EVALUATION OF BASIC PARAMETERS FOR PACKAGING, STORAGE AND TRANSPORTATION OF BIOMASS MATERIAL FROM FIELD TO BIOREFINERY

A Thesis

by

RICHA PALIWAL

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2010

Major Subject: Mechanical Engineering

Evaluation of Basic Parameters for Packaging, Storage and Transportation of Biomass

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Approved by:

Co-Chairs of Committee,	Christian Schwartz
	Stephen W. Searcy
Committee Member,	Kalyan Annamalai
Head of Department,	Dennis O'Neal

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ABSTRACT

Evaluation of Basic Parameters for Packaging, Storage and Transportation of Biomass
Material from Field to Biorefinery. (December 2010)

Richa Paliwal, B.Tech, Osmania University

Co-Chairs of Advisory Committee: Dr. Christian Schwartz
Dr. Stephen Searcy

The universal adoption of biomass materials as an alternate fuel source to fossil fuels for transportation and electricity has been hindered by the high transportation costs involved in fuel production. Optimization of these initial costs will make the eco-friendly fuels more economically viable. Biomass is a promising feedstock for biofuels primarily because it is a renewable and sustainable resource. Among the most studied grassland crops, switchgrass is a perennial warm-season grass and has been identified as a potential energy crop. This research focuses on evaluating various physical parameters which affect the economic feasibility of packaging and transporting switchgrass from the field to the biorefinery.

The switchgrass was harvested using a mower conditioner followed by field chopping after varying drying periods. The first harvesting period spanned from early November to mid December 2007 and the second was August to October 2008. Densification properties of chopped switchgrass were studied under compression. The effects of compressive stresses (41 to 101 kPa), number of strokes (1 to 10), moisture content (9 to 62%) and chopping length (63 and 95 mm) on the densification of chopped switchgrass were studied.

The final dry matter density (DMD) increased with the compressive stresses and the number of strokes, small chop length and low moisture content. The maximum free-standing DMD obtained was 245 kg/m^3.

DEDICATION

To God for His blessings.

To Ma and Papa for their endless love, support and encouragement.

To Didi, Jiju and Bhai for their unconditional love.

To Gautam for his constant love, patience and motivation.

To Dr. Searcy and Dr. Schwartz for their inspiration and support.

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First, I would like to express my heartfelt gratitude to Dr. Steve Searcy for identifying my potential and for his guidance and support throughout the course of my research at Texas A&M University. He has undoubtedly been a great mentor for my academic and professional pursuits. I would also like to thank my advisor, Dr. Cris Schwartz, who has also guided me throughout the course of this research. I am also grateful to Dr. Kalyan Annamalai for serving on my committee.

I would like to thank John Gibson for his support and encouragement during the entire course of this research. I would also like to thank Dr. Searcy’s undergraduate student employees for assisting me in conducting the experiments.

Last but not least I would like to thank my parents for their support and for encouraging me to pursue higher studies.

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1. INTRODUCTION

The world energy crisis, coupled with the pressing need to reduce the world dependence on oil, has placed an important emphasis on developing alternate fuel sources such as wind, solar, geothermal, biofuels, and many more. These are known as renewable energy resources, unlike fossil fuels which are non-renewable. Development of these renewable resources is necessary to reduce the carbon emissions, protect the environment and supply sustainable resources. Among the many challenges of making biomass energy economically and technically feasible is the need to collect and transport extremely large quantities at low cost. This research focuses on developing an efficient method of harvesting and packaging switchgrass, a biomass material, for transportation to a biorefinery.

Biomass, a renewable energy resource, is an organic material derived from plants and animals. It is not only used to produce fibers and chemicals, but also used in the production of fuels like methane gas or transportation fuels such as ethanol and biodiesel. Biomass fuels, also known as biofuels, are extracted from plants and can be solid, liquid or gas. Some of the biofuels include bioethanol, biomethanol, vegetable oil, biodiesel, biogas and bio-synthetic gas. The most commonly used biofuels are ethanol and biodiesel.

Biomass is a promising feedstock for biofuels primarily because it is a renewable

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This thesis follows the style of Biomass and Bioenergy.

and sustainable resource. Secondly, it has a low sulfur content and a positive impact on the environment[1]. Biomass energy crops can be beneficial to farmers as a profitable alternative crop that can be grown on underutilized farmland or implemented into a crop rotation. The environmental benefits they offer have been shown to minimize net carbon dioxide emissions during biomass combustion [2]. Energy crops have been widely tested to supply high dry matter yields (when converted to energy) while replacing the carbon back in the soil [3, 4].

As the most commonly used biofuel, ethanol is widely extracted from food crops like corn, sugar cane, wheat etc. It can also be obtained from lignocellulosic feedstocks (non-food products) like agricultural residues, forest residues, wood wastes, corn fiber and other grassland crops. Lynd et al. [5] also suggests that lignocellulosic feedstocks are more eco-friendly over the conventional feedstocks like corn and sugarcane. According to House et al. [6], the high cellulose content in biomass feedstock makes it an efficient ethanol conversion technology.

Among the most researched grassland crops, switchgrass is a perennial warm-season grass and has been identified as a potential energy crop. It grows 8-10 feet tall and survives under even the most severe weather conditions [7]. If these energy grasslands can be converted to fuel using high efficiency conversion technologies, they may be able to help replace fossil fuels and also address the environmental (pollution and climate change) concerns.

When compared to fossil fuels, biomass is a low density material because it is spread across a large area (hectares of land); and therefore needs to be collected, packaged, and transported to the conversion facility to convert it to biofuel. The universal adoption of biomass materials as a fuel source has been hindered by the high costs involved in feedstock procurement, storage, and transport. Cost minimization and optimization of these logistical issues are necessary to make such eco-friendly fuels more economically viable. These major expenses contribute to the high cost of biomass fuel. Epplin et al. [8] has estimated the approximately two-thirds of the cost is tied up in the harvesting and transportation operations.

Due to the short span of the harvesting period, it is necessary to collect and store biomass materials for utilization year round. Baling is a widely used method of packaging and storing biomass materials. Bales are usually stored in form of round or square bales. The drawback to this method is that each bale has to be handled individually for loading and unloading which makes it tedious to handle, store, and transport [9].One approach to resolve this issue would be to package biomass into a large single unit for handling, storage and transportation. This can be done by densifying the biomass material and making it into a single unit (i.e. modules) which can reduce the expense in handling and post-processing of this material. The cost estimated for baling and pelleting have been 22 to 48% higher when compared to modularizing and chopping the material [10]. High bulk density is desirable to improve the storage density and reduce the material porosity, reducing material oxidation and storage losses. An increase in density can be achieved by the application of mechanical force on the finely chopped materials to produce pellets, briquettes, cubes or modules, depending on the material condition and the force applied.

The following are the objectives of this research:

- Determine the influence of material properties and applied compressive stresses on the unrestrained density of chopped switchgrass.
- Build a function structure to aid in the understanding of parameters that influence the efficiency of packaging, storing and transporting the biomass material from the field to a biorefinery.

2. LITERATURE REVIEW

Currently, starch and sugar crops (such as corn or sugarcane) are widely used feedstock for the production of ethanol (liquid fuel). Brazil and the United States (US) are the foremost producers of ethanol, accounting for 80% of world production. Brazil uses sugar cane as a feedstock while, the US uses primarily corn grain as a feedstock. The US produces up to 12 Mm^3 (3170.04×10^6 gallon) of ethanol annually [11]. Apart from corn and other starch crops, lignocellulosic biomass, such as agricultural residues, herbaceous crops, wood wastes, forest residues and other wastes, are emerging as potential feedstocks for ethanol production. Producing ethanol from biomass is one of the ways of reducing the consumption of crude oil and also environmental pollution [12]. The annual and perennial energy crops have been under study as alternate energy resources to fossil fuels. Examples of annual crops are corn and sorghum, and perennial crops are switchgrass and reed canary grass. Amongst the two (annual and perennial), perennial crops have been given importance because of their high dry matter yield with low input requirements [13].

2.1 Switchgrass as a Potential Biomass Energy Crop

Switchgrass (Panicum virgatum, L.), is a perennial warm-season grass which complements cool-season species by filling the summer slump i.e. low biomass production period. Its carbon sequestration capability, low nutrient requirement, efficient water usage, drought tolerance, and its adaptability to a wide range of soils have made it a potential energy crop [2, 4, 14, 15]. Cundiff et al. [16] also states the benefit of using switchgrass: it can be harvested and baled using conventional agricultural equipment. A custom rate survey, was conducted on hay harvest cost in Georgia, Tennessee and Virginia, and it was apparent from the survey that herbaceous biomass can be handled using the hay equipment at a lower cost than silage. Several studies have been conducted to evaluate the collective impact of using agricultural land to grow energy crops based on the assumption of growing switchgrass in extensive fashion than intensive [5, 10]. The calorific heat content of switchgrass is reported to be around 17212.4 KJ/kg (7400 Btu/lb), which is higher than other biomass materials like corn stover, wheat straw and barley straw [17]. This has been attributed to the fact that switchgrass has a lower ash content over the other materials considered in this study. Switchgrass can grow 2.4m (7.9 ft) to 3m (9.8 ft) in height under favorable conditions [7] . It starts growing in early spring and reaches its peak growth in mid June [14]. So the material is available for harvesting around mid August to mid December, depending upon the weather conditions. Due to this short span of the harvesting period, biomass materials are collected and stored for utilization year round.

Perennial grasses like switchgrass can be harvested more than once a year. It has been claimed that when switchgrass is cut twice a year, its dry matter yield increases by 47% over a single cut [18]. Some researchers have also claimed that two harvests per year may increase the yield in some cultivars, but one harvest per year gives better yield for other cultivars in places like Oklahoma, Tennessee, and Texas. The high single harvest yield reported were 27.4 Mg/ha in Tennessee, 34.6 Mg/ha in Alabama and 26

Mg/ha in Texas [7, 19, 20]. More than two harvests per year, however, might affect the long term productivity in a negative way [21]. Contrary to these findings, Beaty et al.[22] has claimed that frequent harvests and low cutting heights can result in lower energy conservation that switchgrass needs for winter survival and spring growth[22, 23]. The optimum number of harvests and cutting height required to maximize the productivity and re-growth is uncertain and likely varies with location and weather conditions.

Two of the primary factors that should be considered while harvesting more than once a year are the costs for the harvesting equipment and labor over the increased yield. Up to this point, researchers have neglected to consider these costs, which contribute heavily towards the high expenses of harvesting.

