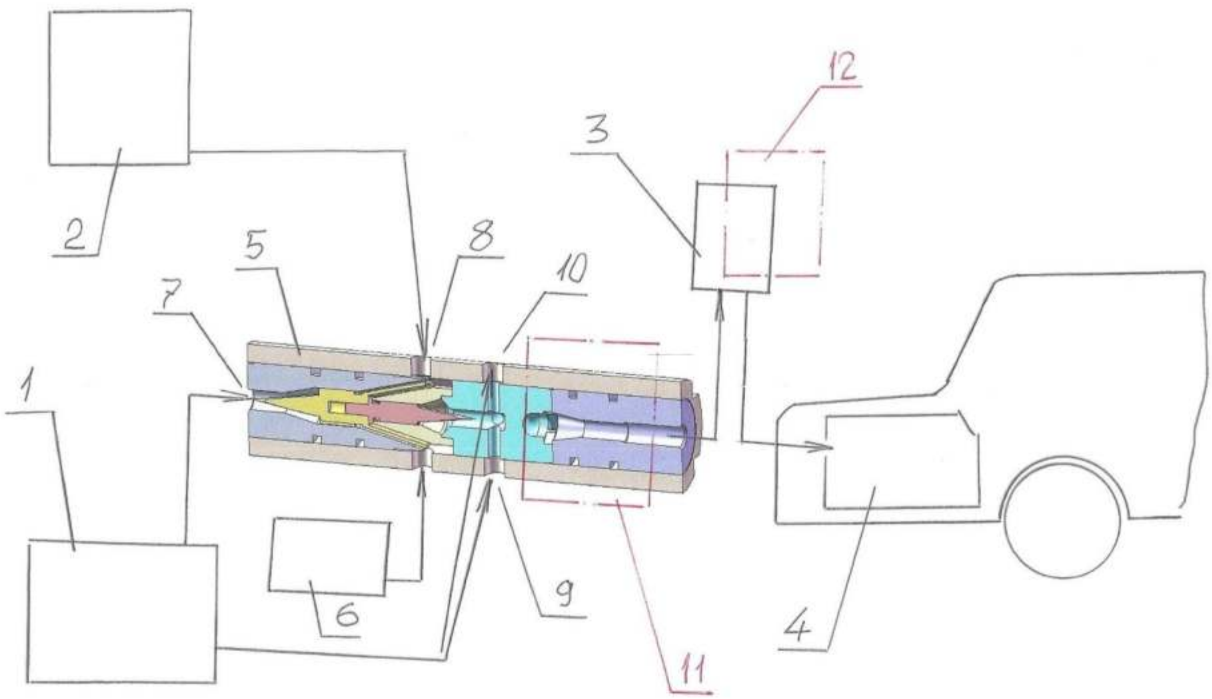


Рисунок 4. Вариант изобретения с подачей наноэмульсии непосредственно в бак автомобиля

1 – бак для бензина или дизельного топлива;

2 – резервуар для этанола;

3 – насос высокого давления (обычный насос высокого давления дизельного двигателя);

4 – топливный бак автомобиля;

5 – устройство для смешивания и активации топлива;

6 (опционально) – резервуар для воды;

7 – основной ввод бензина или дизельного топлива;

8 – ввод этанола;

9, 10 – вторая группа вводов бензина или дизельного топлива (4);

11 – первая стадия гомогенизации турбулентности (новая);

12 – вторая стадия наногогенизации под высоким давлением (новая)

Дополнительная опция для ретрорынка продемонстрированная на рисунке 5.

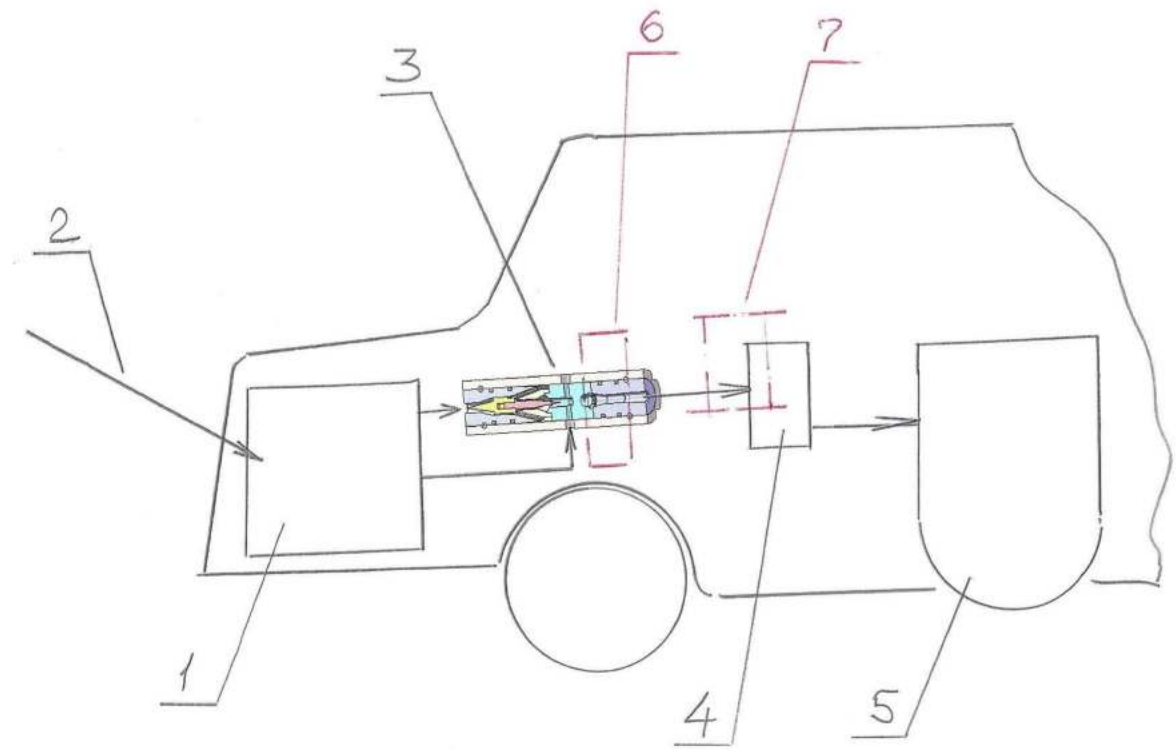


Рисунок 5. Дополнительная опция

1 – топливный бак автомобиля (обычный без каких-либо модификаций);

2 – ввод наноэмульсии бензина или дизельного топлива с автозаправочной станции;

3 – устройство активации подачи топлива с входами только для наноэмульсии из топливного бака автомобиля (давление ~ 45 фунтов на квадратный дюйм;

4 – насос высокого давления автомобиля;

5 – бензиновый или дизельный двигатель автомобиля;

6 – первая дополнительная стадия гомогенизации наноэмульсии (только гомогенизация без перемешивания);

7 – секундная дополнительная стадия гомогенизации наноэмульсии обычным насосом высокого давления двигателя перед впрыском

Результаты первичных испытаний системы

Emulsion/Blend Combustion (Objective #2)

Data was collected from the test cell and combustion analysis system while running the engine at the pre-determined speed and load/timings (see table below). The test points for the baseline data and with the emulsions were selected such that there was sufficient room to adjust the fuel pulse width to account for the additional content of water (when water was used in the emulsions/blends) without reaching the maximum output of the fuel injectors and high-pressure pump. Although the engine used in the testing has on-highway applications, an off-road test cycle set of points were used in the testing as a suitable surrogate and method of reducing the number of speed/load points. The points below were chosen to emulate the most heavily weighted areas of the emissions test cycle for a small off road diesel engine.

RPM	BMEP	Injection timing °BTDC (Final Testing Timing)
2000	5 Bar	4, 8, 12, 14, 16 (8, 12)
2000	10 Bar	4, 8, 12, 14, 16 (8, 12)
2000	15 Bar	4, 8, 12, 14, 16 (8, 12)

Baseline Combustion Testing

No water or other fuel type was introduced for this part of the testing and the bypass fuel from the engine was returned to the dynamometer float bowl to simulate normal vehicle operation. The calibration used was the same one from previous engine testing with the exception of running main injection only for fueling. The engine coolant temperature, oil temperature, inlet air temperature, fuel rail pressure, and intake manifold pressure were held at fixed values, which can be seen in the supplied data files. Next, a sweep of injection event timing was performed. For most of the points tested, the main injection timing was set to a minimum value of 4 ˚BTDC and was advanced in increments of 4 degrees until reaching a maximum of 12 ˚BTDC. Some of the points were increased in timing to 14 & 16 ˚BTDC to see if the additional timing showed further improvement. At each of these injection timing points, the commanded fuel value “throttle %”, as indicated in the dynamometer data, was modified to maintain a constant BMEP (normalized torque) value. Baseline data were recorded each day and at times multiple times during the day to ensure the engine was always operating within normal and expected parameters.

Emulsion Combustion Testing

At each speed and load point, the blend fuel and/or water was introduced to the system with percentages controlled with needle valves. The total flow of diesel was monitored with a Micro-motion flow meter to achieve the target flow supply for the FAD. The side inlet flow was monitored with a separate flow meter to calculate the 60/40 percentages being supplied to the FAD center/side inlets. Flow meters for the blend fuels or water were used to calculate the percentages for the mixtures. A set-up using a combination of 3-way and straight ball valves were used to be able to switch from the FAD and the float bowl fuel supply systems "on the fly" for more efficient testing. This allowed the baseline with No.2 diesel to be performed every day prior to any emulsion testing. When an emulsion was introduced, if the torque output of the engine decreased, then the commanded fuel value was increased to achieve the set BMEP value. This was done to ensure a valid comparison between the baseline and the various fuel mixtures. The injection timing sweeps were performed and the data was collected at each point. Each baseline and emulsion percentage point was performed like this, and afterwards the engine was run for a short period of time with No.2 diesel with the float bowl to flush the system. This also allowed a re-checked with 0% water and with the original base calibration to watch for any degradation in engine performance, or change in emissions values. Essentially, this also allowed for re-verification of the baseline data.

One issue that was encountered during testing with the emulsions was that the flow meter, which was intended to measure the excess FAD emulsion and engine return fuel, could not properly measure the flow into the waste collection barrel. With Diesel fuel only, the flow meter worked as designed, but with the emulsion fuel blends, the flow signal was erratic which resulted in variations in the overall calculated engine fuel flow. This, in turn, caused inaccurate BSFC calculations. A sight tube was installed after the waste flow meter and before the waste barrel to view the mixture coming out of the flow meter. It was found that the emulsion had variations of bubbles and was causing fluctuations in the flow meter readings. To correct this problem, a 10 gallon drum was placed on a scale and the waste fuel was diverted to it using a bypass solenoid operated valve. When taking a data point, the valve was switched to divert the waste flow to the drum/scale for mass measurement of fuel flow over time. Although the data is thought to be accurate, some degree of error may have been introduced due to the difference in measurement equipment between the baseline data and the emulsion testing.

The combustion testing went through three phases. The first phase was designed to be broad and cover all the various speed/load points shown above and multiple blend percentages. The objective in the first phase was to determine a smaller sampling of points for further testing and analysis. After running approximately 300 different tests in the first phase, 12 were selected for Phase 2. The results of Phase 1 are not specifically discussed in this report. During the second phase, more time was spent running the 12 select points and validating the results from Phase 1. In our view, the Phase 2 results (tests 1 – 4 summarized in the table below) were consistent with Phase 1 findings and Turbulent's FAD exhibited consistency in its operation and the resulting performance. The table below includes a summary of the Phase 2 results. The table provides a comparison of the test results versus a baseline. Positive percentages are an improvement and negative percentages are a reduction in performance. It should be noted that the results might not depict what could be achieved if the FAD were put through an optimization process. It is possible that the results might improve further if a calibration effort with the FAD was under taken. The combustion testing was also done with two different injector sizes. Both injector sizes delivered similar results. Phase 3 of the combustion testing is the subject of the "re-blending" tests discussed later in this report.

Table below is a summary of Phase 2 and 3 test results:

Test #	Blend Components	Variables/Results	5 Bar (~70lb/ft)	10 Bar (~140lb/ft)	15 Bar (~210lb/ft)
1	No. 2 Diesel / Methanol	Blend % Methanol	22.6%	22.3%	24.6%
		BSFC	-17.9%	-14.1%	-18.0%
		Net Cost Benefit/unit	-0.7%	3.0%	0.9%
		Nox (ppm)	1.6%	6.4%	15.5%
		Smoke (FSN)	85.7%	81.5%	35.1%
		Brake Thermal Efficiency	-3.9%	-0.8%	-2.8%
		THC	-230.0%	-2.8%	16.1%
		Injection Timing (BTDC)	12	8	8
2	No. 2 Diesel / Methanol / Water (Pre-Mix)	Blend % Methanol	18.9%	20.0%	19.6%
		BSFC	-17.1%	-13.4%	-13.8%
		Net Cost Benefit/unit	-2.7%	1.9%	1.2%
		Nox (ppm)	3.3%	27.8%	38.8%
		Smoke (FSN)	73.7%	62.5%	17.6%
		Brake Thermal Efficiency	-5.3%	-1.6%	-2.1%
		THC	-40.0%	8.5%	9.4%
		Injection Timing (BTDC)	12	12	12
3	No. 2 Diesel / Water	Blend % Water	20.1%	20.4%	19.7%
		BSFC	3.5%	0.6%	-0.4%
		Net Cost Benefit/unit	3.5%	0.6%	-0.4%
		Nox (ppm)	19.8%	25.6%	26.9%
		Smoke (FSN)	86.2%	87.9%	67.4%
		Brake Thermal Efficiency	3.6%	0.6%	-0.4%
		THC	3.9%	8.5%	0.0%

		Injection Timing (BTDC)	12	8	12
4	No. 2 Diesel / Ethanol	Blend % Ethanol	30.5%	40.4%	-
		BSFC	-19.5%	-19.3%	-
		Net Cost Benefit/unit	3.8%	11.5%	-
		Nox (ppm)	-7.7%	17.1%	-
		Smoke (FSN)	86.4%	86.7%	-
		Brake Thermal Efficiency	-6.2%	-2.1%	
		THC	-117.0%	-11.9%	-
		Injection Timing (BTDC)	12	12	-
5	No. 2 Diesel / Methanol (Re-blending w/o FAD - Same Day)	Blend % Methanol	-	20.0%	-
		BSFC	-	-12.9%	-
		Net Cost Benefit/unit	-	2.4%	-
		Nox (ppm)	-	7.8%	-
		Smoke (FSN)	-	66.7%	-
		Brake Thermal Efficiency		-1.1%	
		THC	-	0.0%	-
		Injection Timing (BTDC)	-	8	-
6	No. 2 Diesel / Methanol (Re-blending with FAD - Same Day)	Blend % Methanol	-	20.0%	-
		BSFC	-	-9.7%	-
		Net Cost Benefit/unit	-	5.6%	-
		Nox (ppm)	-	8.7%	-
		Smoke (FSN)	-	70.4%	-
		Brake Thermal Efficiency		1.8%	
		THC	-	-16.9%	-
		Injection Timing (BTDC)	-	8	-
7	No. 2 Diesel / Methanol (Re-blending w/o FAD - Next Day)	Blend % Methanol	-	20.0%	-
		BSFC	-	-10.1%	-
		Net Cost Benefit/unit	-	5.2%	-
		Nox (ppm)	-	7.8%	-
		Smoke (FSN)	-	73.1%	-
		Brake Thermal Efficiency		1.4%	
		THC	-	4.5%	-
		Injection Timing (BTDC)	-	8	-
8	No. 2 Diesel / Methanol (Re-	Blend % Methanol	-	20.0%	-
		BSFC	-	-11.9%	-

	blending with FAD - Next Day)	Net Cost Benefit/unit	-	3.4%	-
		Nox (ppm)	-	7.4%	-
		Smoke (FSN)	-	57.7%	-
		Brake Thermal Efficiency		-0.2%	
		THC	-	10.4%	-
		Injection Timing (BTDC)	-	8	-
Note: Assumes No. 2 Diesel Cost $1,900/MT, Methanol and Ethanol Cost $450/MT					

Engine Brake Thermal Efficiency

Brake Thermal Efficiency is the measure of how efficiently the engine utilizes the fuel energy for crankshaft power output. The methanol and ethanol fuel emulsions had slightly less brake thermal efficiency as compared to 100% diesel #2. After analyzing the combustion pressure data and noticing a delayed start of combustion, one might expect the efficiency to improve similar to baseline through an effort to optimize the engine calibration for the emulsion. The water emulsion was better, in most cases, than the 100% diesel. Water content was not included in engine fuel flow as it was not considered a fuel due to a lack of energy content. With the emulsion having a similar or same brake thermal efficiency as the baseline, it would tell us the emulsion did not adversely affect the combustion process and that these fuels could be utilized in a modern diesel engine in terms of not impacting the thermal efficiency.

Combustion Analysis

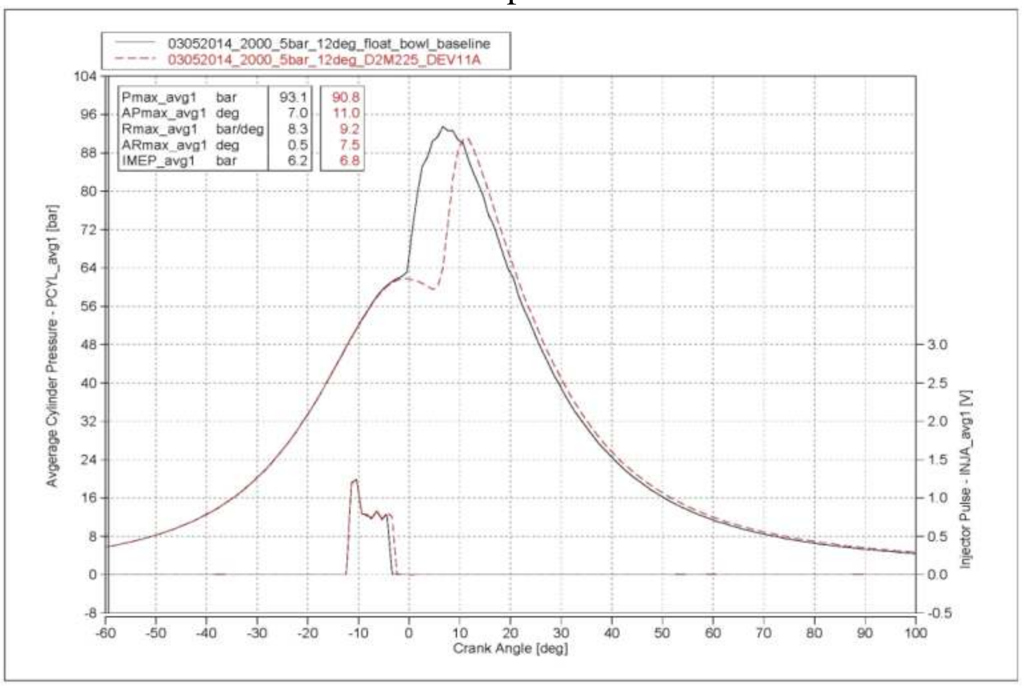
To understand the combustion process during the testing and to be able to compare the emulsion to baseline diesel combustion, the engine was fitted with in-cylinder pressure sensors located in the glow plug ports of cylinder #1 and cylinder #4. High speed cylinder pressure data was recorded vs. engine crank angle for all test points performed. Cylinder #1 data was used for the analysis. The following analysis will look at the test points with diesel #2 and methanol. Graphs for the other fuel blends are available in the Appendix.

Diesel #2 and Methanol 2000 rpm and 5 bar BMEP

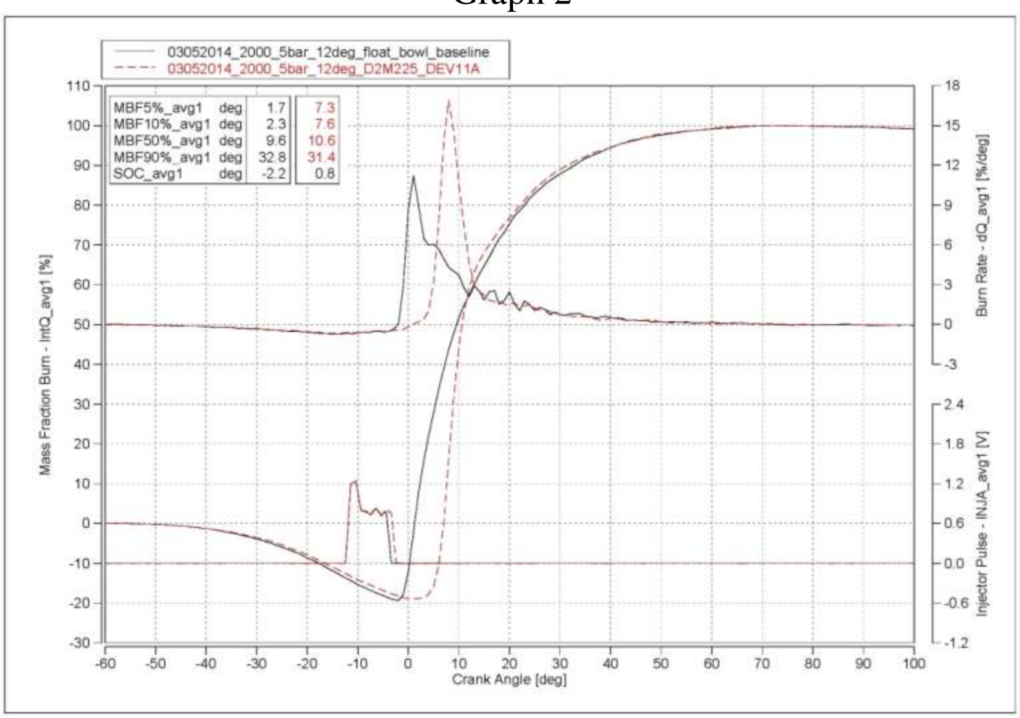
Graph 1 depicts a comparison of the average of 300 cycles of cylinder pressure during the compression and combustion events taken while running the engine at 2000 rpm and 5 bar BMEP and with 100% diesel (baseline) and 22.5% Methanol. Both were run with the same start of injection as shown in the injector firing trace. The pressure plot shows a delayed start of combustion for the methanol blend.

Graph 2 depicts a comparison of the burn characteristics of the baseline and 22.5% methanol blend for the same data test points. This graph also shows the delay in start of combustion for the same start of fuel injection. Of significant note is the faster burn rate for the methanol blend once combustion was initiated. 90% of the combustion completed 1.4 degrees sooner than the baseline even though the 5% mass fraction burn was delayed by 5.6 degrees. The 22.5% methanol blend had ~50% increase in maximum burn rate when compared to the baseline.

Graph 1



Graph 2

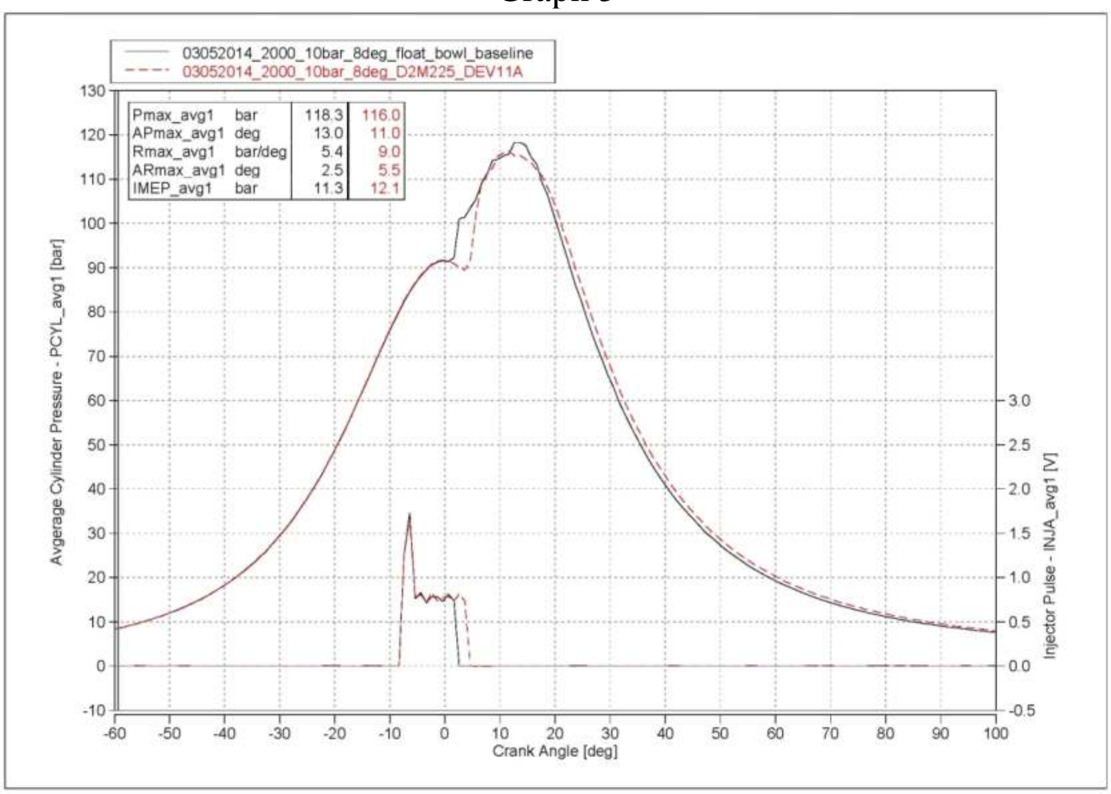


Diesel #2 and Methanol 2000 rpm and 10 bar BMEP

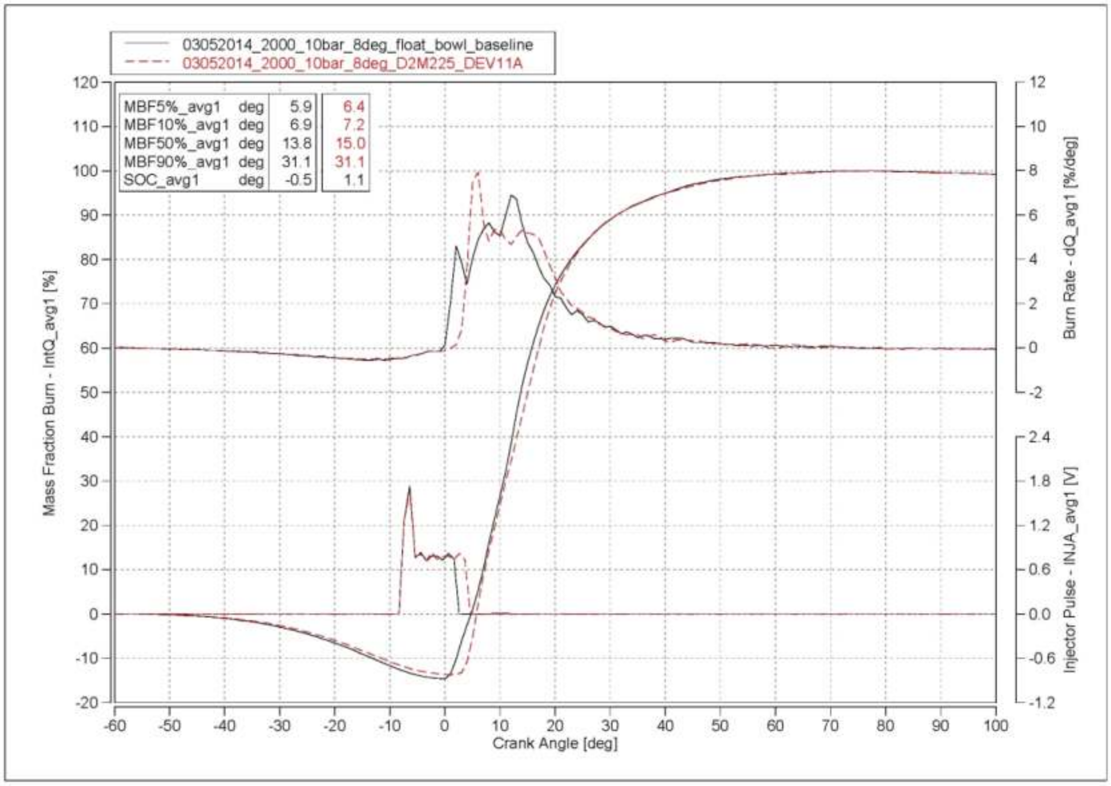
Graph 3 depicts a comparison of the average of 300 cycles of cylinder pressure during the compression and combustion events taken while running the engine at 2000 rpm and 10 bar BMEP and with 100% diesel (baseline) and 22.5% Methanol. Both were run with the same start of injection as shown in the injector firing trace. The delayed start of combustion exists at this engine load as well but not as much of a delay as the 5 bar BMEP point.