2.2 Various Packaging Methods for Biomass Materials

2.2.1 Baling

Today, baling is the most widely used method for the packaging and storing of biomass material. Baling of forages was developed to efficiently handling animal feed. Bales are usually stored in round or square form. Square bales and round bales used for storing biomass materials are typically 0.9m x 1.2m x 2.4 m (3ft x 4ft x 8ft) and 1.8 m x 2.4 m (6ft x 8ft) respectively. If harvested at moisture content above 18%, the bales are often stored in plastic wrapped bale tubes. These bales are wrapped in bale tubes for storage. Square bales are stacked two to three high and round bales are stacked one high. Cuddif et al. has asserted that the maximum dry matter density for round bales was 121 kg/m^3 (7.5 lb/ft^3) while higher densities like 140 kg/m^3 (8.7 lb/ft^3) can be obtained by chopping and compressing the material [16]. They suggested that the two factors that increase the harvest cost at higher yields for round bale system are the baling and the hauling costs. Compared to the round bale system, the harvest cost per dry Mg decreased with the increased yield in the square bale system. The study also evaluated the harvest cost (at 9 Mg ha^{-1} yield) to be 23% more for round bale ($ 15.9/dry Mg) over square bale ($ 12.25/dry Mg). It was also observed that, the density of hay affected the performance of the round baler; i.e., heavier windrows produce low density bales, consequently increasing the harvest cost with the yield (doubling from 9 to 18 Mgha^{-1}). Hence, they concluded that the square bales are the best choice when considering the harvest costs. There are drawbacks to using baling as a packaging method for biomass materials for conversion to biofuel. The first is that each bale has to be handled individually for loading and unloading. The second drawback is the need to grind the biomass to a particle size suitable for the conversion facility. Therefore, densification of chopped biomass seems a likely solution for reducing costs because more material can be handled at one time, and particle size is reduced during the harvest operation.

2.2.2 Silage

Another form of biomass storage that is commonly used is as chopped material, similar to the system of creating silage for animal feed. Silage is chopped in the field and blown into a wagon, which is then transported in loose form to the storage site where it is dumped in piles. These piles are typically compressed with a variety of mechanical approaches, depending on the form of storage. Plastic covers are then placed over these piles to create an anaerobic (oxygen deficient) atmosphere, preserving the material until it is to be used for animal feed. Silage is handled by a loader and hauled in a truck when it is taken out of storage. This creates a similar problem as in baling i.e. several individual loads are needed to fill the truck.

2.2.3 Pelletizing

Pelleting is a densification process that has been used to make fuel pellets made from wood, corn and other biomass materials. Pelletization is a process of converting loose biomass into dense pellets.The costs estimated for baling and pelleting in the past have been 22% to 48% higher when compared to modularizing and loose chop [10]. High compressed densities, like 138 kg/m^3 (8.6 lb/ft^3) to 388 kg/m^3 (24.2 lb/ft^3), were obtained for alfalfa and grass silage. These compressed densities are desired to improve storage and reduce material porosity, which in turn reduces material degradation [24].

2.3 Moduling Concept for Biomass Materials

Seed cotton is harvested using stripper harvesters and then transformed into a module for transport. Cotton modules are formed by dumping harvested cotton into a module builder and compressing it to make a module 9.8m x 2.4m x 2.4m (32ft x 8ft x 8ft) weighing up to 12,000kg. Cotton modules are then picked up by a module truck and moved to cotton gin yards where they are stored until they are ready to be ginned as shown Figure 1. To reduce the number of packages that have to be handled, cotton modules were looked at as an alternative form of packaging for biomass.

Principles of the cotton module concept and the chopped silage process could be combined and applied to biomass, making a chopped biomass module. These modules

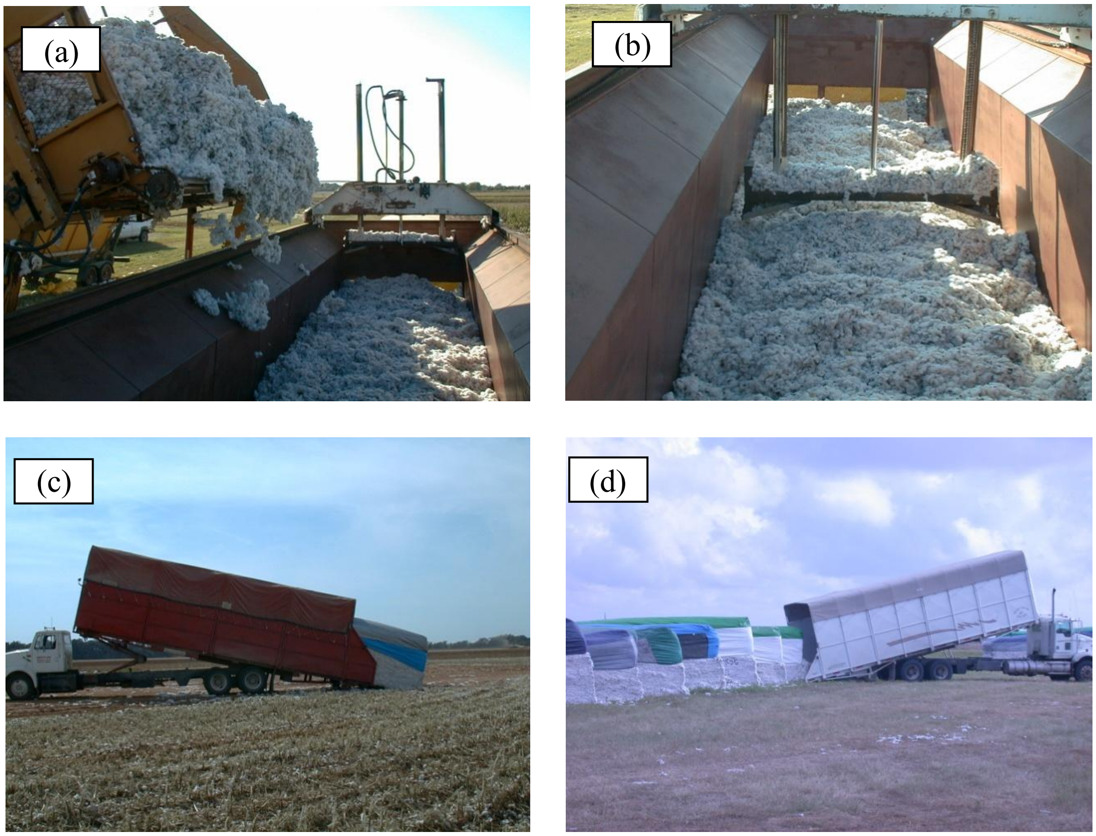

Figure 1. (a) Seed cotton is dumped in a cotton module builder (b) Cotton under tramper (c) Cotton module being loaded in a module truck and (d) Cotton modules being unloaded from the module truck

would have a comparable dry matter density to bales since they are compressed and also have a smaller particle size. Biomass materials require size reduction before they are converted to biofuels to enable the material to properly mix with air. Modules of chopped biomass provide ease of transport as well as exclude the necessity to grind the bales before converting the material to biofuels. Therefore; densification is one solution to reduce the inconsistency in handling i.e. handling one module (9.8m x 2.4m x 2.4m weighing approximately 12000 kgs) over a number of small round (1.8m x 2.4m weighing approximately 400-600 kgs) or ssquare bales (0.9m x 1.2m x 2.4 m weighing

400-600 kgs) and post-processing this material at the conversion facility. There is not enough in the literature stating the switchgrass material properties and its behavior under compression.

2.4 Factors Effecting Densification

Particle size is one of the significant parameters for achieving the high density[25]. Mani et al. [17] states that for biomass energy conversion, size reduction is an essential pretreatment, and also vital for the densification process. To make fuel pellets, the biomass material needs to be transformed to a denser product. They studied four grinds with particle sizes of 0.8 mm. These four grinds produced the bulk density of 121 kg m^{-3} (7.5 lb/ft^3) for wheat straw, 112 kg m^{-3} (7.0 lb/ft^3) for barley straw, 158 kg m^{-3} (9.9 lb/ft^3) for corn stover and the highest bulk density was obtained in case of switchgrass, which is 183 kg m^{-3} (11.4 lb/ft^3). Therefore, they concluded that larger the particle size, the lower is the bulk density and vice versa.

Mani et al [26] makes the comparison of compression behavior of wheat, barley straws, corn stover and switchgrass grinds using three compaction equations: Heckel, Cooper-Eaton, and Kawakita- Ludde models. They studied the compaction mechanism of grinds using variables like applied pressure, particle size and moisture content. Heckel's model was used for compressed powders, and the equation was in terms of density of powered material and the applied pressure. Copper and Eaton's model was based on particle rearrangement and deformation, and the equation describes the ceramic powder's compact behavior. Kawakita and Ludde's model described the pressure – volume relationship. This model was proposed for biomass materials. They concluded that the densification of switchgrass grind was more difficult by particle rearrangement than by particle deformation, which was attributed to its fibrous nature. Hence, particle deformation by compression seems to be a better method for densification of switchgrass. Limited work has been done on the compressive properties of chopped switchgrass.

Apart from particle size, moisture is one of the factors that needs close attention. Higher moisture is usually desirable to achieve high compressed density and compactness. But lower moisture aids in efficient combustion for the conversion of feedstocks to fuel. It is a known fact that moisture can have a considerable effect on fermentation[27]. Han et al. studied the effects of moisture concentration and crop density on chopped alfalfa silage [27]. Mani et al. also studied the physical characteristics of four grinds that include wheat, barley straw, corn stover and switchgrass. They also suggest moisture as an important parameter and concluded that the moisture content has a positive correlation with specific energy consumption, i.e. the higher the moisture content, the higher the specific energy consumption [17].

2.5 Logistics Modeling

Logistics for transportation of agricultural feedstock primarily deal with harvesting, pre-processing, storage and transport. There are various limitations such as randomly distributed raw material, weather-sensitive crop maturity, moisture content, and the harvest window affecting the crop. To minimize the total cost, optimization of harvest activity, storage and transport are required. Sokhansanj et al. developed a simulation model called Dynamic Integrated Biomass Supply Analysis and Logistic model (IBSAL) for biomass materials [28]. This model accounts for the climate, operation constraints, resource availability like labor and equipment for supply, and transportation operations. IBSAL biomass supply model was developed using object oriented high level simulation language EXTEND^{TM}. The system is comprised of two processes: collection and storage, and preparation and transportation of biomass to a biorefinery. This model takes in to consideration collecting and transporting large amounts of biomass material, which can be practically, implemented. It considers the weather and yield data, and it also provides the total costs involved in equipment, labor and structures.

Kumar et al. used IBSAL to study the input energy, cost and carbon emissions for various switchgrass supply systems like baling, ensiling and loafing [29]. The model requires the data input such as local weather data, average biomass yield, land cultivated, crop harvest dates, dry matter loss with time while in storage, moisture content while the material is harvested, equipment operating costs. The model outputs the energy consumption for each supply system, dry matter loss while delivering, green house gas emmisions and total delivered cost (includes the sum of collection and transportation costs) of the switchgrass to the biorefinery. The biorefinery capacity assumed was 2000 dry tons/ day of switchgrass. The study concluded that baling was a better option over others (except loafing) above 4100 dry tonnes/day capacity. The energy consumption for different delivery system varied from 4.8% - 6.3% of switchgrass energy content. Dry matter losses varied from 3% - 4%. The estimated costs for various systems were: $44-

$47/dry tonne for bailing, $37/dry tonne for loafing and $48/dry tonne for ensiling. These costs do not include the farming costs and payment to farmers.

2.6 Implementing Cotton Logistics and Building a Function Structure for Biomass Materials

2.6.1 Cotton Logistics

Ravula et al. produced a cotton logistics model, which can be used for biomass[30]. This model used modularized loads for the trucks and the same could be applied to biomass. Biomass logistics included a number of components that were similar to the ones used for cotton modules. However, there were some differences which had be considered:

- In the case of cotton modules, truck and gin utilization were limited by module call-in rates which might cause a truck shortage (high call-in rates) or under utilization of trucks (low call-in rates). A biomass system was proposed that could monitor the amount of biomass in storage and thereby aid in optimizing hauling.
- The current simulation does not take into account the storage capacity of the gin. In the case of biomass, material and economic limits should be considered.
- Cotton ginning, a mechanical process, could be rescheduled without causing significant economic loss, whereas biomass conversion, a chemical process, would affect the production flow. The negative economic repercussions of biomass feedstock shortage are more serious than that of cotton gin.