Graph 4 depicts a comparison of the burn characteristics of the baseline and 22.5% methanol blend for the same data test points. This graph also shows the delay in start of combustion for the same start of fuel injection. There is a faster burn rate for the methanol blend immediately after combustion was initiated but the rate becomes similar to the baseline. 90% of the combustion completed at the same time as the baseline even though the start of combustion was delayed by 1.6 degrees. The 22.5% methanol blend had ~15% increase in maximum burn rate when compared to the baseline.

Graph 3



Graph 4

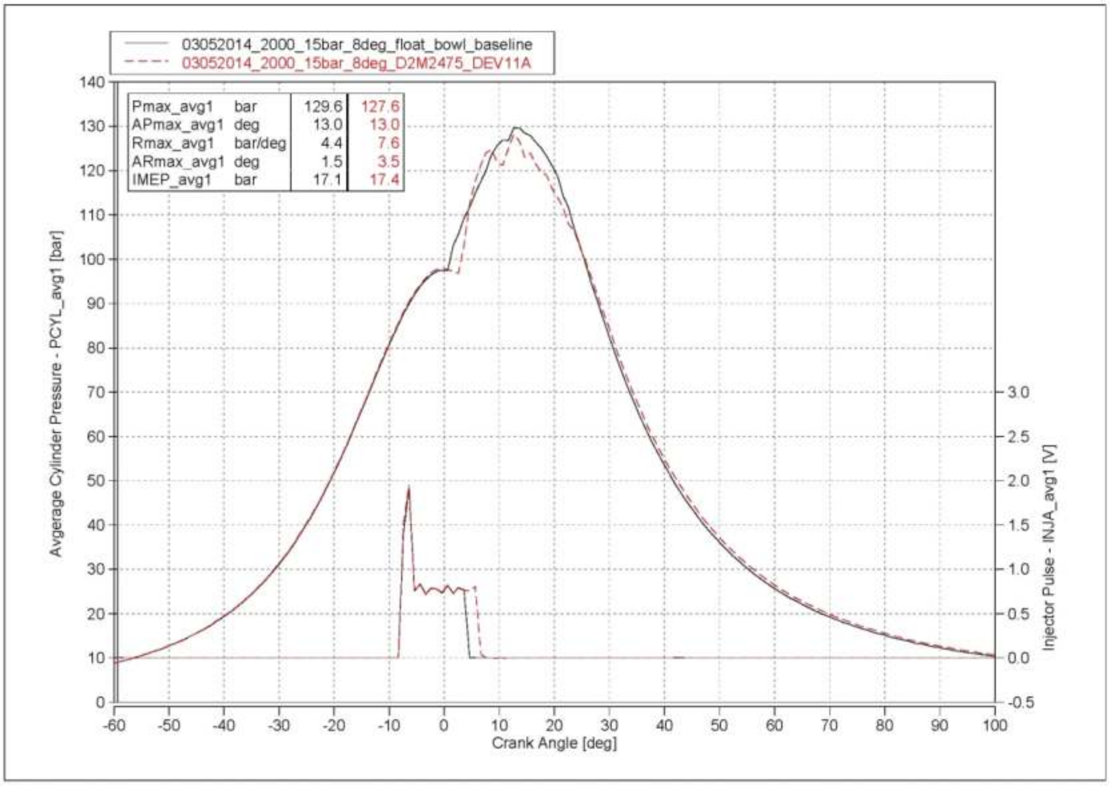


<u>Diesel #2 and Methanol 2000 rpm and 15 bar BMEP</u>

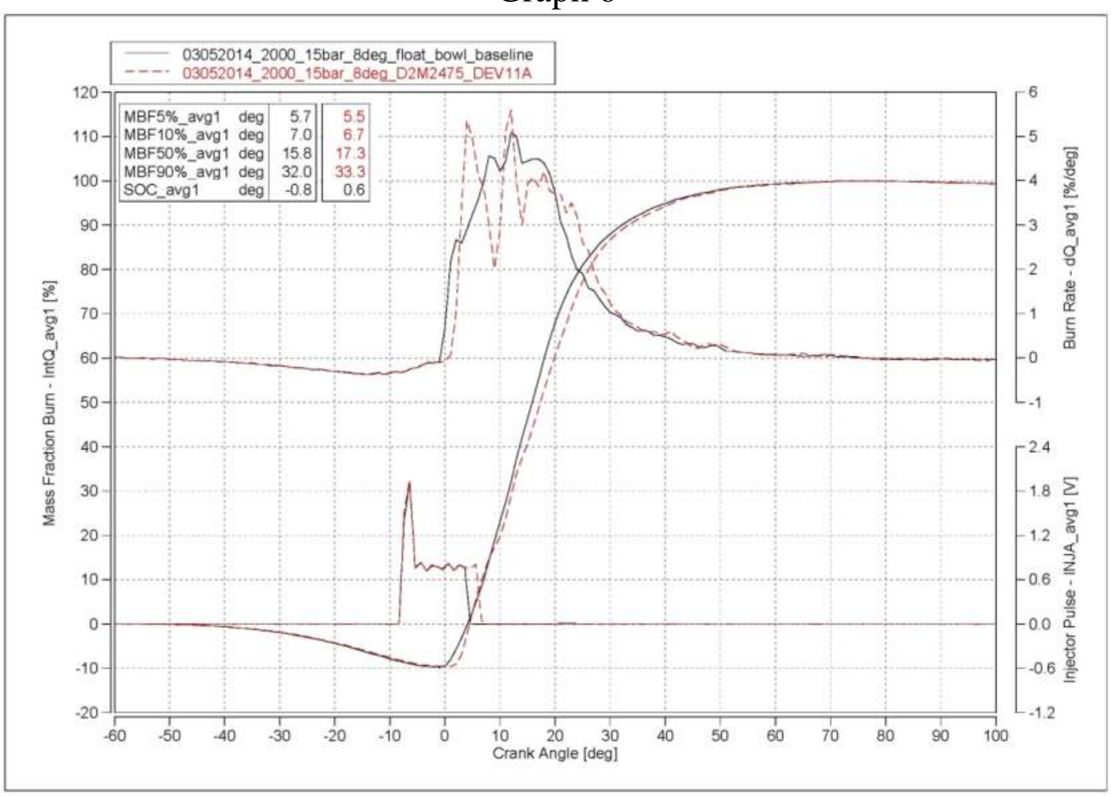
Graph 5 depicts a comparison of the average of 300 cycles of cylinder pressure during the compression and combustion events taken while running the engine at 2000 rpm and 15 bar BMEP and with 100% diesel (baseline) and 24.7% Methanol. Both were run with the same start of injection as shown in the injector firing trace. The delayed start of combustion exists at this engine load as well but not as much of a delay as the 10 bar BMEP point.

Graph 6 depicts a comparison of the burn characteristics of the baseline and 24.7% methanol blend for the same data test points. This graph also shows a slight delay in start of combustion for the same start of fuel injection. There is a faster burn rate for the methanol blend immediately after combustion was initiated but the rate becomes slightly slower than the baseline after 10% Mass Fraction Burn. 90% of the combustion completed 1.3 degrees after the baseline. Start of combustion was delayed by 1.4 degrees. The maximum burn rate was similar but the rate was a little more variable throughout complete combustion.

Graph 5



Graph 6



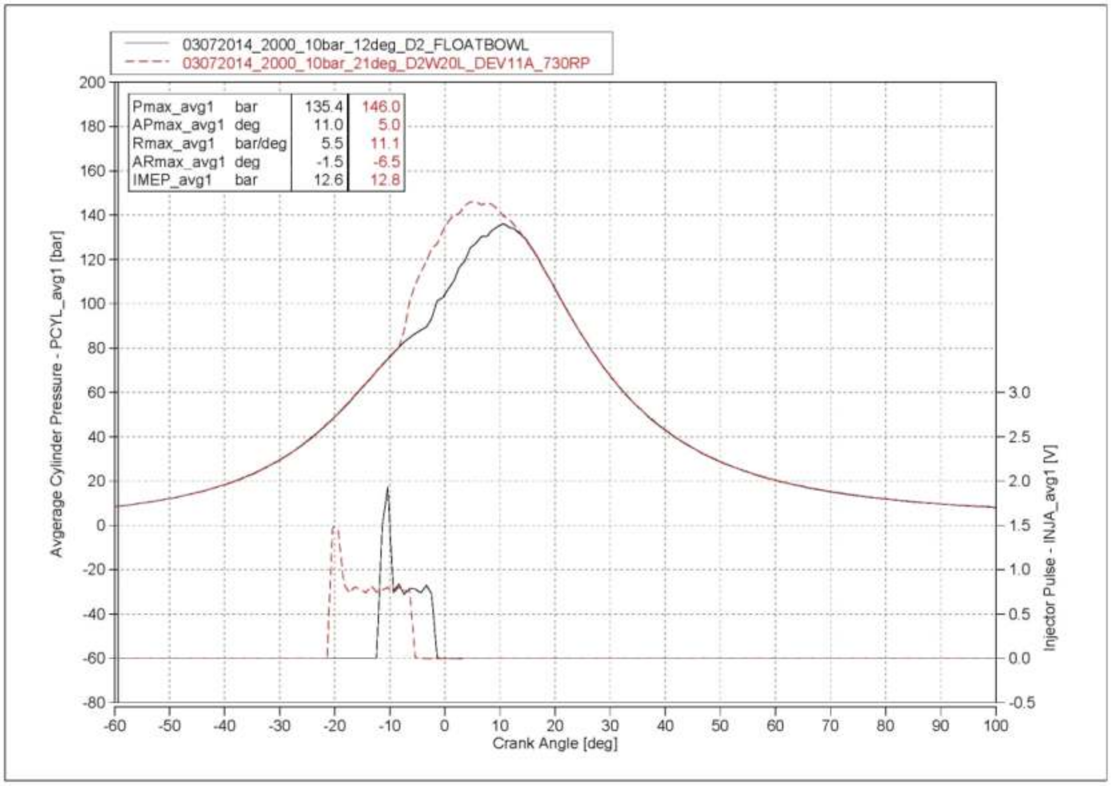
In looking at the combustion curves, the methanol blend would likely benefit from an optimization of engine ECU calibration due to the delayed start of combustion as well as considering tradeoffs with emissions and fuel efficiency. A lower cetane rating of the methanol blend is likely the reason for the ignition delay. However, none of the fuel blends have been analyzed to quantify the change in fuel characteristics. A fuel analysis would be important for continued testing. Further testing would be needed to understand if there are limitations to engine load operation with the methanol blend. We don’t know if the ignition delay would continue to increase at engine loads below 5 bar BMEP to where unstable combustion is experienced.

Diesel #2 and Water 2000 rpm and 10 bar BMEP – Reduced Rail Pressure

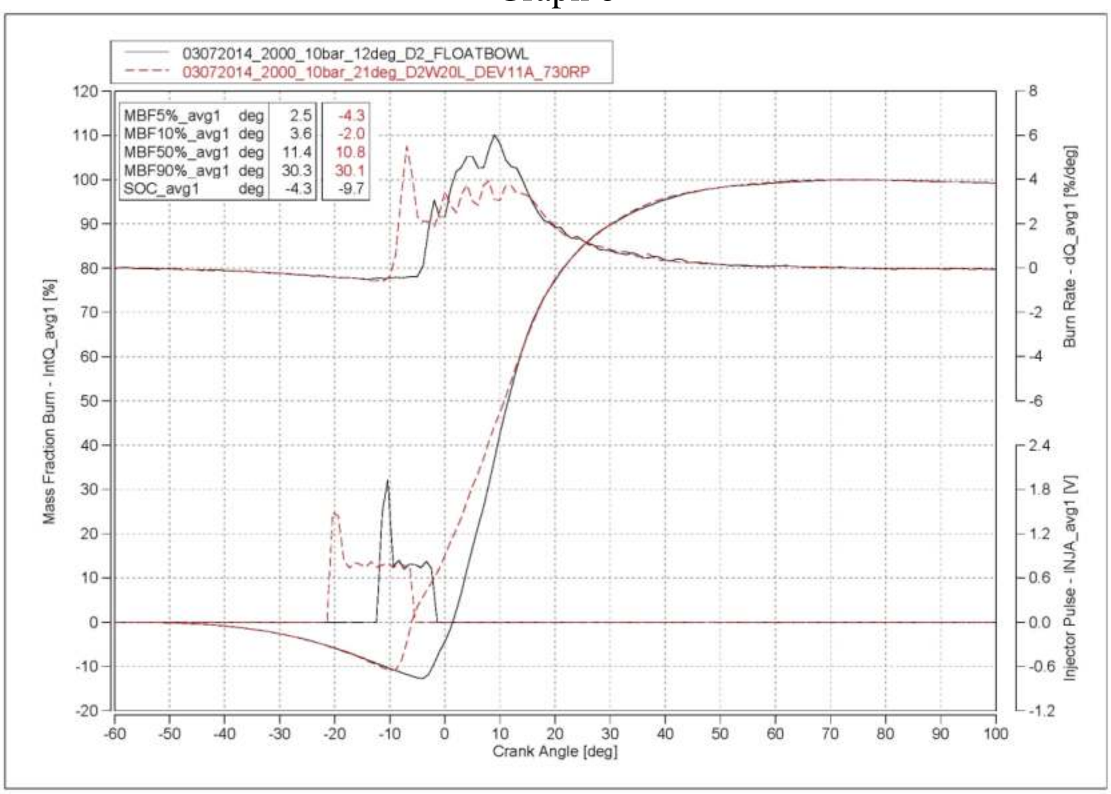
After running the engine on various blends and analyzing the data, we pondered how else we could take advantage of the reduced emissions levels. Since the diesel fuel and water emulsion had lowered the feedgas NOx and AVL smoke FSN number, lowering the fuel rail pressure seemed to be a candidate to see if we could improve BSFC due to potentially lower high pressure fuel pumping losses. The baseline point ran a fuel rail pressure of 1130 MPa. We were able to lower the fuel rail pressure down to 730 MPa and still maintain similar NOx and smoke numbers as baseline. Fuel injection timing had to be advanced to accommodate the slower burn rate. This resulted in a measurable reduction in BSFC of about 3%. Graph 7 shows the comparison of the average of 300 cycles of cylinder pressure during the compression and combustion events taken while running the engine at 2000 rpm and 10 bar BMEP and with 100% diesel (baseline) and 20% Water with reduced fuel rail pressure.

Graph 8 depicts a comparison of the burn characteristics of the baseline and 20% water blend for the same data test points. There is a faster burn rate for the water blend immediately after combustion was initiated, as observed in other data comparisons, but the combustion rate decreases below the baseline after about 5-10% Mass Fraction Burn. 90% of the combustion completed at about the same crank angle as the baseline fuel. This exercise shows that there is a potential to further optimize the engine calibration while considering a reduction in fuel rail pressure.

Graph 7



Graph 8



Engine Durability

Based on the scope of the testing, no attempt was made to assess the effects of the blends on the engine and fuel system long-term durability. Throughout the many weeks of testing, some degradation/ variability in engine operation was observed. Periodic replacement of the fuel injectors limited the variability of the collected data. Engine and fuel system disassembly will be required to determine if any internal components were affected by delivery and combustion of the emulsified fuel blends. To make any assessment of these impacts, further testing would be required to ascertain material and performance impacts and requirements of engines utilizing the diesel, water and alcohol blends over a longer period of time.

Emulsion/Blend Re-Blending and Agitation (Objective #3)

Given the blends were separating and thus making a store and later use approach difficult, a re-blending approach (Phase 3) was constructed using a simple low technology agitator designed and provided by Turbulent. The re-blending demonstrated that the shelf life of the emulsion/blend could be extended (potentially indefinitely) through simple agitation or mixing. Two approaches were taken to prove that re-blending was a feasible method of extending the usefulness of the fuel blends. The first approach was to immediately subject a FAD created emulsion to agitation therefore never allowing it to "separate". Immediate agitation did enable the blend based on visual observation to remain stable. The agitated blend was used in combustion tests (tests #5 and #6 in table above) with the engine and very similar emission and improved BSFC results were observed in comparison to real-time inline FAD created No. 2 diesel and methanol blend. The second approach to re-blending was allowing the FAD created emulsion to separate and be stored for ~18 hours before re-blending with the Turbulent agitator. This approach proved that the blends could be stored and re-blended and be used in combustion with the same positive results as real-time inline created blends. The re-blending approach also demonstrated how the new fuel blends could be used in modern diesel engines with return fuels systems. The return fuel from the engine was directed back to the storage tank with the blend therefore functioning in a similar fashion to fuel tanks used on today's diesel applications.

The picture below is the re-blending and agitator set-up.

Pictured below is the re-blending and agitation in process. Using the agitator the re-blending started immediately once the agitator was on and required only seconds to complete the re-blending of a 10 gal stored sample of the No.2 diesel and methanol blend. Depending upon the final system design, additional efforts would be required to make the agitation approach part of a final production commercial system installation.

Conclusions:

There were three broad objectives of the testing:

- To create new and unique liquid fuel blends of hydrocarbon based fuels, alcohols and/or water
- To use the blends in compression ignition combustion and positively impact engine performance
- To create blends that could be stored and delivered for later use with the existing combustion infrastructure

Blending Capabilities:

The testing clearly proves the FAD's ability to blend hydrocarbon fuels, alcohol based fuels and/or water at low pressure (e.g. ~3 to 4 bar) without the addition of surfactants or other chemicals. There were no observed blending issues regardless of the liquid inputs. The FAD successfully blended No. 2 diesel and methanol, No.2 diesel and ethanol, No. 2 diesel and water, and No.2 diesel, methanol and water. The FAD also successfully blended a heavier hydrocarbon based fuel (No. 5 diesel) with methanol. The FAD demonstrated its ability to make all of these blends in seemingly unlimited proportions. Most of the blends consisted of No.2 diesel and ~20% of the secondary liquid (e.g. methanol, ethanol or water). Blends with less than 10% and as much as 50% of the secondary liquid, however, were also made. To the tester's knowledge there is no other commercially available device that can blend these liquids with no chemical additives at relatively low pressures. Although it was found that all of the blends experienced some degree of separation shortly after they were made, complete separation was not observed even after several weeks. In all cases, the No.2 diesel blends were made in-line and were sufficiently stable and emulsified so that they could be immediately injected into the engine's combustion chamber utilizing the engine's existing fuel system. Under this scenario blend stability is not a factor given that injection occurs within seconds or less after the blend is created.

Combustion Improvements:

During the testing the blends made with No.2 diesel fuel were successfully used in combustion on a modern high-pressure common rail Ford diesel engine. No mechanical modifications were made to the engine; the FAD was simply installed upstream of the existing engine high-pressure pump. The fuel blends were either made in-line with the engine running or in some cases made in advance (e.g. pre-mixed and stored) and supplied to the engine as needed. All blend types, whether the blend contained methanol, ethanol or water demonstrated their ability to successfully be used as fuel. Not only did the blends exhibit successful combustion, they also substantially reduced smoke and had a meaningful impact on NOx. Smoke reductions as high as 90% were observed and consistent reductions in the 70 and 80% range were common. NOx reductions were consistent and recorded as high as 39%. While the substitution of diesel fuel with lower energy content alcohols (e.g. methanol or ethanol) increased the BSFC, the increase was proportionally less than the amount substituted. Given this proportionality and depending upon the cost of the fuels, a net fuel cost benefit is achievable. At the low and medium load points the BSFC with No. 2 diesel and water actually decreased which could directly provide fuel economy benefits. Minimal reductions in Brake Thermal Efficiency (BTE) were observed and in some cases improvements in BTE were recorded. All of these observations combined with the combustion analysis performed (which clearly showed later ignition combined with an increased rate of combustion) lead the tester to conclude there can be combustion benefits with the new fuel blends. The engine used was designed and programmed to operate efficiently with 100% No.2 diesel. The testing scope did not include any attempts to optimize the engine to operate with the new and entirely different blends. The fact that the engine ran as well as it did without optimization leaves significant opportunity for further calibration and optimization efforts to improve the performance recorded in the tests. Given the scope limits of the testing we can make no judgment on the maximum potential of the new fuel blends or the engine modifications required to realize them.

Tests were also performed to evaluate the FAD's ability to atomize the fuel blend. The testing data shows the FAD improves the atomization of the fuel blend (shown through combustion effects) at only 3 to 4 bar. In the testing it was found that the 3 to 4 bar of pressure used by the FAD to create the blend had an atomization effect on combustion, which was equivalent to 400 to 500 bar from the high-pressure pump. This is evidence that the FAD may be a highly effective means to atomize fuel, which is necessary in order to reduce emissions in combustion engines. The scope of the testing did not encompass the optimization of the engine's performance with the fuel blends but the atomization ability of the FAD provides engine developers and calibrators additional degrees of freedom in managing the emissions trade-offs between NOx and smoke. Additionally, the FAD's ability to atomize the fuel blend could result in BSFC improvements, if less pressure (energy) is needed to reach the acceptable emissions profile for engine certification.

Extended Usefulness of Blends:

The third objective of the testing was to evaluate methods for extending the useful life of the new fuel blends and to deliver pre-made blends to be used on-site with minimal, if any, infrastructure modifications. Using an "agitator" designed and supplied by Turbulent, it was demonstrated that the useful life of the blends can be extended for a significant portion of time, if not indefinitely. The scope of the testing did not include long-term storing and holding periods of the blends for later use in the engine. What was observed was the ability to make a fuel blend of No.2 diesel and methanol, store the blend overnight and use the blend the next day. The positive engine performance and combustion effects using the stored and then agitated blends proved to be similar to the in-line testing. Given that the blends never completely separated after they were made, there is a property of the blend (the testing scope did not include chemical analysis of the blends) that allows it to be "re-blended" with Turbulent's agitator which restores the blend back to its original state or at least a state that produces the same positive engine performance and emissions reductions. Since the engine used had a fuel return system where by fuel returns to the vehicle's fuel tank from the fuel injectors, a testing protocol was established to mimic this system. During the testing the FAD was fed a pre-mixed fuel blend from a storage tank. The blend was injected and the return fuel was routed back to the storage tank. This testing protocol simulated the process used today with vehicles with modern diesel fuel systems. The evaluations performed met the objectives of the testing, and demonstrated a closed loop method from which further development can build upon.

In summary, the FAD testing conducted over a nine week period conclusively and successfully demonstrated its ability to make emulsions/blends with hydrocarbon fuels, alcohol based fuels and/or water. The testing also showed that these blends could be used in modern diesel engines with positive effects on reducing feed gas exhaust emissions. Data from this testing indicates that the FAD and the emulsion it creates have a significant impact on smoke emissions and some impact on feed gas NOx emissions. Large decreases in smoke were observed at all of the points and overall NOx emissions were lower when testing with the various emulsions. In the final stages of testing, using the Turbulent provided agitator, the ability to extend the shelf life of the emulsion/blends and retain the positive engine performance was proven. BSFC increased with all fuel blends, with the exception of the majority of water points tested. The cost reduction associated with substituting fossil fuels with alcohol fuels more than compensated for the energy loss when applied to certain fuel supply markets. The engine testing data supports a fuel cost/unit benefit for those specific markets. Also, additional testing to optimize the engine calibration and FAD could further improve the benefits of utilizing the fuel blends.

Приложение 1

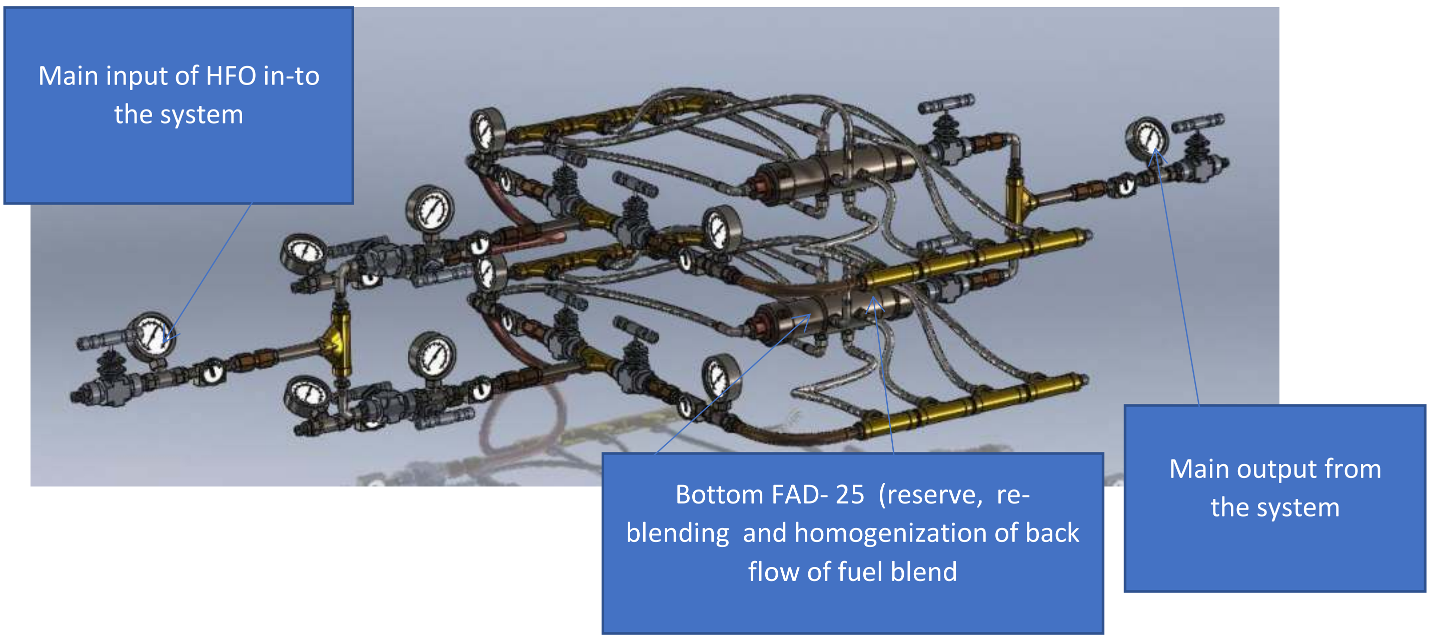
Technical proposal for Beta Site testing of Industrial boiler with integrated mixing technology

Technical task:

In-line installation of Dynamic Fuel mixing, activation and homogenization system in-to fuel line of industrial boiler, with productivity equivalent – 50 kg of HFO per hour [0.5 metric ton of steam per hour]

Figure 1

Fuel mixing, activation and homogenization system, based on two FAD - 25



Manometers and flow meters – optional

PROCESS:

For online stream mixing heavy diesel oil with methanol, a system of dynamic mixing, activation and homogenization, which consists of two parallel connected devices, with a diameter of 25 millimeters worker

In general (at the top level) device mixes the heavy flow of diesel fuel (fuel oil) with methanol – version 1; Mixing with steam in the same configuration – version -2;

Mix Ratio - 40% of heavy diesel fuel (fuel oil), 60% methanol or 80% of HFO with 20% of steam, - version -2

This device has two inputs for heavy diesel fuel (fuel oil), - of which one axial input capacity of 60% of the total number and the integral one radial entrance accommodates 40% of the total amount of heavy diesel fuel supplied to the mixing