To replace this system with modules requires an understanding of various physical and logistical parameters which affect the economics of the module packaging system. Many researchers have evaluated and developed simulation models for cotton gin wastes, sugar cane, corn stover and also wheat straw [31, 32]. For example, the wheat straw simulation model (SHAM – Straw Handling Model) was developed for baling and transporting the material to district heating plants in Sweden. The model has the capability to analyze and predict the amount and cost of biomass supply while optimizing resource allocation to minimum bottlenecks. However the system fails to accommodate bulk handling of biomass[33].

2.6.2 Function Structure

Axiomatic Design is a method that can be applied to any design activity. To analyze and optimize the logistical issues involved in harvesting, storing, and processing the materials, Axiomatic Design methodology was employed. With the help of this design process a function structure was developed with basic building blocks namely the functional requirements and the physical (design) parameters.

Design has been defined as "an interplay between what we want to achieve and how we want to achieve it" [34]. A function structure is a structured hierarchy which represents the individual logistical challenges in functional terms as well as subdivides the larger problem into a collection of smaller, more manageable design goals. The purpose of a function structure is to analytically break down a set of generalized problem requirements in to a specific set of design parameters, while avoiding an early convergence on a solution. This approach generalizes the problem in a way that allows for solutions to be proposed that are not entangled with existing solutions that may be problematic. These parameters would help answer the question “What specific aspects need to be addressed” without addressing how these particular aspects need to be solved.

Once the general functional requirements are defined, a solution is conceptualized by mapping the functional domain to the physical domain. As we start progressing down the hierarchy defining more specific functional requirements, the problem can be broken down to the specific physical domain called the design parameters (DP) following the same conceptual approach. These DPs are the essential physical variables in the physical domain which help in characterizing the design as well as fulfilling the functional requirements. The mapping process, i.e. defining from “what” to “how” based on a particular concept, requires generating many solutions to each functional requirement and then selecting the best fit. This process is complete when the design parameters are identified with a particular concept in place.

Baling forages and cotton modules are the two packaging methods that have been studied for their economic feasibility for handling, storage and transport. A basic understating of these systems aided in creating the functional requirements (FRs) and the laboratory experiments with the design parameters (DPs). For current research, the main goal was to maximize the ratio of output energy to input energy, thus maximizing overall system efficiency, i.e., optimizing the logistics to implement biomass as a renewable energy resource. Since the function structure is not solution driven it can be applicable not only to switchgrass but also to other biomass materials.

This research makes an attempt to understand the material behavior of switchgrass so that the compression as well as the moduling concepts can be applied to this material hence making it possible to reduce the handling and transportation costs of the material to the conversion facility.

3. BEHAVIOR OF CHOPPED SWITCHGRASS UNDER COMPRESSION

3.1 Background

Biomass is a promising feedstock for biofuels primarily because it is a renewable and sustainable resource. Secondly, it has a low sulfur content and a positive impact on the environment [1]. Biomass energy crops can be beneficial to farmers as a profitable alternative crop that can be grown on underutilized farmland or implemented into a crop rotation. Switchgrass (Panicum virgatum, L.), is a perennial warm-season grass. Switchgrass' carbon sequestration capability, low nutrient requirement, efficient water usage, drought tolerance, and adaptability to a wide range of soils have made it a potential energy crop [2, 4, 14, 15]. Cundiff et al. [16] also states the benefit of using switchgrass: it can be harvested and baled using conventional agricultural equipment. The calorific heat content of switchgrass is reported to be around 17212.4 KJ/kg (7400 Btu/lb), which is higher than other biomass materials like corn stover, wheat straw and barley straw [17]. This has been attributed to the fact that switchgrass has a lower ash content over the other materials considered in this study. Switchgrass can grow 2.4m (7.9 ft) to 3m (9.8 ft) in height under favorable conditions [7] . Baling is the most widely used method for the packaging and storing of biomass material. Other methods of packaging biomass materials are silage, pelletizing, loose chop etc. Principles of the cotton module concept and the chopped silage process could be combined and applied to biomass, making a chopped biomass module. These modules would have a comparable dry matter density to bales since they are compressed and also have a smaller particle size. Biomass materials require size reduction before they are converted to biofuels to enable the material to properly mix with air. Modules of chopped biomass could provide ease of transportation or minimize the energy requirement. Depending on the required particle size, grinding may still be needed bales before converting the material to biofuels. There is very little published information available that pertains to the engineering properties of switchgrass and its behavior under compression.

The objective of this research is to determine the influence of material properties and applied compressive stresses on the unrestrained density of chopped switchgrass. Particle size is one of the significant parameters for achieving the high density[25]. Mani et al. [17] states that for biomass energy conversion, size reduction is an essential pretreatment, and also vital for the densification process. To make fuel pellets, the biomass material needs to be transformed to a denser product. They studied four grinds with particle sizes of 0.8 mm. These four grinds produced the bulk density of 121 kg m^{-3} (7.5 lb/ft^3) for wheat straw, 112 kg m^{-3} (7.0 lb/ft^3) for barley straw, 158 kg m^{-3} (9.9 lb/ft^3) for corn stover. The highest bulk density was obtained in case of switchgrass, which is 183 kg m^{-3} (11.4 lb/ft^3). Using additional experiments with different particle sizes, they concluded that a smaller particle size produces a higher bulk density.

Mani et al [26] makes the comparison of compression behavior of wheat, barley straws, corn stover and switchgrass grinds using three compaction equations: Heckel, Cooper-Eaton, and Kawakita-Ludde models. They studied the compaction mechanism of grinds using variables like applied pressure, particle size and moisture content. Heckel's model was used for compressed powders, and the equation was in terms of density of powered material and the applied pressure. Copper and Eaton's model was based on particle rearrangement and deformation, and the equation describes ceramic powder's compact behavior. Kawakita and Ludde's model described the pressure – volume relationship. This model was proposed for biomass materials. They concluded that the densification of switchgrass grind was more difficult by particle rearrangement than by particle deformation, which was attributed to its fibrous nature. Hence, particle deformation by compression seems to be a better method for densification of switchgrass. Limited work has been done on the compressive properties of chopped switchgrass.

Apart from particle size, moisture is another factor that needs close attention. Higher moisture is usually desirable to achieve high bulk density and compactness whereas lower moisture aids in efficient combustion for the conversion of feedstocks to fuel. Han et al. studied the effects of moisture concentration and crop density on chopped alfalfa silage [27]. Mani et al. also studied the physical characteristics of four grinds that include wheat, barley straw, corn stover and switchgrass. They suggest moisture as an important parameter and concluded that the moisture content has a positive correlation with specific energy consumption, i.e. the higher the moisture content, the higher the specific energy consumption [17].

3.2 Materials and Methods

To achieve the objective of this research, two sets of compression tests were conducted. The first set was preliminary tests which helped to determine the basic parameters that will help to attain maximum dry matter density in switchgrass mini modules. The conclusions drawn from the first set helped to modify the second set of tests.

3.2.1 Material Collection

The switchgrass used for the experiments was obtained from Texas A&M research farm near College Station, Texas (30.5287 latitude, -96.4282 longitude and 67.056 m elevation). The harvesting period for the first set of experiments was from November to mid December of fall 2007 and the second set was August to October 2008. This work was conducted between 2007 and 2009 . The research farm is located on weswood silt loam, 0 to 1 percent slopes, rarely flooded (WeA) soil type [35] . Approximately 0.9 hectares (2.2 acres) of Alamo switchgrass variety was established in year 2001. The crop was harvested using a MacDon mower conditioner (MacDon Inc., R80 rotary disk pull type windrower with “n” bar conditioning rolls) with effective cutting width of 3.9m (12.78ft) as shown in Figure 2. The conditioner was used to crimp the crop, opening up the stem along the plant allowing for faster dry down time.

Figure 2. (a) MacDon 13’ PT mower-conditioner with rotary disc header and (b) MacDon mower conditioner laying down windrows in the switchgrass field

The windrows were then chopped using a John Deere 3955 towed forage harvester and collected in a Sunflower 8010 dump wagon, as shown in Figure 3. The theoretical chop length would be referred to as chop length throughout. The chopper's length of cut has two different settings: viz. 63 mm (1/4 inch) and 95 mm (3/8 inch). The chopped material was dumped onto a tarp of 4.8 m (16 ft) by 6.1 m (20 ft) for transport to the laboratory. The material was wrapped in the tarp to maintain its original moisture content. The material was stored in the same tarp during the entire course of the experiments i.e, about a day or two.

The material was harvested at the research farm on a weekly basis. At the beginning of the week, three swathes of material were laid down on the ground. One row of material was immediately chopped and transported to laboratory for testing. The other 2 rows were allowed to field dry for 24 and 48 hours respectively. Five such replications were conducted.

Figure 3: (a) John Deere 3955 towed forage harvester (b) Sunflower 8210 dump wagon (c) Towed harvester picking up a windrow and (d) Dump wagon collecting chopped material from the towed forage harvester

3.2.2 Moisture Test

The chopped switchgrass collected in the tarp was transported to the laboratory and a moisture test was conducted using the ASAE standard S358.2 for forages. Approximately 100g of sample was weighed on an analytical balance (accuracy of 0.1 mg) in an aluminum pan and then kept in the convection drying oven, with temperature control of 105ºC ± 3ºC for 24 hours. The material was thoroughly mixed in the tarp and 100 g of sample was weighed along with the aluminum pan. The standard procedure was followed to determine the moisture content of the material. The moisture tests were conducted before and after the compression tests every day. The tests for each batch of material took an average of two days to complete. During the two day process, the difference in the moisture content for the same sample was minimal i.e., around 0.1% or less. Since the material was properly wrapped and thoroughly mixed before the experiment, the change in moisture content was neglected while analyzing the data. The samples overall, however, varied greatly in moisture content over the range of 9% to 60%.