The device has an additional integral radial entrance, designed for 100% methanol supplied to the mixing or for 20% of steam;

After mixing and homogenizing simultaneously, it is fed to the nozzle of the boiler, but only part of the stream is injected, and the rest of the mixture returns to a special container

In a special container there is a standard device for re-blending, which supports the quality and uniformity of the mixture at the appropriate level

Special container also has a level sensor and a temperature sensor mix mixture

At the outlet of the pump has a special container with the necessary control and measuring equipment

Upon reaching inside a special container mix level sufficient to start the pump, it is switched on and feeds the mixture into the second device on the integrated input (in the upper level of the input device designed methanol)

The second device, the flow is homogenized and fed into the common summing the pipeline, where the nozzle is fed to the boiler

Figure 2

Inputs and output of the system

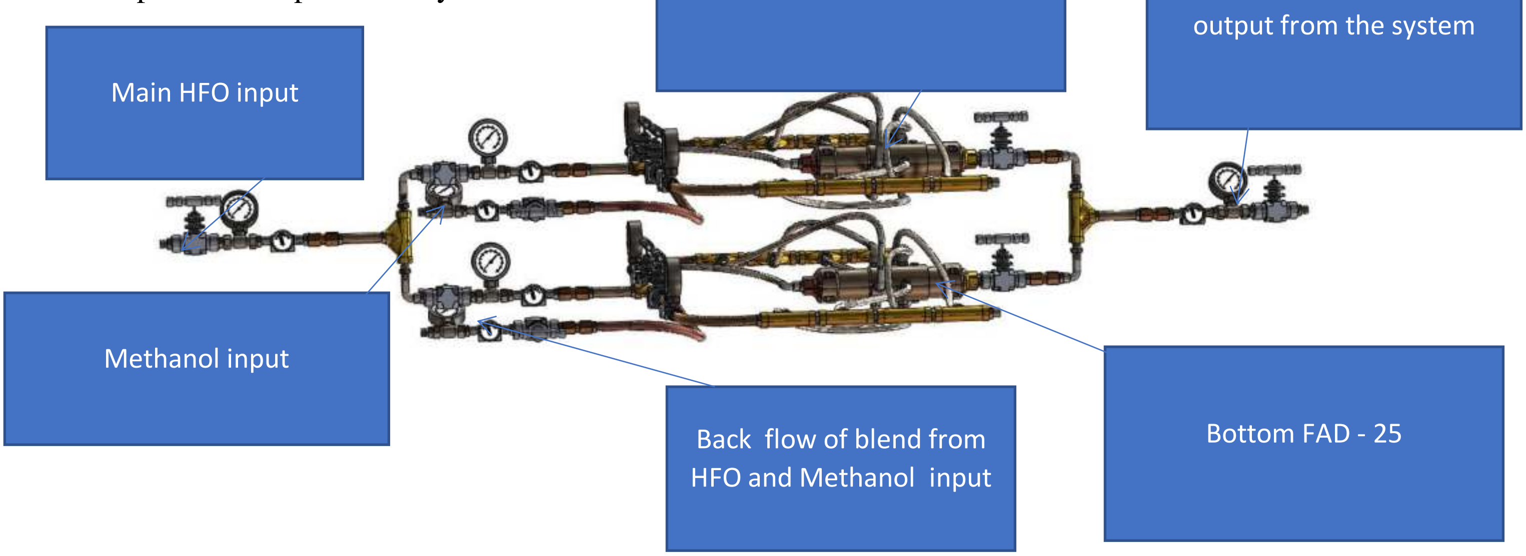
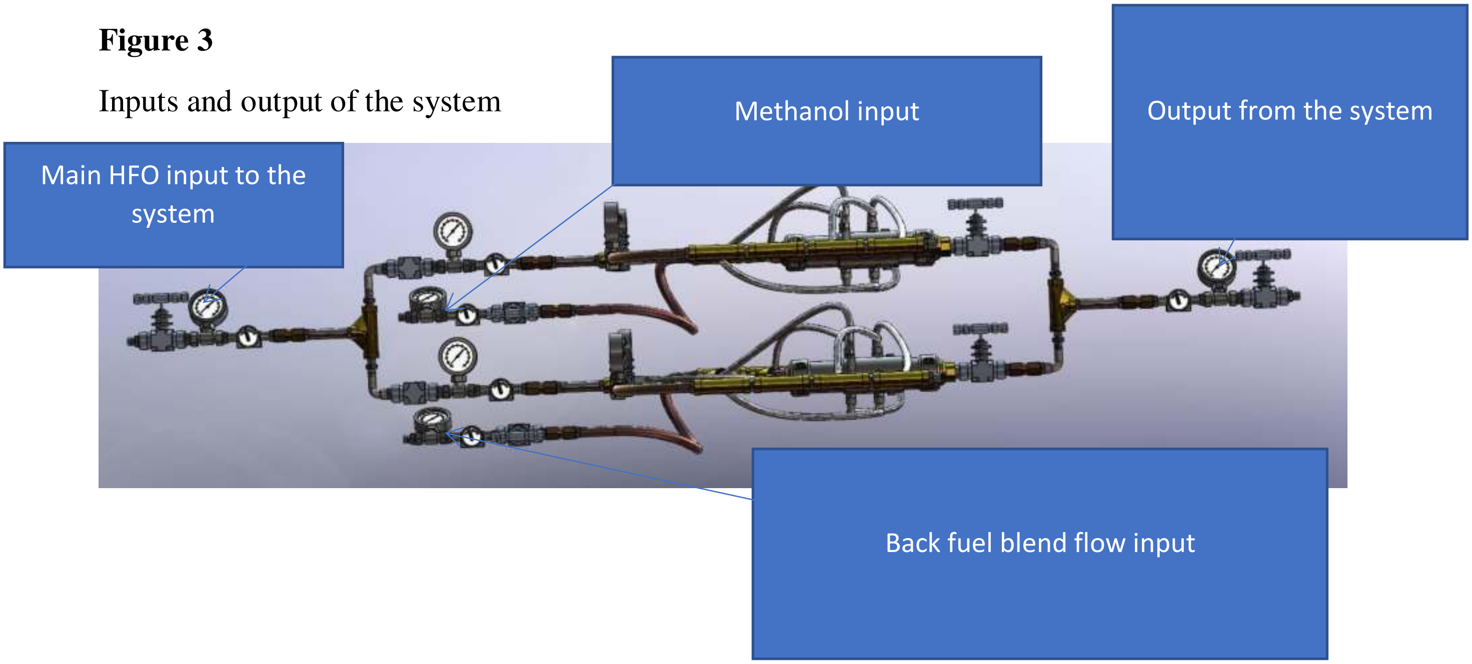


Figure 3

Inputs and output of the system



The system consist of two FAD – 25 mm

The maximal flow of HFO for each = 50 kg per hour

Figure 4

3-d model of the system

The system consist of the following inputs- outputs:

- input for 100% flow of the HFO [divided to two lines for the top FAD- 25 and to the bottom FAD- 25
- input for the 100% of methanol to the top FAD- 25 [related only for current configuration]
- input for the 100% of the returned fuel blend flow
- output from the system[combined the flow of prepared in system fuel blend from 40% of HFO [Mazut] mixed and homogenized with 60% of Methanol and returned back flow of the same blend, homogenized in the second [bottom] FAD- 25; The proportions of the output between new blend and back flow is adjustable

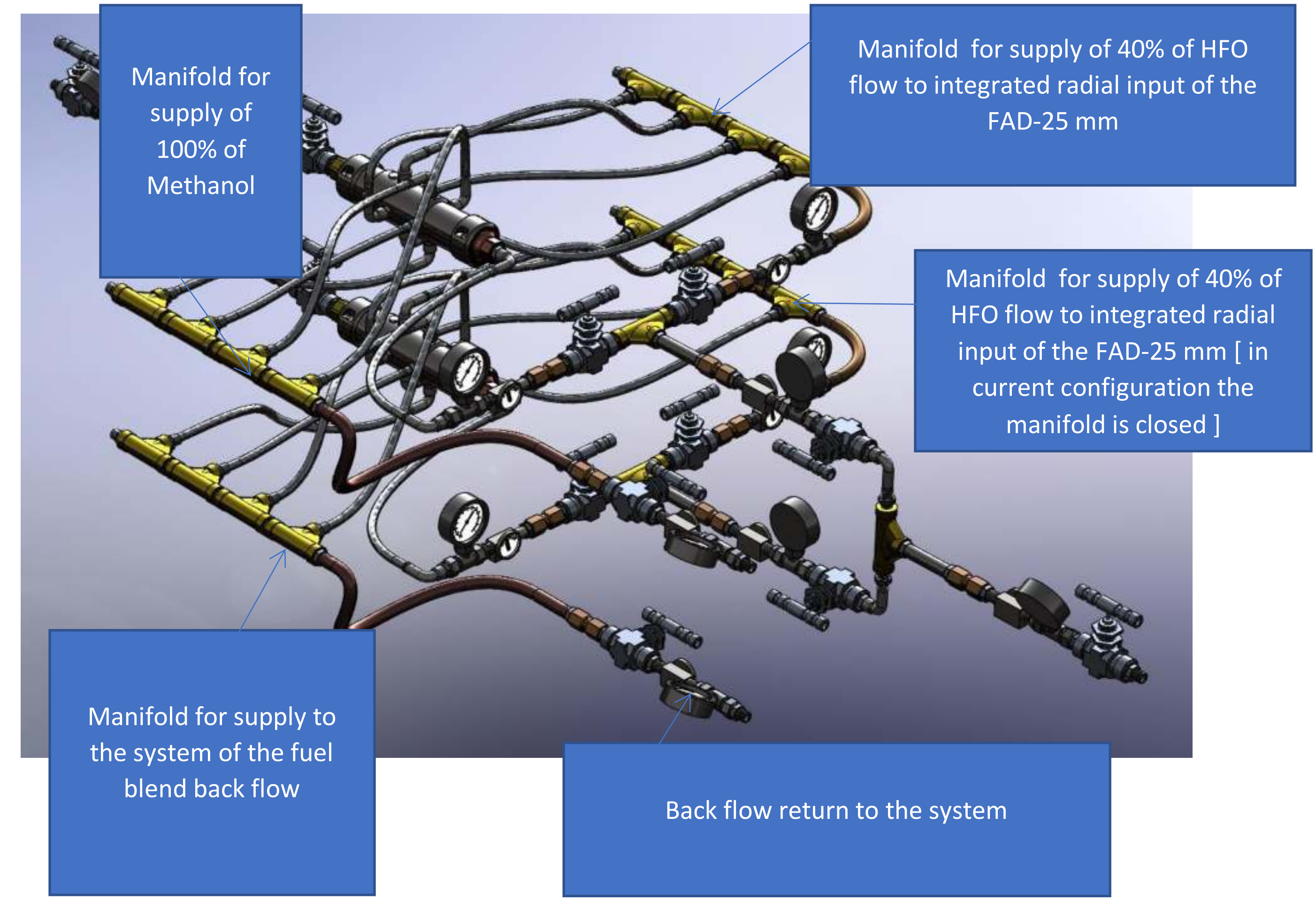
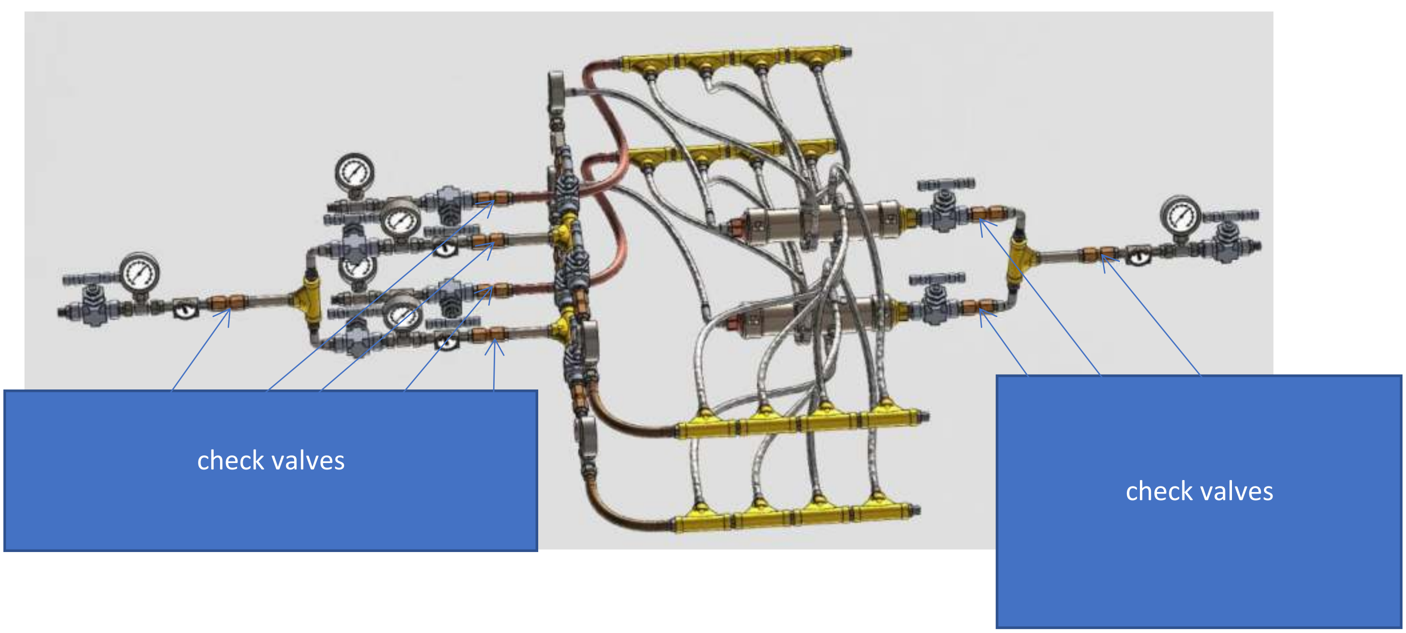


Figure 5

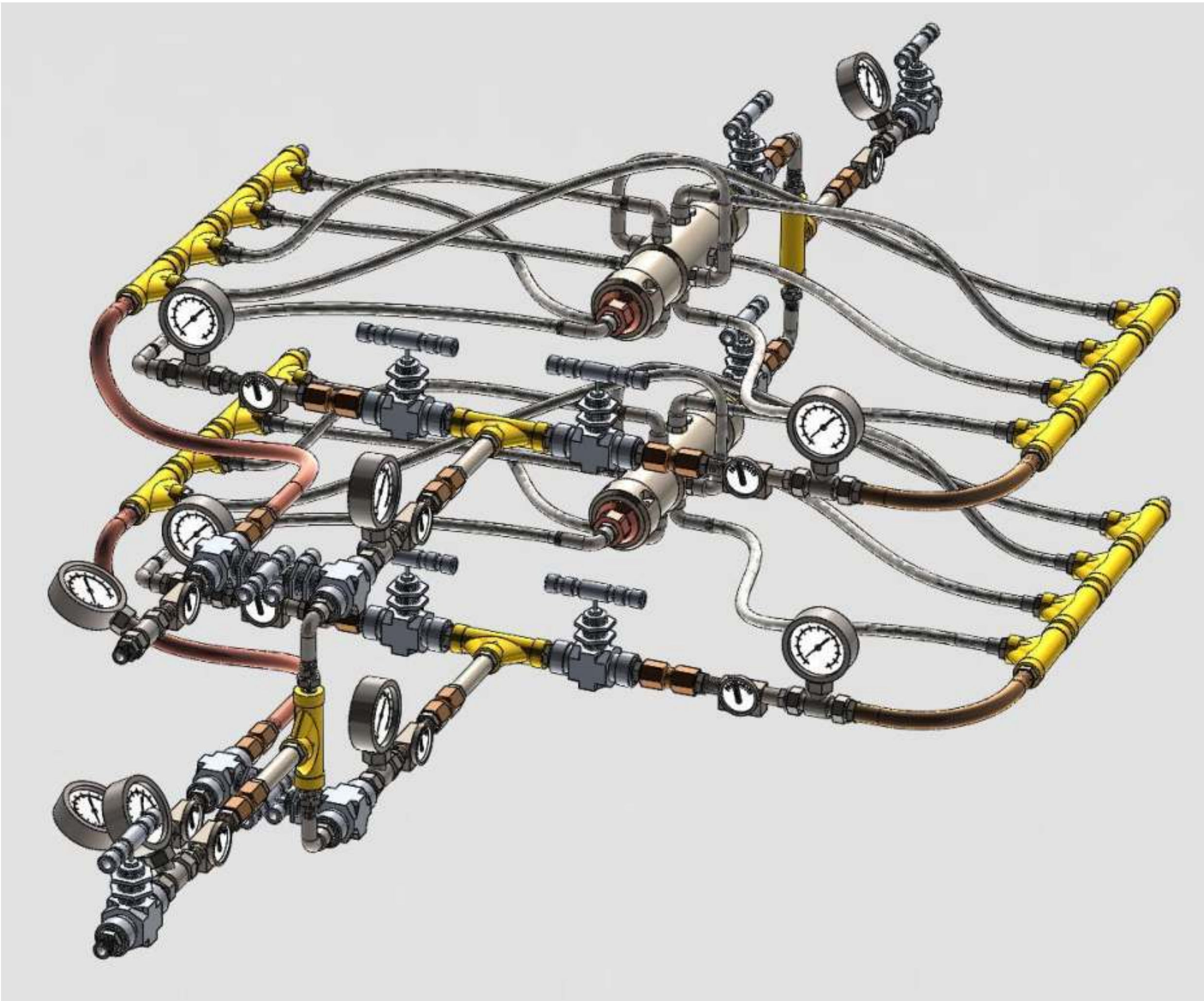
3-d model of the system



The system can be configured according to local conditions and requirements

Figure 6

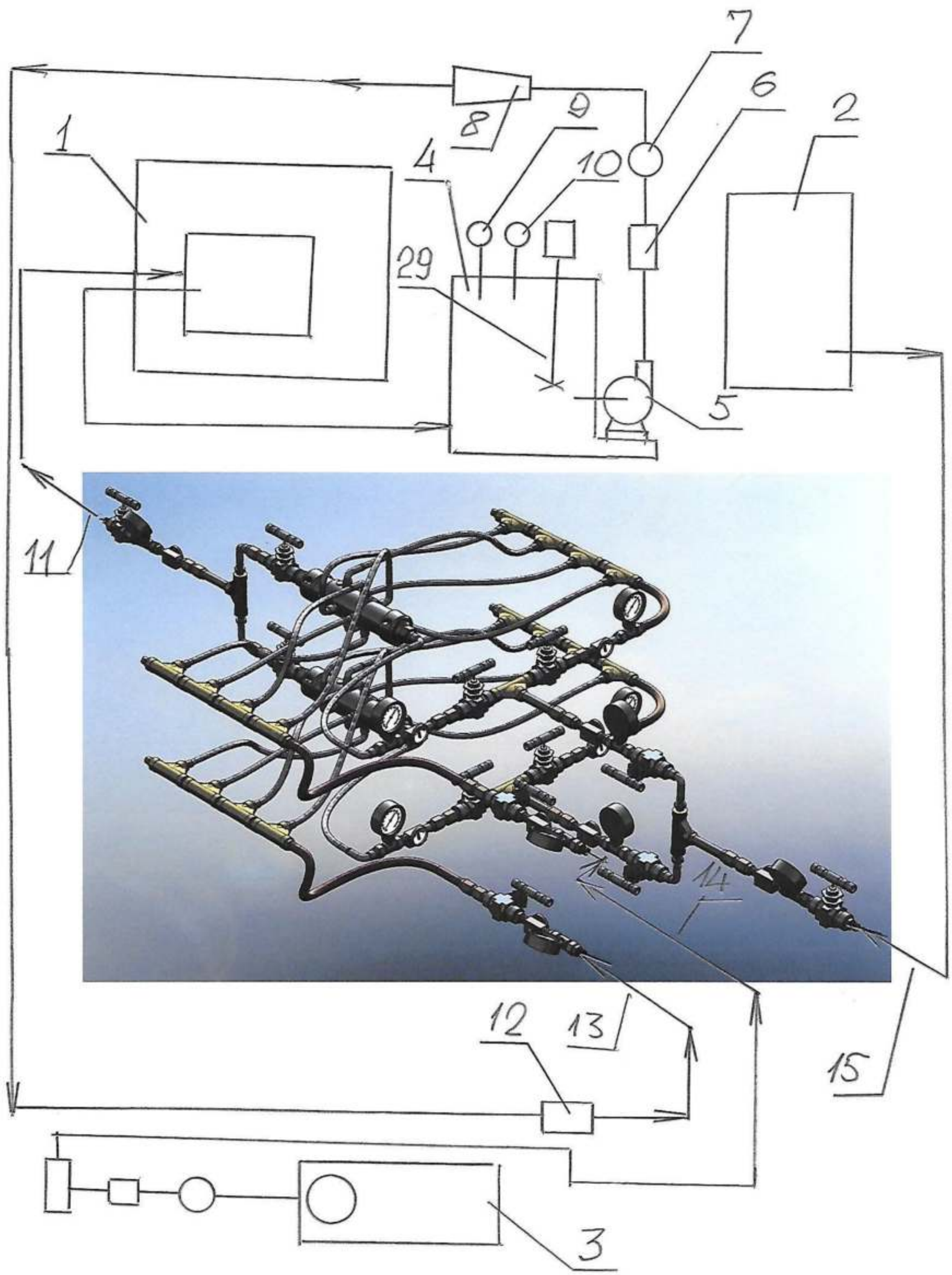
3-d model of the system



All components and pipe fittings of the system is standard; The assembly and calibration process designed based on standard materials and standard components and unification technical decisions

About new design concept of FAD

New design concept of FAD, include the device security requirements of Dor Chemicals and other companies; The dimensions of the device are extremely small; In the picture, in real scale factor is demonstrated FAD – 30 with maximal fuel flow = 285 liter per hour



1 – Tech Energy boiler [500 kg of steam per hour]

2- present tank and environment for HFO

3 – present tank for Methanol, including all environment

4 – tank for fuel back flow [fuel blend from 40% of HFO and 60% of Methanol]

5 – pump for fuel blend back flow

6 – control valve

7 – manometer

8 – flow meter

9 – level sensor

10 – thermometer

11 – integrated output, included new fuel blend and same fuel blend from the back flow

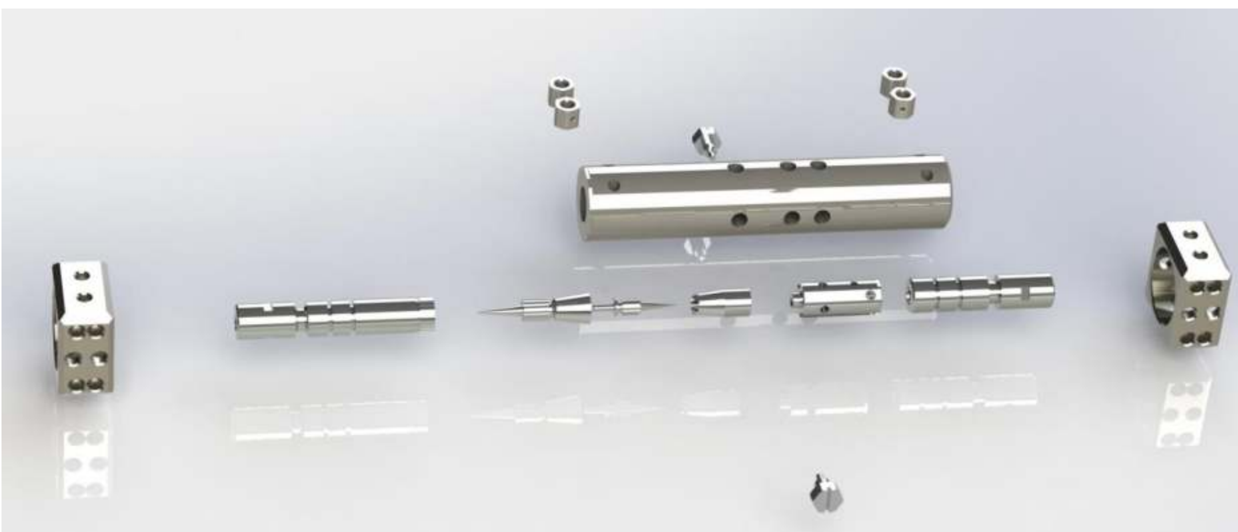
12 – back fuel flow return line to the FAD system, optional heating device

13 – back fuel flow input to the FAD system

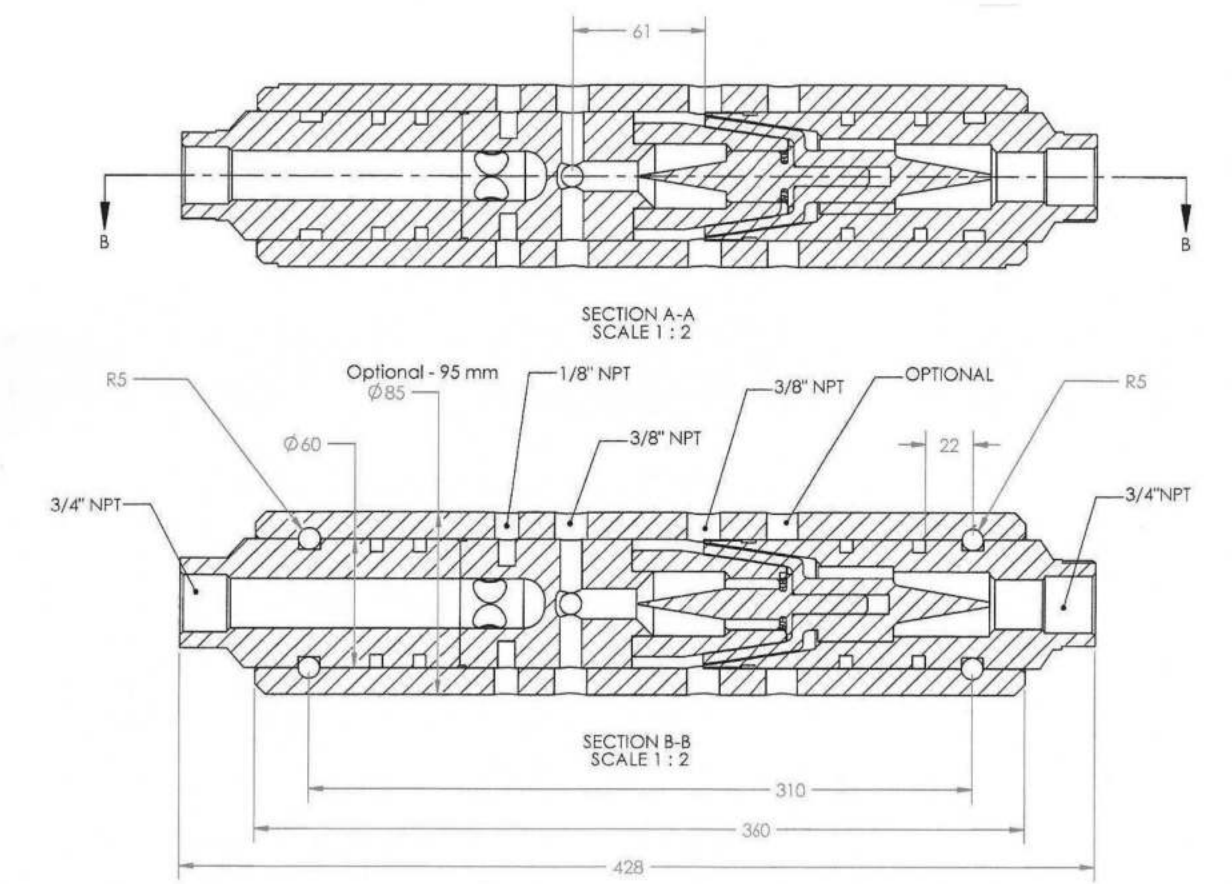
14 – Methanol [60% of the blend] input to the FAD system

15 – HFO input to the FAD system

29 – re-blending device [standard device]




Top device, HFO main input; Calibrated for 60% of the total HFO flow
Methanol integrated input – 4 radial inputs, 25% of the methanol flow each
Top device, HFO second integrated input for 40% of the total HFO flow; 4 radial inputs for 10% of the total HFO flow each
Top device; The HFO/methanol blend output; Proportion 60%/40%
Turbulent Energy-30
Turbulent Energy-30
Bottom device; Closed main input
Bottom device; Output of secondary re-blended and secondary homogenized back flow of the blend from 60% of the HFO and 40% of methanol
Bottom device; Bach flow of the HFO /METHANOL, integrated input; Consist of – 4 radial inputs for 25% of the total back flow each
Collector positioning system


61
B
B
SECTION A-A
SCALE 1 : 2
R5
Optional - 95 mm
Ø85
1/8" NPT
3/8" NPT
OPTIONAL
R5
Ø60
3/8" NPT
22
3/4" NPT
3/4"NPT
SECTION B-B
SCALE 1 : 2
310
360
428


Turbulent Energy-30

Characteristics of new design concept of FAD – 25, using in the system:

The device has no moving parts and is therefore highly durable and reliable. All of the internal components are made via standard machines with numerical control without the use of special techniques or cutting tools.