3.2.3 Compression Test Apparatus

The compression testing apparatus used for the experiments was mounted on a robust frame, and force was applied using a hydraulic cylinder with a 30.5 mm (12 inch) diameter plate on the ram as shown in Figure 4. The shear beam load cell (Hottinger Baldwin Measurements) was mounted on the other end of the cylinder as shown in Figure 5, and had a rated capacity of 22240N (5000 lb). The combined error of the load

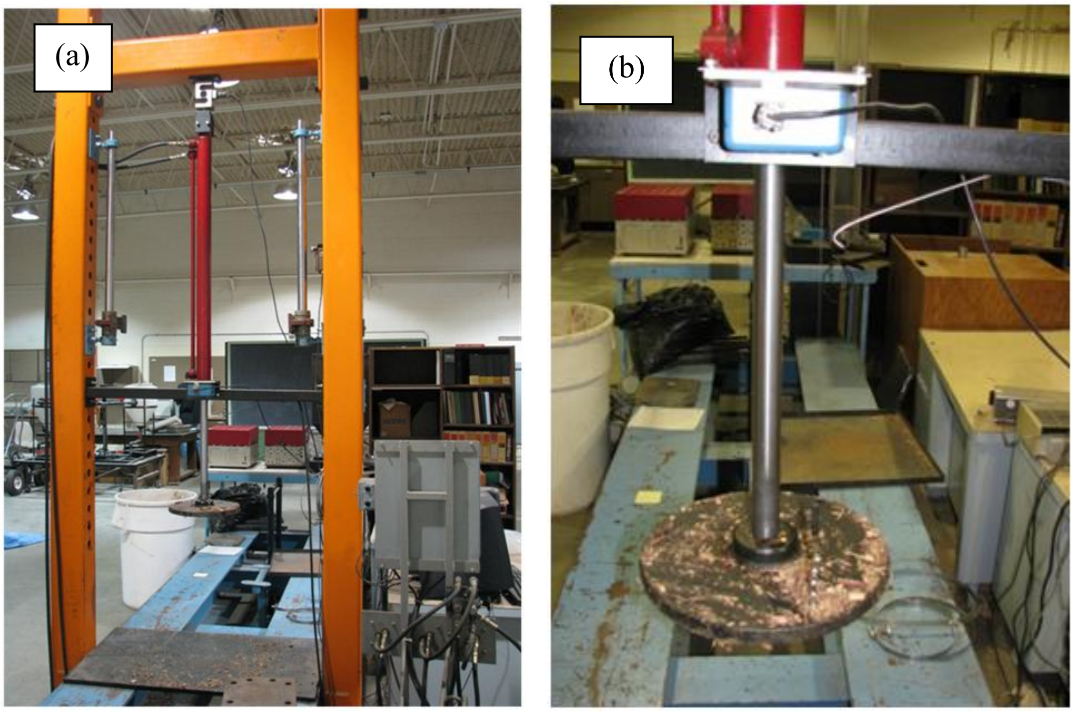

Figure 4: (a) Compression testing apparatus and (b) String potentiometer and compression plate

cell was 8.9 N (2 lb). The extension of the hydraulic cylinder was measured using the string potentiometer (1850-030 Houston Scientific String Potentiometer), as shown in Figure 3b. The base of the position transducer was mounted to the frame of the testing apparatus and the cable was connected to the plate. The maximum string extension was 0.84m (33 in) and the non linearity of the potentiometer was 0.084% (0.025 in). The reported repeatability was 0.0004m (0.015 in), resulting in a total maximum height error of 0.001m (0.040 in).

Figure 5: Hottinger Baldwin Measurement load cell

The output of each sensor was sampled at 3.33 Hz using an Agilent 34970A data acquisition unit equipped with the 34901A a 20-channel multiplexer. The maximum voltage measurement error was calculated based on the actual reading and the voltage range used by the analog-to-digital converter within the data logger. The maximum force measurement error ranged from 2.5N (0.56 lb) at zero force to 3.6 N (.81 lb) at the rated load. The resulting total error in the force measurement ranged from 11.4N (2.6 lb) to 12.5 N (2.8 lb). Because of the larger voltage range of the string potentiometer, the voltage measurement error was insignificant, compared to the actual error of the sensor.

The chopped biomass material was compressed in a PVC cylinder of 0.135 m (12 inches) diameter and 0.914 m (36 inches) height as shown in Figure 5. The cylinder was split into two equal halves and quick-release hose clamps were used to hold them together around the circumference during compression of the biomass. After completion of the series of compression strokes, the cylinder halves were removed to allow uninhibited expansion as the compressive stress was released when retracting the hydraulic ram. This design enabled the compressed material to remain undisturbed and also avoided the interference of wall friction with the material. The PVC cylinder was placed over a metal plate to form the cylindrical module. This allowed for the column of compressed material to be easily moved after compression.

Figure 6: PVC cylinder along quick release hose clamps mounted on a metal plate

3.2.4 Compression Test

The parameters tested for in these experiments are the compressive stresses, number of strokes and chop length (theoretical chop length). When the PVC cylinder was filled with the chopped switchgrass it was observed that an approximate initial density of 80 kg/m^3 (5 lbs/ft^3) was obtained and so this initial density was used for all the experiments. The average temperature maintained in the lab was 21°C (70°F). The first set of experiments were conducted from September to mid October 2007 with six different compressive stresses applied by the plate were 41.1, 48.6, 56.1, 63.3, 71.1 and 78.6 kPa. Each compression cycle comprised of 10 strokes. In 2007, only one chopping length, 95 mm (0.375 inch), was used. Before loading the material in the cylinder, it was thoroughly mixed using a shovel to ensure the uniformity of moisture in the complete sample. The chopped switchgrass was loaded into the PVC cylinder and compressed with the hydraulic pressures listed above. When the maximum applied pressure was reached, it was held for 2 seconds and then the pressure was removed, that is the plate was retracted to its initial position. A total of 10 compression strokes were applied at each hydraulic pressure. Once each compression cycle was completed, the quick release hose clamps were unscrewed, and the column of switchgrass was set aside on the floor as shown in Figure 7. The height of the compressed module after relaxation was measured using a measuring tape to calculate the recovered density.

The initial loaded density was calculated from the mass of the loaded material in the cylinder and from the height of the cylinder. The mass necessary to achieve the initial density was weighed and filled in the cylinder. Effort was taken to obtain a uniform loading density throughout the PVC cylinder. In some cases, slight manual pressure was applied to get all the measured mass into the cylinder. The material was loaded into the cylinder and compressed once, then the hydraulic ram was retracted after the applied force reached the maximum for the set hydraulic pressure. Multiple compression cycles were applied on each sample. The sides of the cylinder were removed following the last compression stroke to measure the unrestricted recovery of the column of chopped switchgrass.

Figure 7: Switchgrass modules set aside after the compression tests

The height of the column was measured at 0, 15, 30, 45 and 60 minutes and 24, 48, 72 hours after removal from the cylinder. Initially, some of the columns fell over before 24 hours elapsed. Therefore, supports were made that allowed the columns to remain upright and expand without significant friction.

Based on the analysis of the first set of experiments, the procedures for the second set were modified. The analysis showed that the final dry matter density (DMD) was almost linearly proportional to the hydraulic pressure applied, so two higher hydraulic pressures, 7584.23 KPa and 9307.92 KPa (1100 and 1350 psi respectively), were chosen along with one of the hydraulic pressures 5860.54 KPa (850 psi) used in the first set of experiments. The numbers of strokes were reduced from 10 to 5 because it was observed that, after fifth stroke, the increase in the final DMD did not justify the additional time and energy of the additional strokes. Also, in this set of experiments each pressure and moisture set had four replications. To study the affect of the chopping length on the final DMD, two chopping lengths of 0.063 m (0.25 inch) and 0.095 m (0.375 inch) were included. These experiments were conducted from August to mid October 2008. For this set of experiments, an attempt was made to maintain the moisture content between 10%– 50%. To achieve this goal the material was field dried for 24 and 48 hours. The experiments were designed so that they would apply the independent variables in a random order.

The data was retrieved from the data acquisition system and then transferred to an Excel spreadsheet. Before the data was interpreted, the actual density and the dry matter density were calculated using the following formulas:

Actual Density = Mass/ Volume

= Mass of material loaded / (pi × radius^2 × height of the plate extended)

Dry matter density (DMD) = Actual Density × (100% - % moisture content)

The height was measured at the end of the compression phase with the potentiometer reading and was then used to calculate the compressed density.

The data from the two sets of experiments was analyzed using the statistics software, JMP. The technique used to analyze the data was Analysis of Variance (ANOVA). This technique correlated the interaction between the parameters of the experiment. In Analysis of variance (ANOVA) using a model that included all interaction terms was performed on both the sets of data individually. Since large number of terms were involved, ANOVA procedures were performed again with a reduced model consisting of only parameters and interactions that were statistically significant.

3.3 Results and Discussion

The experimental procedure analyzed the effect of parameters such as compressive stresses, particle size (chopping length), moisture content and number of strokes on the final dry matter density. The compressive stress, number of strokes, particle size and moisture content were the design (independent) variables and the final dry matter density (DMD) was the dependent variable. The experimental design helped determine the interactions between the compressive stress, number of strokes, particle size and moisture content.

3.3.1 Analysis of 2007 data

The 2007 data used for the statistical analysis had only one chopping length of 0.095 m (0.375 inch). The final dry matter density was the dependent variable in the

ANOVA procedure for the compression analysis. The three independent variables used were compressive stresses, number of strokes and moisture content.

The final DMD was calculated with the height measured at the end of the compression phase. This DMD was the dependent variable used in the ANOVA procedure. For the analysis of the DMD, the compressive stresses and moisture content interactions were significant in the full model and were included in the reduced model. All the main effects and the interaction between compressive stress and moisture content were significant factors in the reduced model . R^2 for the reduced model with DMD as the dependent variable was 0.565.

Comparison of the means for each effect was done using the least square means. Statistically significant differences were seen for the mean DMD between the first two and the bottom two levels of compressive stresses tested. Table 1 illustrates the mean DMD for the six compressive stresses. For all tables, means in a column followed by the same letter were not significantly different at the 5% level.

Table 1. Least square means of DMD for various compressive stresses (2007)

Level	Compressive stress (kPa)	DMD (kg/m^3)
1	41.1	175^d
2	48.6	183^c
3	56.1	187^{bc}
4	63.6	192^b
5	71.1	191^b
6	78.6	216^a

Although the difference in the DMD between compressive stress levels 3, 4 and 5 are statistically insignificant, the mean DMD for level 5 is higher than level 4 and level 4 higher than 3. The data also showed the increase in the DMD with increase in compressive stresses. Therefore, this disparity could be attributed to the interaction between the compressive stress and the moisture content.

The DMD increased with number of strokes, but the magnitude of this increase decreased with additional compressions after the fifth stroke. This is illustrated in Table 2. It was seen that the increase in DMD after fifth stroke was statistically insignificant even though the mean DMD continued to increase with number of strokes. The increase in DMD after the fifth stroke was not large enough to justify the additional time required to achieve it. Therefore for the second set of experiments (fall 2008) only five compression strokes would be used.

Table 2. Least square means of DMD for number of strokes (2007)

Number of strokes	DMD (kg/m^3)
1	174^{i}
2	181^{h}
3	184^{g}
4	188^{f}
5	191^{e}
6	194^{de}
7	196^{cd}
8	198^{bc}
9	199^{ab}
10	201^{a}

To determine the effect of moisture content on DMD it was categorized into three levels; low (9 – 20%), medium (21 – 45%) and high (>46%). The difference in DMD for the medium and high moisture content was statistically insignificant. These results are seen in Table 3. Therefore, low moisture content would be preferred to attain high DMD and this would also help with reducing the storage losses by decreasing the material deterioration.

Table 3. Least square means of DMD for moisture content (2007)

Moisture content	DMD (kg/m^3)
Low	191^a
Medium	185^b
High	185^b

3.3.2 Analysis of 2008 data

An additional chopping length was included in this set to study the effect of chop length on the final DMD. The chopping length of the switchgrass used for this set of experiments was 95 mm (0.25 inches) and 63 mm (0.375 inches). This length was adjusted on the chopper before every harvest. The initial DMD was approximately 80 kg/m^3, same as in 2007. Therefore, the independent variables for these experiments were compressive stresses, number of strokes, moisture content and chop length.

For the analysis of the DMD, the interactions between compressive stresses and moisture content, and the interactions between chop length and moisture content were both significant in the full model and were included in the reduced model. All the main effects and the interaction between compressive stress and moisture content and chop length were significant factors in the reduced model at the 5% level. R^2 for the reduced model with DMD as the dependent variable was 0.548.

Statistically significant differences were seen in the DMD with increased compression strokes. Therefore, depending on the desired density anywhere between one to five strokes could be used. This is illustrated in Table 4.

Table 4. Least square means of DMD for number of strokes (2008)

Number of strokes	DMD (kg/m^3)
1	201^e
2	207^d
3	212^c
4	215^b
5	217^a

The DMD increased with reducing chop length. This is shown in Table 5. Statistically significant differences were seen in DMD with chop length. Therefore, small chop length could be used in achieve high DMD.

Table 5. Least square means of DMD for chop length (2008)

Chop length (mm)	DMD (kg/m^3)
63	215^a
95	206^b

Statistically significant differences were seen in DMD with moisture content. At low moisture content, high DMD is expected as shown from previous experiments. But a slightly different trend is seen with respect to medium and high moisture range and this could be because, higher range of compressive stresses were used for this set of experiments and also the highest moisture content was 49% whereas earlier it was 62%. However, low moisture content would be recommended to make the modules.

Table 6. Least square means of DMD for moisture content (2008)

Moisture content	DMD (kg/m^3)
Low	210^a
Medium	201^c
High	203^b

Based on the data collected a sample switchgrass module dimensions calculations were done.

Assuming the legal limitations of the weigth and size for a 2 axel truck:

Weight (2 axel truck) – 18144 kgs (40000 lbs)

Dimensions : length- 19.8 m (65ft), width – 4.27 m (14ft), height – 4.27 m (14 ft)

Consider MC: 20% ,Number of strokes : 5, Particle size: 0.063 m (0.25in) and

Minimum CS: 63.6 kPa (9.2 psi)

Final DMD : 210 kg/m^3 (13 lb/ft^3)

Bulk density: 250 kg/m^3 (15.6 lb/ft^3)

Therefore, estimated module dimensions: 7.6m × 2.4m × 2.4m (25ft × 8ft × 8ft)

3.4 Conclusions

The experiments show that the final dry matter density (DMD) increases with low moisture content (10 – 25%), high compressive stresses, five compressive strokes and small chopping length. The low moisture content would be most beneficial for biomass materials in reducing the storage losses and also maximizing the dry matter packaged and transported per module.

This study was focussed on studying the material properties of chopped switchgrass under applied compressive stresses. Hence, it can be concluded that the final dry matter density (DMD) increases with low moisture content (10 – 25%), high compressive stresses, five compressive strokes and small chopping length.

4. FUNCTION STRUCTURE

The objective of this research is to maximize the efficiency of the biomass logistics system by maximizing the energy output, E_o, (energy content of the material), while minimizing the energy input, E_i, (energy required for harvesting, transporting and post processing). To maximize the efficiency of packaging and transporting the biomass material, its density should be increased to reduce the number of packages being handled. One way of maximizing the density is by increasing the mass of the material packed. The bulk density can be increased by chopping the material, applying compressive stresses and increasing the moisture content. Transportation of more material per trip can help minimize the energy input. This can be achieved by densifying the material loaded and also minimizing the moisture content of the material so that the amount of dry matter transported is maximized.

One of the methods used for densifying the material is by compressing it and transforming them into modules. The use of modules could reduce the number of packages that need to be handled. Also, modules of chopped biomass would provide ease of transport as well as eliminate the necessity to grind the bales before converting the material into biofuels.

To minimize the energy input for transportation, the material should be densely packaged, which would reduce the transportation energy, required storage space and storage losses. Storage losses are of two types; mechanical and degradation losses. Mechanical losses occur due to the loss of dry matter during pick up and transportation.

Degradation losses are caused due to material deterioration. Deterioration increases with increase in oxygen and moisture content in the material.

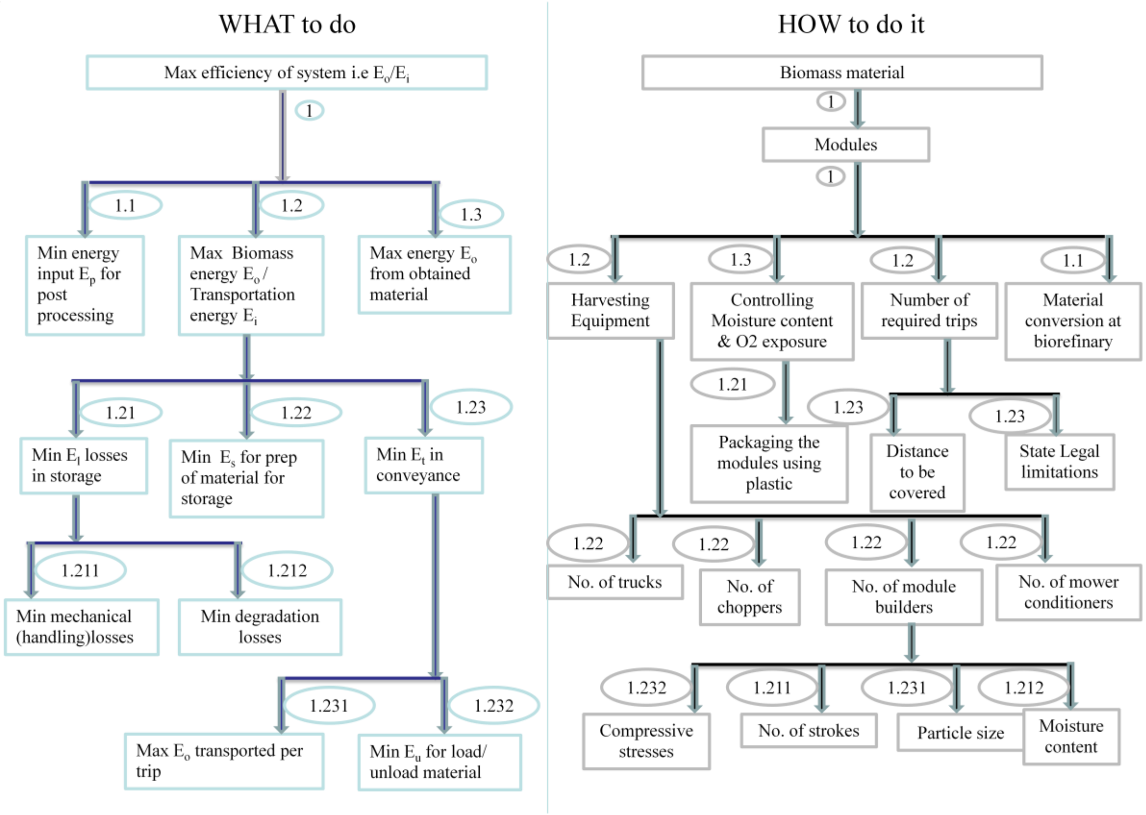

Figure 8: Function structure block

The function structure consists of the functional requirements (FR) on the left side of the Figure 8 and the design parameters (DP) on the right. In the figure above, each FR has a corresponding DP represented by the same number. The design parameters (DP's) on the right side of the figure were identified to help achieve the main objective i.e. optimizing the logistics of the biomass transportation. Overall efficiency is increased by minimizing the energy input for harvest, storage, transportation and post processing.

The harvesting costs result from the cost to operate harvesting equipment and the duration for which the equipment is used each day. One of the ways of reducing the equipment cost would be to use conventional agricultural equipment without having to invest heavily on new equipment, if that equipment has suitable performance. The equipment used for forage harvesting includes the forage mower/conditioners and forage choppers. Also the cotton module builders and trucks would be used to move the modules. In case of the module builders, the energy input to make the modules can be reduced by optimizing the compressive stress applied by the builder, the number of strokes, chopping length of the material and moisture content of the material. This would help in reducing the overall energy spent in making the modules which then would be ready to for storage or transportation to the facility.

The modules should also be packaged in plastic to control the moisture and oxygen exposure to reduce the material degradation, in turn reducing the storage losses. The low moisture content in the material would also contribute to lowering the transportation costs as more dry matter would be transported per trip.

To reduce the transportation energy (costs), the number of trips made to transport the material to refinery should be reduced i.e., maximize dry matter per trip. The transportation energy spent also depends on the state legal limitation for the loads allowed. These are the DP’s that would help optimizing the biomass logistics.

5. CONCLUSIONS

This research work focussed on studying the material properties of chopped switchgrass under applied compressive stresses. The results show that the final dry matter density (DMD) increases with low moisture content (10 – 25%), high compressive stresses, five compressive strokes and small chopping length.

The second objective of this research is to understand the parameters that influence the efficiency of packaging, storing and transporting the biomass material from the field to a biorefinary. The desired DMD should also consider the state legal limitations on the size and weight for the vehicles and the loads. Hence, the DMD would be determined based on the legal size limitations, so that minimum energy would be invested in making these modules. The following is a sample calcuation showing the DMD that can be achieved in accordance with the state legal limitations.

An assumption is made with legal size and weight limits for a Flatbed semi trailer:

Gross Vehicle Weight (GVW) – 36287 kgs (80000 lbs)
Truck and Semi trailer weight – 11340 kgs (25000 lbs)
Load (Module mass) – 24947 kgs (55000 lbs)
Allowable length – 16m (53 ft)
Allowable height – 4.3m (14 ft)
Allowable width – 2.4m (8ft)
Bed height – 1.2m (4 ft)

Module length – 14.6m (48 ft)

Module height – 3m (10 ft)

Module width – 2.3m (7.5 ft)

Module bulk density (Module mass/ Module volume) – 245 kg/m^3 (15.27 lbs/ft^3)

Assuming material moisture content – 10%

Module DMD = 220 kg/m^3 (13.75 lbs/ft^3)

Number of strokes – 5

Chopping length – 63mm

The equivalent compressive stress from the data collected is – 101 kPa (14.65 psi).

Therefore, depending on the state legal limitations on weight and size we can calculate the bulk density of the module and according to the material availability and the moisture content of the material the DMD can be calculated.

The function structure helped in understanding the basic parameters and their effects, not only on the packaging but also on the storage and transportation costs i.e., the logistics of biomass materials. For example, the low moisture content in the material would help in reducing the harvesting costs by packaging more dry matter per module; the storage losses by reducing the dry matter losses and also the transportation costs by transporting more dry matter per trip.

6. FUTURE WORK

In this research cylinderical modules were tested under compression whereas the real modules will be rectangular in shape, so mini modules will need to be tested. It was observed that the modules fell apart at low moisture content and would need some support, so the modules will need to be wrapped. The future study should accommodate actual module size so that the module integrity can be tested. Since the modules will be about 14m × 2.4m × 2.4m they will need to be wrapped with plastic. Various types of plastic wraps will need to be tested to ensure that they can withstand the module weight (55000 lbs), and prevent the modules from falling apart . The module should be subjected to bending stresses to test its integrity.

The cost and energy invested in the module logistics should be calculated so that an informed decision could me made regarding this packaging method. IBSAL can also be used to do the same.

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APPENDIX A

This is 2007 data used for analysis.