In the shown emboddiment, the device is made of stainless steel, which allows the installation of systems in harsh environments in terms of temperatures or corresive elements such as marine vessels. Depending upon the operating enviroment and flow requirements others materials could be used.

The device is extremely compact and has dimensions which allow it to be packaged in almost any internal combustion engine such as a stationary engine (e.g. marine engine, generators) as well as in engines installed in vehicles (e.g. automobiles or trucks). The device should be integrated into the fuel system between the fuel storage tank and the engines fuel injection system. All standard attachment methods are possible on the input or output side of the device.

The device can be made via serial production equipment with digital program management for the manufacture and assembly. Quality control does not require special technologies, materials and tools.

Homogeneous process description

To homogenize the liquid fuel, the process simply requires the liquid fuel supply line to be connected with a standard fitting to the input of the device. The liquid enters the device in the first accelerating hydrodynamic section; the liquid then passes through a coaxial second section with an integrated vortex generator. These internal geometries create an amplified level of hydrodynamic turbulence.

Devices specifics

An industrial installation for the homogenization of liquid fuel i.e. diesel fuel number 6 (Heavy Fuel Oil) and diesel fuel number 2 (Light Fuel Oil), as well as for micro-miniaturization and optimization of dispersion during injection of bio-fuel, methanol, ethanol and also kerosene obtained from waste plastics and automobile and other tires; Capacity of the device, despite its small size [for example FAD – 40], - 1000 liters per hour under pressure of 7-10 bar.

Description to the general installation diagram

For installation and mounting in an industrial boiler fuel line for on-line mixing of the flow of heavy diesel fuel and methanol, provides a system of dynamic mixing, activation and homogenization, which consists of two parallel connected devices, with a diameter of 25 millimeters worker

In general, the boiler itself and all equipment included in its fuel cells are arranged as follows:

Scheme 1 shows a boiler which is connected from the output 11 of the dynamic mixing and activation homogenization consisting of two parallel-connected devices having a working diameter of 25 mm each;

The tank 2 (includes all associated equipment) contain heavy fuel oil (mazut), which through the heating system is fed to the input 15 of the dynamic mixing, activation and homogenization.

Methanol contained in the tank 3 with all necessary equipment from where it is fed to the input 14 of the system.

The system methanol is mixed with fuel oil in the ratio - 40% oil to 60% methanol and 11 through the outlet nozzle is fed to the boiler 1.

Part of the flow of the fuel mixture is returned to the tank 4 where a special pump 5 through a valve 6, a pressure gauge and a flowmeter 7, 8, through the heater 12 is routed to input 13.

The principle provides for the installation of the line heater 12

The return flow of the fuel mixture is introduced into the second device, wherein homogenized and connects to a new stream of the fuel mixture produced in the first device

Joint flow of the fuel mixture is then introduced into the boiler 1 and the injection process is repeated.

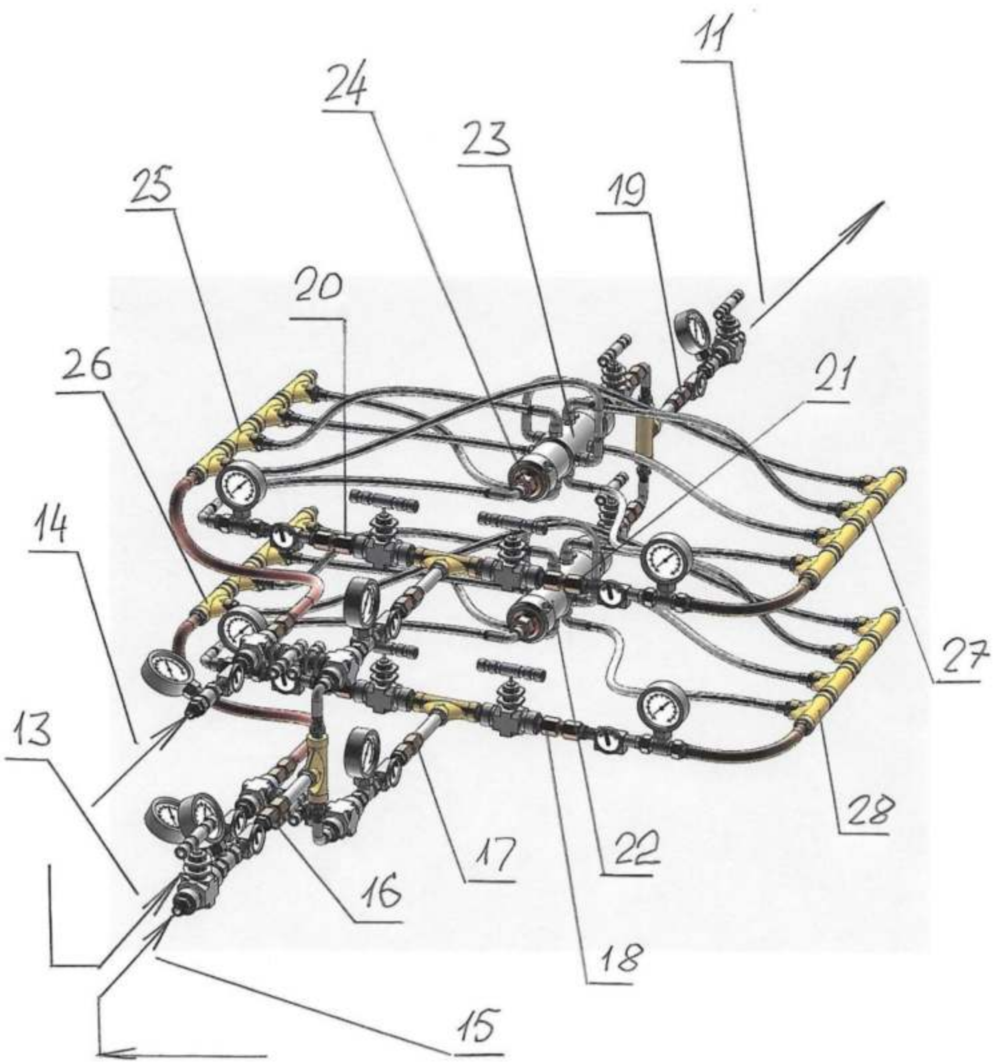
To eliminate the pulsations in the system at each branch conduit has the check valves, - 16, 17, 18, 19, 20, 21;

Backup unit 22 for installation in an industrial boiler is used only for inputting and return homogenizing the mixture; Return the mixture is injected and distributed through the Manifold 26;

Methanol is injected and distributed through the Manifold 25;

Putting oil in the radial input through Manifold 27;

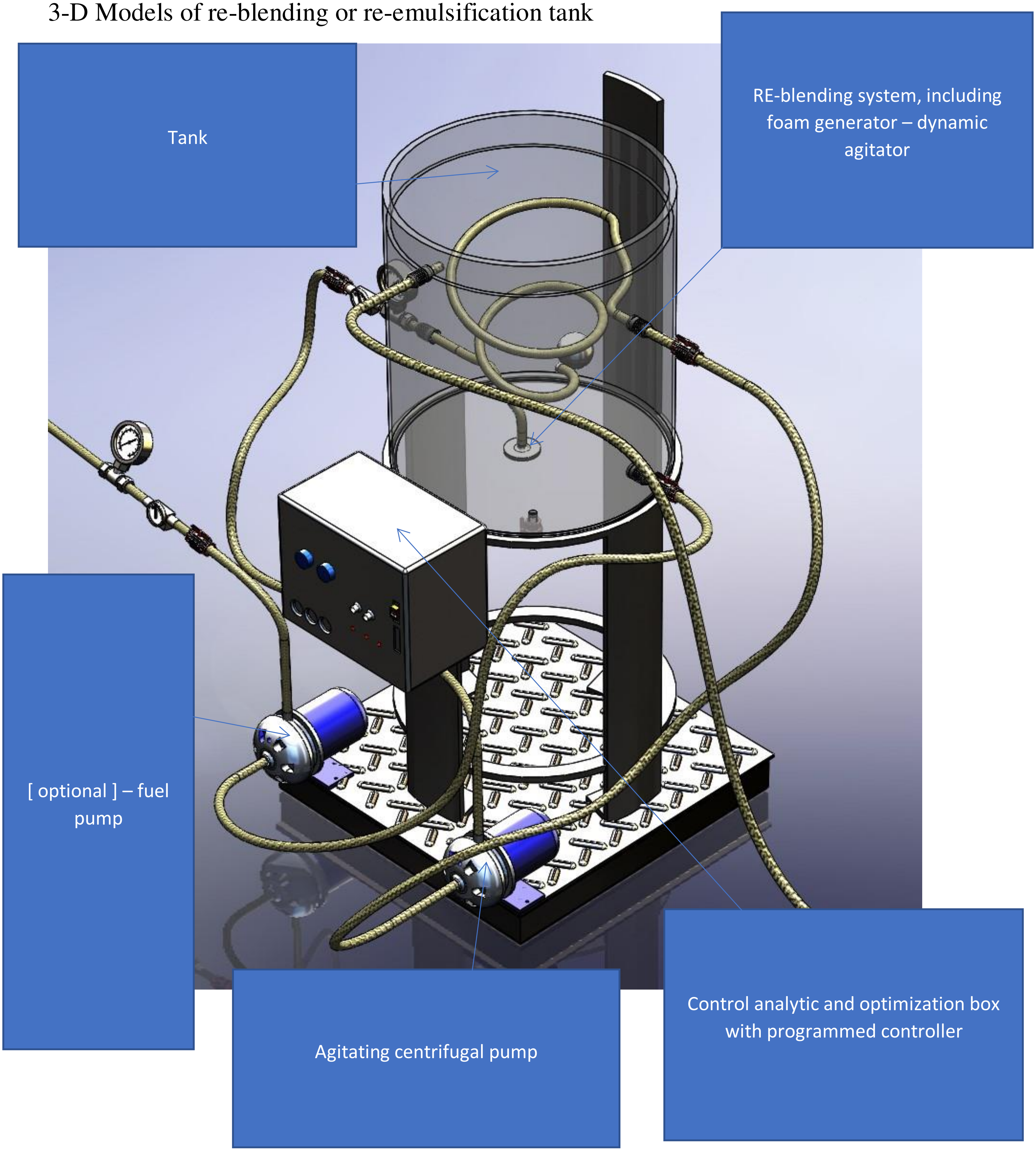
Manifold 28 for this version of the installation, - closed

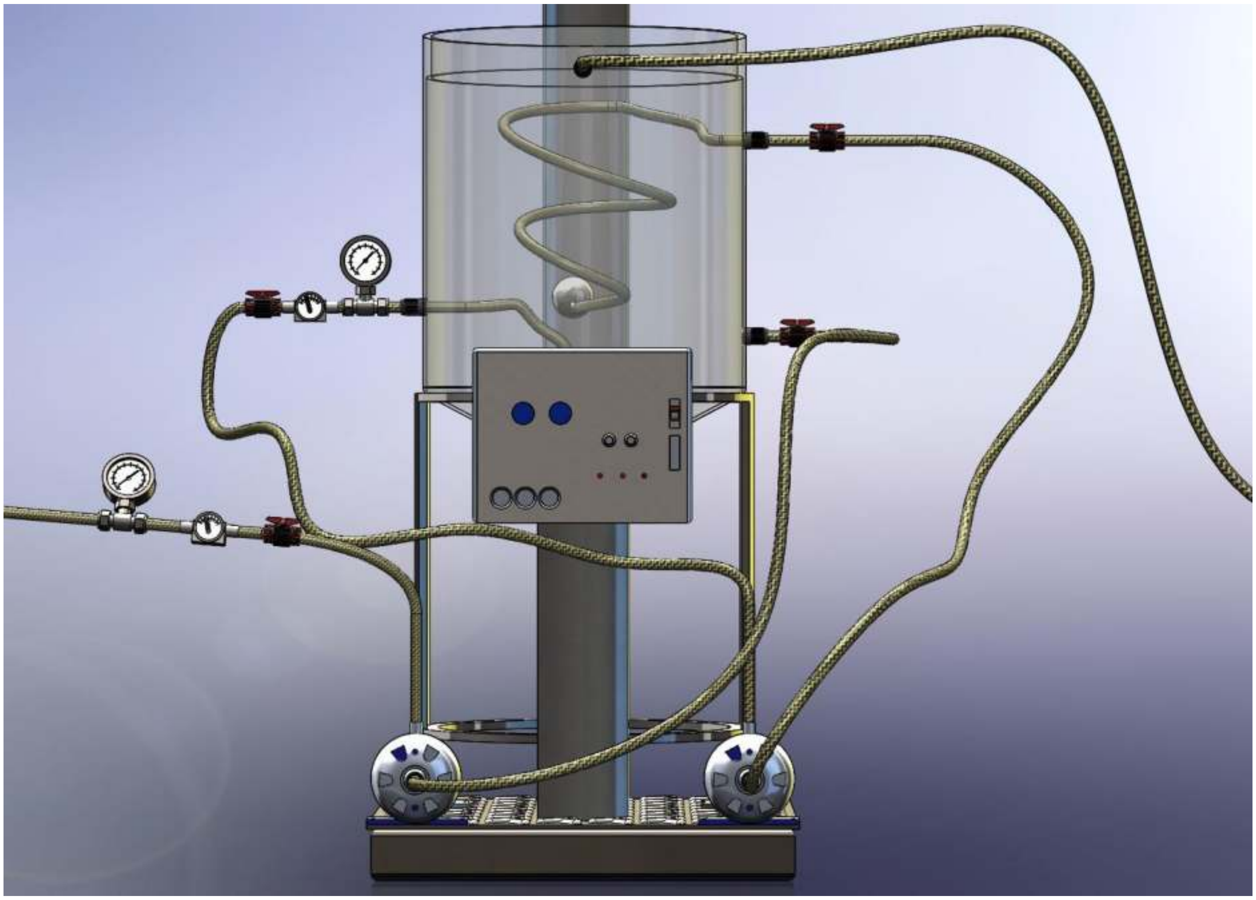


16 – check valve
17 – check valve
18 – check valve
19 – check valve
20 – check valve
21 – check valve
22 – bottom FAD – 25
23 – top FAD – 25
24 – main HFO input [~ 60 % of the HFO flow]
25 – top methanol manifold
26 – bottom manifold for blend back flow / bottom methanol manifold
27 – main HFO manifold [40% of total HFO flow]
28 – bottom HFO manifold of the system [optional]