Chopper	Compressive Stress(psi)	Compressive Stress (Kpa)	Moisture (%)	Stroke	DMD (kg/m^3)	DMD (lb/ft^3)
C2	5.97	41	46	1	167	10.42
C2	5.97	41	46	2	166	10.37
C2	5.97	41	46	3	167	10.45
C2	5.97	41	46	4	171	10.69
C2	5.97	41	46	5	172	10.72
C2	5.97	41	46	6	173	10.78
C2	5.97	41	46	7	174	10.85
C2	5.97	41	46	8	174	10.87
C2	5.97	41	46	9	176	10.97
C2	5.97	41	46	10	177	11.06
C2	7.05	49	46	1	160	9.96
C2	7.05	49	46	2	166	10.35
C2	7.05	49	46	3	168	10.49
C2	7.05	49	46	4	169	10.58
C2	7.05	49	46	5	172	10.75
C2	7.05	49	46	6	175	10.91
C2	7.05	49	46	7	176	10.99
C2	7.05	49	46	8	177	11.07
C2	7.05	49	46	9	179	11.18
C2	7.05	49	46	10	179	11.18
C2	8.14	56	46	1	162	10.1
C2	8.14	56	46	2	167	10.44
C2	8.14	56	46	3	171	10.7
C2	8.14	56	46	4	174	10.89
C2	8.14	56	46	5	169	10.53
C2	8.14	56	46	6	176	10.96
C2	8.14	56	46	7	177	11.05
C2	8.14	56	46	8	179	11.19
C2	8.14	56	46	9	181	11.33
C2	8.14	56	46	10	182	11.35

C2	9.22	64	46	1	167	10.41
C2	9.22	64	46	2	172	10.74
C2	9.22	64	46	3	175	10.9
C2	9.22	64	46	4	178	11.14
C2	9.22	64	46	5	180	11.22
C2	9.22	64	46	6	191	11.94
C2	9.22	64	46	7	192	12.01
C2	9.22	64	46	8	186	11.59
C2	9.22	64	46	9	183	11.44
C2	9.22	64	46	10	188	11.72
C2	10.31	71	46	1	171	10.65
C2	10.31	71	46	2	176	10.98
C2	10.31	71	46	3	179	11.19
C2	10.31	71	46	4	182	11.38
C2	10.31	71	46	5	184	11.51
C2	10.31	71	46	6	187	11.67
C2	10.31	71	46	7	189	11.79
C2	10.31	71	46	8	191	11.9
C2	10.31	71	46	9	190	11.85
C2	10.31	71	46	10	191	11.94
C2	11.39	79	46	1	177	11.02
C2	11.39	79	46	2	178	11.12
C2	11.39	79	46	3	179	11.18
C2	11.39	79	46	4	169	10.53
C2	11.39	79	46	5	193	12.04
C2	11.39	79	46	6	192	12
C2	11.39	79	46	7	172	10.73
C2	11.39	79	46	8	171	10.67
C2	11.39	79	46	9	200	12.48
C2	11.39	79	46	10	191	11.9
C2	5.97	41	26	1	164	10.21
C2	5.97	41	26	2	170	10.6
C2	5.97	41	26	3	174	10.88
C2	5.97	41	26	4	177	11.06
C2	5.97	41	26	5	172	10.75
C2	5.97	41	26	6	175	10.94
C2	5.97	41	26	7	177	11.08

C2	5.97	41	26	8	179	11.18
C2	5.97	41	26	9	179	11.2
C2	5.97	41	26	10	181	11.3
C2	7.05	49	26	1	165	10.32
C2	7.05	49	26	2	172	10.71
C2	7.05	49	26	3	178	11.11
C2	7.05	49	26	4	180	11.22
C2	7.05	49	26	5	182	11.37
C2	7.05	49	26	6	184	11.5
C2	7.05	49	26	7	186	11.62
C2	7.05	49	26	8	187	11.69
C2	7.05	49	26	9	189	11.8
C2	7.05	49	26	10	186	11.64
C2	8.14	56	26	1	168	10.46
C2	8.14	56	26	2	174	10.86
C2	8.14	56	26	3	177	11.07
C2	8.14	56	26	4	183	11.45
C2	8.14	56	26	5	188	11.72
C2	8.14	56	26	6	188	11.73
C2	8.14	56	26	7	194	12.11
C2	8.14	56	26	8	189	11.82
C2	8.14	56	26	9	198	12.33
C2	8.14	56	26	10	197	12.32
C2	9.22	64	26	1	171	10.66
C2	9.22	64	26	2	179	11.17
C2	9.22	64	26	3	181	11.29
C2	9.22	64	26	4	195	12.17
C2	9.22	64	26	5	194	12.1
C2	9.22	64	26	6	197	12.3
C2	9.22	64	26	7	201	12.55
C2	9.22	64	26	8	194	12.09
C2	9.22	64	26	9	201	12.57
C2	9.22	64	26	10	201	12.54
C2	10.31	71	26	1	176	10.99
C2	10.31	71	26	2	183	11.42
C2	10.31	71	26	3	192	11.97
C2	10.31	71	26	4	198	12.37

C2	10.31	71	26	5	203	12.69
C2	10.31	71	26	6	200	12.51
C2	10.31	71	26	7	209	13.05
C2	10.31	71	26	8	209	13.07
C2	10.31	71	26	9	221	13.79
C2	10.31	71	26	10	215	13.45
C2	11.39	79	26	1	174	10.89
C2	11.39	79	26	2	186	11.64
C2	11.39	79	26	3	184	11.5
C2	11.39	79	26	4	185	11.58
C2	11.39	79	26	5	190	11.88
C2	11.39	79	26	6	197	12.27
C2	11.39	79	26	7	205	12.77
C2	11.39	79	26	8	212	13.22
C2	11.39	79	26	9	201	12.55
C2	11.39	79	26	10	207	12.93
C2	5.97	41	10	1	168	10.46
C2	5.97	41	10	2	176	10.96
C2	5.97	41	10	3	175	10.95
C2	5.97	41	10	4	178	11.13
C2	5.97	41	10	5	178	11.14
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C2	5.97	41	10	8	182	11.36
C2	5.97	41	10	9	185	11.55
C2	5.97	41	10	10	184	11.47
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C2	7.05	49	10	2	176	11.01
C2	7.05	49	10	3	181	11.32
C2	7.05	49	10	4	184	11.49
C2	7.05	49	10	5	186	11.59
C2	7.05	49	10	6	187	11.7
C2	7.05	49	10	7	188	11.72
C2	7.05	49	10	8	190	11.85
C2	7.05	49	10	9	188	11.72
C2	7.05	49	10	10	189	11.8
C2	8.14	56	10	1	171	10.67

C2	8.14	56	10	2	178	11.11
C2	8.14	56	10	3	181	11.29
C2	8.14	56	10	4	183	11.45
C2	8.14	56	10	5	191	11.9
C2	8.14	56	10	6	190	11.89
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C2	8.14	56	10	9	193	12.05
C2	8.14	56	10	10	191	11.9
C2	9.22	64	10	1	176	11
C2	9.22	64	10	2	182	11.38
C2	9.22	64	10	3	186	11.61
C2	9.22	64	10	4	195	12.2
C2	9.22	64	10	5	197	12.3
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C2	9.22	64	10	8	204	12.76
C2	9.22	64	10	9	203	12.68
C2	9.22	64	10	10	200	12.49
C2	10.31	71	10	1	176	10.96
C2	10.31	71	10	2	181	11.27
C2	10.31	71	10	3	184	11.49
C2	10.31	71	10	4	186	11.62
C2	10.31	71	10	5	187	11.7
C2	10.31	71	10	6	191	11.91
C2	10.31	71	10	7	192	11.99
C2	10.31	71	10	8	194	12.13
C2	10.31	71	10	9	194	12.1
C2	10.31	71	10	10	193	12.07
C2	11.39	79	10	1	181	11.28
C2	11.39	79	10	2	187	11.69
C2	11.39	79	10	3	198	12.36
C2	11.39	79	10	4	196	12.25
C2	11.39	79	10	5	202	12.59
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C2	11.39	79	10	7	202	12.59
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C2	11.39	79	10	9	205	12.8
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C2	5.97	41	46	1	163	10.19
C2	5.97	41	46	2	165	10.33
C2	5.97	41	46	3	171	10.66
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C2	5.97	41	46	7	189	11.83
C2	5.97	41	46	8	189	11.81
C2	5.97	41	46	9	188	11.73
C2	5.97	41	46	10	193	12.05
C2	7.05	49	46	1	166	10.35
C2	7.05	49	46	2	172	10.73
C2	7.05	49	46	3	175	10.94
C2	7.05	49	46	4	182	11.36
C2	7.05	49	46	5	181	11.32
C2	7.05	49	46	6	189	11.8
C2	7.05	49	46	7	189	11.82
C2	7.05	49	46	8	195	12.17
C2	7.05	49	46	9	194	12.09
C2	7.05	49	46	10	199	12.41
C2	8.14	56	46	1	175	10.91
C2	8.14	56	46	2	173	10.82
C2	8.14	56	46	3	178	11.1
C2	8.14	56	46	4	187	11.65
C2	8.14	56	46	5	194	12.1
C2	8.14	56	46	6	196	12.24
C2	8.14	56	46	7	198	12.38
C2	8.14	56	46	8	202	12.58
C2	8.14	56	46	9	193	12.06
C2	8.14	56	46	10	198	12.34
C2	9.22	64	46	1	175	10.91
C2	9.22	64	46	2	179	11.19
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C2	9.22	64	46	4	188	11.75
C2	9.22	64	46	5	192	11.96

C2	9.22	64	46	6	191	11.93
C2	9.22	64	46	7	194	12.12
C2	9.22	64	46	8	197	12.29
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C2	9.22	64	46	10	204	12.75
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C2	10.31	71	46	8	205	12.8
C2	10.31	71	46	9	206	12.86
C2	10.31	71	46	10	203	12.66
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C2	11.39	79	46	2	185	11.52
C2	11.39	79	46	3	189	11.78
C2	11.39	79	46	4	192	11.98
C2	11.39	79	46	5	195	12.17
C2	11.39	79	46	6	197	12.27
C2	11.39	79	46	7	199	12.41
C2	11.39	79	46	8	203	12.66
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C2	11.39	79	46	10	217	13.57
C2	5.97	41	40	1	178	11.13
C2	5.97	41	40	2	186	11.63
C2	5.97	41	40	3	190	11.87
C2	5.97	41	40	4	189	11.79
C2	5.97	41	40	5	189	11.82
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C2	5.97	41	40	8	193	12.07
C2	5.97	41	40	9	193	12.05
C2	5.97	41	40	10	196	12.23
C2	7.05	49	40	1	182	11.36
C2	7.05	49	40	2	187	11.65

C2	7.05	49	40	3	185	11.54
C2	7.05	49	40	4	192	12
C2	7.05	49	40	5	195	12.2
C2	7.05	49	40	6	197	12.3
C2	7.05	49	40	7	200	12.47
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C2	7.05	49	40	9	202	12.61
C2	7.05	49	40	10	202	12.63
C2	8.14	56	40	1	181	11.28
C2	8.14	56	40	2	183	11.42
C2	8.14	56	40	3	187	11.66
C2	8.14	56	40	4	196	12.26
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C2	8.14	56	40	9	202	12.59
C2	8.14	56	40	10	202	12.6
C2	9.22	64	40	1	180	11.23
C2	9.22	64	40	2	186	11.62
C2	9.22	64	40	3	190	11.88
C2	9.22	64	40	4	193	12.04
C2	9.22	64	40	5	197	12.28
C2	9.22	64	40	6	200	12.46
C2	9.22	64	40	7	202	12.58
C2	9.22	64	40	8	202	12.64
C2	9.22	64	40	9	204	12.72
C2	9.22	64	40	10	207	12.94
C2	10.31	71	40	1	183	11.43
C2	10.31	71	40	2	190	11.85
C2	10.31	71	40	3	195	12.19
C2	10.31	71	40	4	200	12.5
C2	10.31	71	40	5	202	12.64
C2	10.31	71	40	6	206	12.84
C2	10.31	71	40	7	206	12.89
C2	10.31	71	40	8	210	13.14
C2	10.31	71	40	9	214	13.38

C2	10.31	71	40	10	222	13.86
C2	11.39	79	40	1	189	11.78
C2	11.39	79	40	2	194	12.11
C2	11.39	79	40	3	202	12.6
C2	11.39	79	40	4	204	12.74
C2	11.39	79	40	5	217	13.57
C2	11.39	79	40	6	223	13.91
C2	11.39	79	40	7	226	14.08
C2	11.39	79	40	8	234	14.61
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C2	5.97	41	62	1	178	11.11
C2	5.97	41	62	2	186	11.63
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C2	5.97	41	62	10	201	12.54
C2	7.05	49	62	1	194	12.14
C2	7.05	49	62	2	198	12.33
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C2	7.05	49	62	4	200	12.51
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C2	7.05	49	62	6	205	12.8
C2	7.05	49	62	7	209	13.04
C2	7.05	49	62	8	209	13.06
C2	7.05	49	62	9	214	13.36
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C2	8.14	56	62	1	194	12.09
C2	8.14	56	62	2	199	12.42
C2	8.14	56	62	3	203	12.69
C2	8.14	56	62	4	206	12.88
C2	8.14	56	62	5	208	13
C2	8.14	56	62	6	216	13.49

C2	8.14	56	62	7	211	13.18
C2	8.14	56	62	8	218	13.6
C2	8.14	56	62	9	221	13.78
C2	8.14	56	62	10	222	13.84
C2	9.22	64	62	1	189	11.78
C2	9.22	64	62	2	194	12.09
C2	9.22	64	62	3	196	12.23
C2	9.22	64	62	4	200	12.48
C2	9.22	64	62	5	203	12.65
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C2	9.22	64	62	8	207	12.92
C2	9.22	64	62	9	209	13.06
C2	9.22	64	62	10	210	13.1
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C2	10.31	71	62	2	199	12.4
C2	10.31	71	62	3	201	12.57
C2	10.31	71	62	4	204	12.73
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C2	10.31	71	62	9	220	13.75
C2	10.31	71	62	10	221	13.8
C2	11.39	79	62	1	201	12.54
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C2	11.39	79	62	3	201	12.57
C2	11.39	79	62	4	204	12.73
C2	11.39	79	62	5	207	12.9
C2	11.39	79	62	6	208	12.96
C2	11.39	79	62	7	211	13.17
C2	11.39	79	62	8	210	13.13
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C2	11.39	79	62	10	213	13.3
C2	5.97	41	47	1	156	9.71
C2	5.97	41	47	2	159	9.94
C2	5.97	41	47	3	152	9.46

C2	5.97	41	47	4	165	10.3
C2	5.97	41	47	5	169	10.58
C2	5.97	41	47	6	169	10.52
C2	5.97	41	47	7	169	10.57
C2	5.97	41	47	8	171	10.67
C2	5.97	41	47	9	170	10.62
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C2	7.05	49	47	4	154	9.64
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C2	7.05	49	47	8	155	9.7
C2	7.05	49	47	9	156	9.75
C2	7.05	49	47	10	157	9.82
C2	8.14	56	47	1	165	10.28
C2	8.14	56	47	2	170	10.62
C2	8.14	56	47	3	176	10.96
C2	8.14	56	47	4	178	11.12
C2	8.14	56	47	5	181	11.32
C2	8.14	56	47	6	183	11.41
C2	8.14	56	47	7	184	11.48
C2	8.14	56	47	8	186	11.62
C2	8.14	56	47	9	187	11.7
C2	8.14	56	47	10	188	11.71
C2	9.22	64	47	1	173	10.8
C2	9.22	64	47	2	180	11.22
C2	9.22	64	47	3	185	11.56
C2	9.22	64	47	4	188	11.72
C2	9.22	64	47	5	190	11.86
C2	9.22	64	47	6	191	11.93
C2	9.22	64	47	7	192	11.98
C2	9.22	64	47	8	195	12.18
C2	9.22	64	47	9	196	12.26
C2	9.22	64	47	10	197	12.29

C2	10.31	71	47	1	166	10.34
C2	10.31	71	47	2	173	10.78
C2	10.31	71	47	3	177	11.07
C2	10.31	71	47	4	182	11.37
C2	10.31	71	47	5	189	11.81
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C2	10.31	71	47	8	194	12.12
C2	10.31	71	47	9	196	12.26
C2	10.31	71	47	10	200	12.47
C2	11.39	79	47	1	173	10.78
C2	11.39	79	47	2	178	11.11
C2	11.39	79	47	3	186	11.62
C2	11.39	79	47	4	191	11.92
C2	11.39	79	47	5	202	12.59
C2	11.39	79	47	6	206	12.88
C2	11.39	79	47	7	214	13.37
C2	11.39	79	47	8	220	13.72
C2	11.39	79	47	9	220	13.74
C2	11.39	79	47	10	230	14.33
C2	5.97	41	31	1	163	10.18
C2	5.97	41	31	2	169	10.56
C2	5.97	41	31	3	172	10.75
C2	5.97	41	31	4	174	10.89
C2	5.97	41	31	5	178	11.12
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C2	5.97	41	31	9	188	11.75
C2	5.97	41	31	10	193	12.03
C2	7.05	49	31	1	172	10.72
C2	7.05	49	31	2	177	11.02
C2	7.05	49	31	3	182	11.36
C2	7.05	49	31	4	185	11.55
C2	7.05	49	31	5	189	11.79
C2	7.05	49	31	6	190	11.87
C2	7.05	49	31	7	190	11.86

C2	7.05	49	31	8	192	11.99
C2	7.05	49	31	9	193	12.06
C2	7.05	49	31	10	195	12.17
C2	8.14	56	31	1	177	11.02
C2	8.14	56	31	2	180	11.22
C2	8.14	56	31	3	183	11.4
C2	8.14	56	31	4	186	11.61
C2	8.14	56	31	5	192	11.98
C2	8.14	56	31	6	191	11.93
C2	8.14	56	31	7	192	11.97
C2	8.14	56	31	8	193	12.05
C2	8.14	56	31	9	194	12.11
C2	8.14	56	31	10	200	12.46
C2	9.22	64	31	1	178	11.1
C2	9.22	64	31	2	183	11.43
C2	9.22	64	31	3	189	11.82
C2	9.22	64	31	4	196	12.25
C2	9.22	64	31	5	199	12.43
C2	9.22	64	31	6	196	12.23
C2	9.22	64	31	7	197	12.31
C2	9.22	64	31	8	201	12.52
C2	9.22	64	31	9	201	12.56
C2	9.22	64	31	10	202	12.61
C2	10.31	71	31	1	176	10.97
C2	10.31	71	31	2	182	11.36
C2	10.31	71	31	3	186	11.64
C2	10.31	71	31	4	194	12.12
C2	10.31	71	31	5	203	12.69
C2	10.31	71	31	6	206	12.85
C2	10.31	71	31	7	211	13.19
C2	10.31	71	31	8	216	13.47
C2	10.31	71	31	9	220	13.71
C2	10.31	71	31	10	221	13.79
C2	11.39	79	31	1	182	11.34
C2	11.39	79	31	2	189	11.81
C2	11.39	79	31	3	192	12.01
C2	11.39	79	31	4	193	12.07

C2	11.39	79	31	5	195	12.19
C2	11.39	79	31	6	197	12.28
C2	11.39	79	31	7	201	12.57
C2	11.39	79	31	8	202	12.63
C2	11.39	79	31	9	205	12.82
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C2	5.97	41	28	4	174	10.89
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C2	5.97	41	28	6	178	11.09
C2	5.97	41	28	7	178	11.11
C2	5.97	41	28	8	183	11.42
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C2	5.97	41	28	10	182	11.36
C2	7.05	49	28	1	161	10.07
C2	7.05	49	28	2	168	10.47
C2	7.05	49	28	3	170	10.6
C2	7.05	49	28	4	173	10.77
C2	7.05	49	28	5	174	10.89
C2	7.05	49	28	6	177	11.05
C2	7.05	49	28	7	178	11.11
C2	7.05	49	28	8	179	11.16
C2	7.05	49	28	9	181	11.28
C2	7.05	49	28	10	181	11.27
C2	8.14	56	28	1	166	10.35
C2	8.14	56	28	2	172	10.72
C2	8.14	56	28	3	175	10.9
C2	8.14	56	28	4	184	11.47
C2	8.14	56	28	5	181	11.31
C2	8.14	56	28	6	184	11.46
C2	8.14	56	28	7	187	11.68
C2	8.14	56	28	8	192	11.98
C2	8.14	56	28	9	194	12.09
C2	8.14	56	28	10	203	12.68
C2	9.22	64	28	1	170	10.63

C2	9.22	64	28	2	175	10.95
C2	9.22	64	28	3	182	11.39
C2	9.22	64	28	4	187	11.7
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C2	9.22	64	28	6	201	12.55
C2	9.22	64	28	7	202	12.59
C2	9.22	64	28	8	206	12.86
C2	9.22	64	28	9	216	13.47
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C2	10.31	71	28	1	170	10.62
C2	10.31	71	28	2	204	12.73
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C2	10.31	71	28	4	208	12.99
C2	10.31	71	28	5	210	13.14
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C2	10.31	71	28	8	218	13.58
C2	10.31	71	28	9	213	13.27
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C2	11.39	79	28	1	179	11.2
C2	11.39	79	28	2	187	11.67
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C2	11.39	79	28	4	192	11.96
C2	11.39	79	28	5	194	12.09
C2	11.39	79	28	6	198	12.38
C2	11.39	79	28	7	203	12.66
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C2	11.39	79	28	9	208	12.98
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C2	5.97	41	40	1	136	8.52
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C2	5.97	41	40	3	163	10.2
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C2	5.97	41	40	5	166	10.39
C2	5.97	41	40	6	165	10.32
C2	5.97	41	40	7	167	10.41
C2	5.97	41	40	8	171	10.67