Приложение 2

3-D Models of re-blending or re-emulsification tank





Приложение 3

General diagram of the installation of the system in boiler environment

The in- line mixing system of heavy diesel fuel (fuel oil) with methanol in a proportion - 40% of heavy diesel fuel and 60% of methanol for simultaneous homogenization before injection into the combustion chamber, it is a functionally complete unit with parallel sub-system for re-blending, regeneration and return the balance of the fuel return flow of fuel mixture

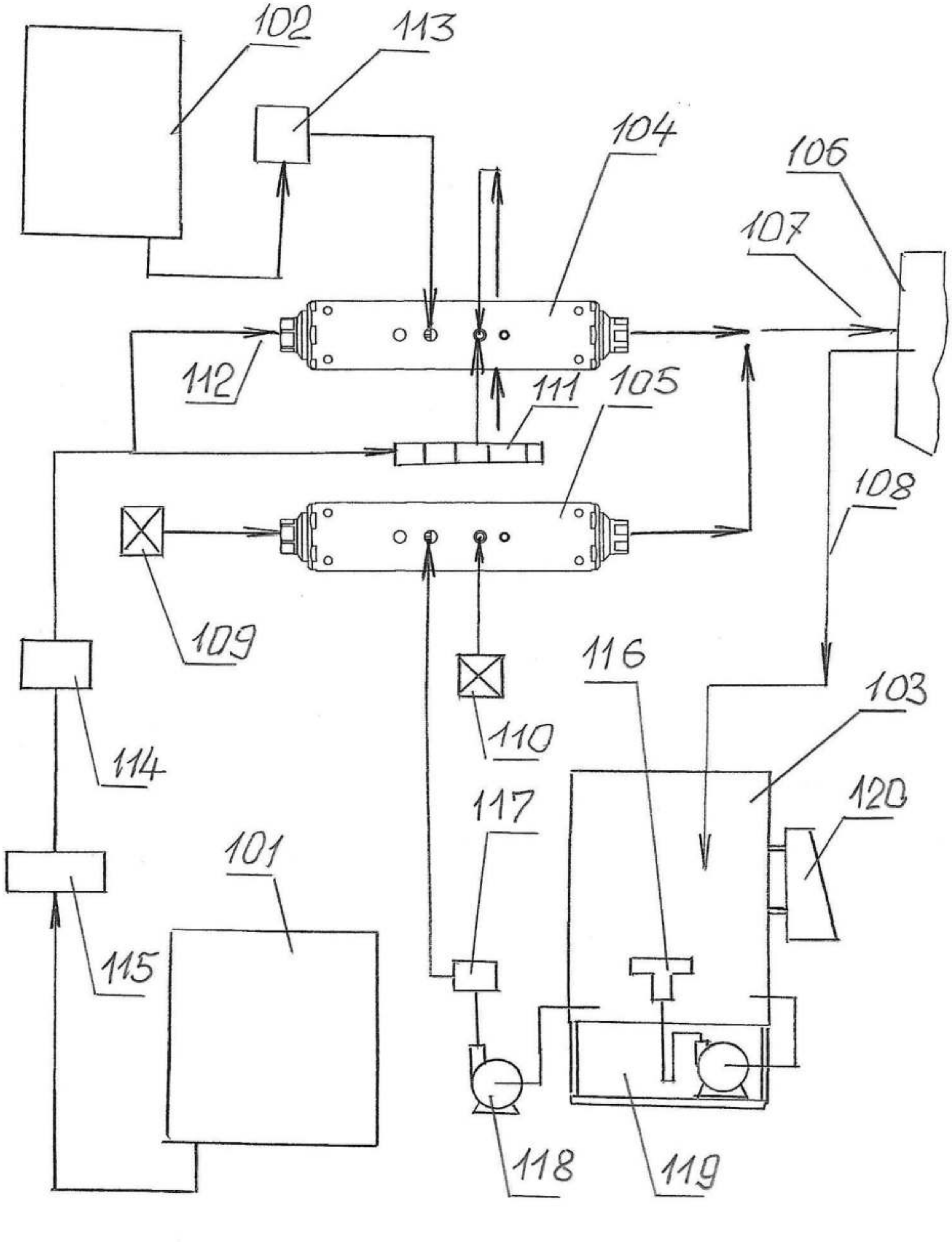
The system connected to present HFO tank of the boiler – 101 and present methanol tank – 102;

The system including an original re-blending multifunctional tank – 103

In the system, according to required optimal fuel blend flow is in specific functional use two parallel Dynamic Fuel Activation and in-line homogenization devices with working internal diameter 25 mm, - the top device – 104 and the bottom device – 105

The top device – 104 in the system used for preparation, in-line mixing and homogenization of “ new “ fuel blend with direct input to boilers injection system of the combustion chamber

The bottom device – 105 used for re-blending, regeneration and secondary homogenization of the fuel blende back flow and re-sending it to boiler combustion chamber


102
113
104
106
107
112
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119

The boiler – 106 require the maximal fuel flow – 50 kg per hour and create back flow of the fuel blend

The combined flow of the fuel blend – 107 is injected to the boiler – 106, combustion chamber and is divided for big part of the stream – direct injected to the combustion chamber and small part of the stream – creating the back flow – 108, sent to tank – 103

The fuel lines of the second bottom device – 105, central – 109 and back integrated – 110 is closed

The top device – 104, connected to the HFO pipe-line with manifold – divider – 111 and central input – 112

The local methanol supply line including local control system – 113, controlled and calibrated all necessary parameters of the methanol flow

The main HFO flow is under control of control system 115 and heating system – 115

The back flow of the blend – 108 entranced to tank – 103 where is re-blended with re-blending agitator -116, - a main part of local re-blending system 119

The re-blended blend from tank – 103, with pump -118, under control and calibration and on-line adjustment of control system – 117, send to bottom device – 105, which output flow is combined with output from top device – 104 and from this two flows is combined flow – 107

On the tank 103 is mounted central control-analytic box - 120

Installation is as follows:

Inputs to the system are connected to the outputs of existing capacities for the HFO - 101 and methanol - 102. A controlled fuel pump control systems - 113, 114, 115 and fed HFO methanol in the proportions necessary to the upper device - 104, where these components are dynamically mixed and homogenized and then fed at the input - to the boiler 107

Part of this stream (excess) is returned along line - in the tank 108 - 103.

The tank 103 system 119 by means of the activator - foam generator - 116 regenerates the blend after dynamic homogenization connects with the flow of the new blend - 107

This process is repeated continuously during operation of the boiler.

СПИСОК ИСПОЛЬЗОВАННОЙ ЛИТЕРАТУРЫ, ПАТЕНТНОЙ И ЛИЦЕНЗИОННОЙ ИНФОРМАЦИИ

United States Patent **8,715,378**
May 6, 2014

Fluid composite, device for producing thereof and system of use

Abstract

The current disclosure relates to a new fluid composite, a device for producing the fluid composite, and a method of production therewith, and more specifically a fluid composite made of a fuel and its oxidant for burning as part of different systems such as fuel burners, where the fluid composite after a stage of intense molecular between a controlled flow of a liquid such as fuel and a faster flow of compressed highly directional gas such as air results in the creation of a three dimensional matrix of small hallow spheres each made of a layer of fuel around a volume of pressurized gas. In an alternate embodiment, external conditions such as inline pressure warps the spherical cells into a network of oblong shape cells where pressurized air is used as part of the combustion process. In yet another embodiment, additional gas such as air is added via a second inlet to increase the proportion of oxidant to carburant as part of the mixture.

United States Patent **8,746,965**
June 10, 2014

Method of dynamic mixing of fluids

Abstract

Methods are provided for achieving dynamic mixing of two or more fluid streams using a mixing device. The methods include providing at least two integrated concentric contours that are configured to simultaneously direct fluid flow and transform the kinetic energy level of the first and second fluid streams, and directing fluid flow through the at least two integrated concentric contours such that, in two adjacent contours, the first and second fluid streams are input in opposite directions. As a result, the physical effects acting on each stream of each contour are combined, increasing the kinetic energy of the mix and transforming the mix from a first kinetic energy level to a second kinetic energy level, where the second kinetic energy level is greater than the first kinetic energy level.

United States Patent **8,844,495**
September 30, 2014

Engine with integrated mixing technology

Abstract

The present disclosure generally relates to an engine with an integrated mixing of fluids device and associated technology for improvement of the efficiency of the engine, and more specifically to an engine equipped with a fuel mixing device for improvement of the overall properties by inline oxygenation of the liquid, a change in property of the liquid such as cooling form improved combustion, or the use of re-circulation of exhaust from the engine to further improve engine efficiency and reduce unwanted emissions.

United States Patent **8,871,090**
October 28, 2014

Foaming of liquids

Abstract

Methods and systems for processing of liquids using compressed gases or compressed air are disclosed. In addition, methods and systems for mixing of liquids are disclosed.

United States Patent **9,144,774**
September 29, 2015

Fluid mixer with internal vortex

Abstract

The present disclosure generally relates to a fluid mixer, a system for mixing fluids utilizing the fluid mixer, and a method of mixing fluids using the fluid mixer or the system for mixing fluids, and more specifically, to a compact static mixing device with no moving parts and capable of mixing any fluid, such as air, nitrogen gas, water, oil, polluted water, and the like. A first pressurized, incoming fluid is accelerated locally by a section reduction, is split into streams, and then is released into a second fluid found in a closed volume or an open volume after a period of stabilization. The directed and controlled first fluid slides along an insert up to directional and angled fins at a vortex creator where suction forces from a self-initiating vortex in an internal cavity draws in at least part of the first fluid to fuel the vortex. The compactness and simplicity of the fluid mixer with internal vortex can be used alone within a closed volume in a conduit, in a sprayer, or within a fixed geometry to direct the mixing vortex to specific dimensions. One or more fluid mixers can also be used in an open volume such as a reservoir, a tank, a pool, or any other fluid body to conduct mixing. The technology alone, as part of a multimixer system, or as a method of mixing using the fluid mixer with internal vortex is contemplated to be used in any field where mixing occurs.

United States Patent **9,310,076**
April 12, 2016

Emulsion, apparatus, system and method for dynamic preparation

Abstract

The invention relates to a fluid composite, a device for producing the fluid composite, and a system for producing an aerated fluid composite therewith, and more specifically a fluid composite made of a fuel and its oxidant for burning as part of different systems such as fuel burners or combustion chambers and the like. The invention also relates to an emulsion, an apparatus for producing an emulsion, a system for producing an emulsion with the apparatus for producing the emulsion, a method for producing a dynamic preparation with the emulsion, and more specifically to a new type of a stable liquid/liquid emulsion in the field of colloidal chemistry, such as a water/fuel or fuel/fuel emulsion for all spheres of industry.

United States Patent **9,399,200**

July 26, 2016

Foaming of liquids

Abstract

A foaming mechanism configured to receive a plurality of streams of gas and generate a foamed liquid, having an aerodynamic component and an aerodynamic housing disposed around at least a portion of the aerodynamic component. The aerodynamic housing includes a plurality of first channels and a plurality of second channels connected to the plurality of first channels at regular intervals on a distributed plane. The distributed plane is about perpendicular to the plurality of first channels, wherein the plurality of first channels and the plurality of second channels are configured to transform an axial stream of the gaseous working agent into a plurality of radial high-speed streams of the gaseous working agent by channeling the gaseous working agent through the plurality of first channels and into the plurality of second channels on the distributed plane. A hydrodynamic conical reflector and a hydrodynamic housing form a ring channel in an area between the hydrodynamic conical reflector and the hydrodynamic housing. An accumulation mechanism is configured to disperse the plurality of radial high-speed streams of the gaseous working agent into the ring channel and create turbulence to foam the liquid.

United States Patent **9,400,107**

July 26, 2016

Fluid composite, device for producing thereof and system of use

Abstract

The current disclosure relates to a new fluid composite, a device for producing the fluid composite, and a method of production therewith, and more specifically a fluid composite made of a fuel and its oxidant for burning as part of different systems such as fuel burners, where the fluid composite after a stage of intense molecular between a controlled flow of a liquid such as fuel and a faster flow of compressed highly directional gas such as air results in the creation of a three dimensional matrix of small hallow spheres each made of a layer of fuel around a volume of pressurized gas. In an alternate embodiment, external conditions such as inline pressure warps the spherical cells into a network of oblong shape cells where pressurized air is used as part of the combustion process. In yet another embodiment, additional gas such as air is added via a second inlet to increase the proportion of oxidant to carburant as part of the mixture.