C2	5.97	41	40	9	169	10.54
C2	5.97	41	40	10	168	10.47
C2	7.05	49	40	1	109	6.83
C2	7.05	49	40	2	159	9.93
C2	7.05	49	40	3	162	10.14
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C2	7.05	49	40	5	171	10.66
C2	7.05	49	40	6	172	10.73
C2	7.05	49	40	7	174	10.86
C2	7.05	49	40	8	172	10.71
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C2	7.05	49	40	10	176	10.99
C2	8.14	56	40	1	158	9.89
C2	8.14	56	40	2	164	10.22
C2	8.14	56	40	3	168	10.51
C2	8.14	56	40	4	170	10.64
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C2	8.14	56	40	6	179	11.15
C2	8.14	56	40	7	177	11.02
C2	8.14	56	40	8	182	11.36
C2	8.14	56	40	9	183	11.42
C2	8.14	56	40	10	183	11.42
C2	9.22	64	40	1	165	10.32
C2	9.22	64	40	2	169	10.54
C2	9.22	64	40	3	174	10.89
C2	9.22	64	40	4	173	10.8
C2	9.22	64	40	5	179	11.19
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C2	9.22	64	40	7	181	11.29
C2	9.22	64	40	8	183	11.4
C2	9.22	64	40	9	189	11.83
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C2	10.31	71	40	9	189	11.81
C2	10.31	71	40	10	186	11.61
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C2	11.39	79	40	3	188	11.75
C2	11.39	79	40	4	194	12.14
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C2	5.97	41	20	2	164	10.26
C2	5.97	41	20	3	161	10.08
C2	5.97	41	20	4	171	10.68
C2	5.97	41	20	5	174	10.87
C2	5.97	41	20	6	180	11.23
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C2	5.97	41	20	8	169	10.56
C2	5.97	41	20	9	167	10.41
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C2	7.05	49	20	1	168	10.48
C2	7.05	49	20	2	162	10.12
C2	7.05	49	20	3	164	10.22
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C2	7.05	49	20	5	160	9.98
C2	7.05	49	20	6	169	10.56
C2	7.05	49	20	7	169	10.54
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C2	7.05	49	20	10	176	10.98
C2	8.14	56	20	1	177	11.05
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C2	8.14	56	20	3	175	10.91
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C2	8.14	56	20	5	184	11.48
C2	8.14	56	20	6	178	11.11
C2	8.14	56	20	7	176	10.98
C2	8.14	56	20	8	188	11.71
C2	8.14	56	20	9	184	11.5
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C2	9.22	64	20	3	189	11.78
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C2	9.22	64	20	7	210	13.08
C2	9.22	64	20	8	206	12.89
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C2	10.31	71	20	1	174	10.88
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C2	10.31	71	20	4	189	11.81
C2	10.31	71	20	5	192	11.99
C2	10.31	71	20	6	196	12.23
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C2	10.31	71	20	8	202	12.59
C2	10.31	71	20	9	205	12.8
C2	10.31	71	20	10	211	13.2
C2	11.39	79	20	1	179	11.17
C2	11.39	79	20	2	187	11.65
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C2	11.39	79	20	4	193	12.06
C2	11.39	79	20	5	199	12.42
C2	11.39	79	20	6	195	12.2
C2	11.39	79	20	7	202	12.6
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C2	5.97	41	18	4	175	10.94
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C2	5.97	41	18	8	179	11.18
C2	5.97	41	18	9	182	11.35
C2	5.97	41	18	10	183	11.42
C2	7.05	49	18	1	179	11.17
C2	7.05	49	18	2	173	10.82
C2	7.05	49	18	3	177	11.05
C2	7.05	49	18	4	179	11.17
C2	7.05	49	18	5	180	11.26
C2	7.05	49	18	6	185	11.53
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C2	7.05	49	18	8	187	11.66
C2	7.05	49	18	9	184	11.49
C2	7.05	49	18	10	190	11.85
C2	8.14	56	18	1	173	10.8
C2	8.14	56	18	2	180	11.25
C2	8.14	56	18	3	181	11.31
C2	8.14	56	18	4	186	11.63
C2	8.14	56	18	5	189	11.81
C2	8.14	56	18	6	192	12.01
C2	8.14	56	18	7	194	12.1
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C2	9.22	64	18	1	177	11.05
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C2	9.22	64	18	5	191	11.91
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C2	9.22	64	18	10	198	12.36
C2	10.31	71	18	1	177	11.08
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C2	10.31	71	18	3	187	11.67
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C2	10.31	71	18	5	196	12.26
C2	10.31	71	18	6	201	12.54
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C2	10.31	71	18	10	204	12.76
C2	11.39	79	18	1	208	13.01
C2	11.39	79	18	2	217	13.53
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C2	11.39	79	18	4	230	14.38
C2	11.39	79	18	5	236	14.72
C2	11.39	79	18	6	241	15.06
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C2	5.97	41	48	1	155	9.7
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C2	5.97	41	48	10	178	11.13
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C2	7.05	49	48	3	177	11.06

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C2	7.05	49	48	9	189	11.78
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C2	8.14	56	48	2	169	10.54
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C2	8.14	56	48	6	179	11.18
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C2	8.14	56	48	9	189	11.82
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C2	9.22	64	48	1	162	10.1
C2	9.22	64	48	2	168	10.47
C2	9.22	64	48	3	174	10.89
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C2	10.31	71	48	5	189	11.78
C2	10.31	71	48	6	192	12
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C2	10.31	71	48	10	208	13.01

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C2	11.39	79	48	3	186	11.59
C2	11.39	79	48	4	186	11.63
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C2	7.05	49	42	3	161	10.06
C2	7.05	49	42	4	163	10.2
C2	7.05	49	42	5	166	10.36
C2	7.05	49	42	6	170	10.64
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C2	7.05	49	42	8	176	11.01
C2	7.05	49	42	9	178	11.1
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C2	8.14	56	42	3	167	10.4
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C2	9.22	64	42	2	163	10.17
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C2	9.22	64	42	10	189	11.81
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C2	10.31	71	42	8	185	11.56
C2	10.31	71	42	9	182	11.35
C2	10.31	71	42	10	191	11.91
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C2	11.39	79	42	5	179	11.18
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C2	11.39	79	42	9	189	11.78
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C2	5.97	41	51	1	148	9.25
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C2	5.97	41	51	7	164	10.24
C2	5.97	41	51	8	165	10.32
C2	5.97	41	51	9	167	10.4
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C2	7.05	49	51	2	162	10.14
C2	7.05	49	51	3	167	10.44
C2	7.05	49	51	4	168	10.51
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C2	7.05	49	51	6	172	10.76
C2	7.05	49	51	7	174	10.84
C2	7.05	49	51	8	175	10.92
C2	7.05	49	51	9	174	10.84
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C2	8.14	56	51	2	162	10.14
C2	8.14	56	51	3	168	10.51
C2	8.14	56	51	4	170	10.59
C2	8.14	56	51	5	172	10.76
C2	8.14	56	51	6	176	10.98
C2	8.14	56	51	7	173	10.82
C2	8.14	56	51	8	177	11.06
C2	8.14	56	51	9	180	11.23
C2	8.14	56	51	10	185	11.52
C2	9.22	64	51	1	160	9.97
C2	9.22	64	51	2	167	10.4
C2	9.22	64	51	3	170	10.62
C2	9.22	64	51	4	174	10.84
C2	9.22	64	51	5	177	11.07
C2	9.22	64	51	6	182	11.36
C2	9.22	64	51	7	187	11.68
C2	9.22	64	51	8	189	11.81
C2	9.22	64	51	9	190	11.88
C2	9.22	64	51	10	193	12.07
C2	10.31	71	51	1	166	10.36

C2	10.31	71	51	2	172	10.75
C2	10.31	71	51	3	174	10.88
C2	10.31	71	51	4	183	11.44
C2	10.31	71	51	5	186	11.6
C2	10.31	71	51	6	189	11.81
C2	10.31	71	51	7	193	12.05
C2	10.31	71	51	8	196	12.22
C2	10.31	71	51	9	202	12.6
C2	10.31	71	51	10	206	12.88
C2	11.39	79	51	1	176	10.96
C2	11.39	79	51	2	181	11.28
C2	11.39	79	51	3	188	11.72
C2	11.39	79	51	4	192	11.97
C2	11.39	79	51	5	195	12.19
C2	11.39	79	51	6	202	12.63
C2	11.39	79	51	7	200	12.49
C2	11.39	79	51	8	206	12.83
C2	11.39	79	51	9	207	12.94
C2	11.39	79	51	10	211	13.15

APPENDIX B

This is 2008 data used for analysis

Chopper	Compressive Stress (kPa)	Compressive Stress (psi)	Moisture (%)	Stroke	DMD (kg/m^3)	DMD(lb/ft^3)
C1	64	9.22	49	1	151	9.45
C1	64	9.22	49	2	194	12.09
C1	64	9.22	49	3	200	12.48
C1	64	9.22	49	4	206	12.85
C1	64	9.22	49	5	208	13.01
C1	64	9.22	49	1	195	12.16
C1	64	9.22	49	2	210	13.08
C1	64	9.22	49	3	212	13.21
C1	64	9.22	49	4	214	13.34
C1	64	9.22	49	5	219	13.70
C1	64	9.22	49	1	195	12.18
C1	64	9.22	49	2	197	12.30
C1	64	9.22	49	3	208	13.01
C1	64	9.22	49	4	214	13.34
C1	64	9.22	49	5	222	13.89
C1	64	9.22	49	1	190	11.88
C1	64	9.22	49	2	195	12.15
C1	64	9.22	49	3	197	12.28
C1	64	9.22	49	4	201	12.52
C1	64	9.22	49	5	206	12.85
C1	82	11.94	49	1	191	11.94
C1	82	11.94	49	2	201	12.52
C1	82	11.94	49	3	204	12.72
C1	82	11.94	49	4	211	13.16
C1	82	11.94	49	5	220	13.75
C1	82	11.94	49	1	196	12.22
C1	82	11.94	49	2	207	12.95
C1	82	11.94	49	3	217	13.55
C1	82	11.94	49	4	223	13.90
C1	82	11.94	49	5	229	14.27
C1	82	11.94	49	1	191	11.93
C1	82	11.94	49	2	203	12.68
C1	82	11.94	49	3	221	13.8
C1	82	11.94	49	4	224	14.01
C1	82	11.94	49	5	239	14.91
C1	82	11.94	49	1	199	12.4

C1	82	11.94	49	2	207	12.9
C1	82	11.94	49	3	211	13.19
C1	82	11.94	49	4	215	13.43
C1	82	11.94	49	5	214	13.38
C1	101	14.65	49	1	203	12.65
C1	101	14.65	49	2	206	12.84
C1	101	14.65	49	3	213	13.3
C1	101	14.65	49	4	227	14.19
C1	101	14.65	49	5	202	12.64
C1	101	14.65	49	1	199	12.4
C1	101	14.65	49	2	195	12.17
C1	101	14.65	49	3	218	13.6
C1	101	14.65	49	4	222	13.84
C1	101	14.65	49	5	226	14.13
C1	101	14.65	49	1	201	12.53
C1	101	14.65	49	2	216	13.48
C1	101	14.65	49	3	216	13.51
C1	101	14.65	49	4	223	13.92
C1	101	14.65	49	5	222	13.88
C1	101	14.65	49	1	203	12.7
C1	101	14.65	49	2	209	13.07
C1	101	14.65	49	3	212	13.25
C1	101	14.65	49	4	219	13.68
C1	101	14.65	49	5	221	13.78
C2	64	9.22	49	1	155	9.65
C2	64	9.22	49	2	187	11.65
C2	64	9.22	49	3	187	11.67
C2	64	9.22	49	4	196	12.22
C2	64	9.22	49	5	204	12.76
C2	64	9.22	49	1	176	11.00
C2	64	9.22	49	2	184	11.48
C2	64	9.22	49	3	197	12.29
C2	64	9.22	49	4	196	12.24
C2	64	9.22	49	5	197	12.27
C2	64	9.22	49	1	184	11.50
C2	64	9.22	49	2	190	11.87
C2	64	9.22	49	3	204	12.75
C2	64	9.22	49	4	217	13.55
C2	64	9.22	49	5	231	14.43
C2	82	11.94	49	1	188	11.76
C2	82	11.94	49	2	200	12.46
C2	82	11.94	49	3	214	13.33

C2	82	11.94	49	4	222	13.89
C2	82	11.94	49	5	229	14.30
C2	82	11.94	49	1	190	11.89
C2	82	11.94	49	2	199	12.42
C2	82	11.94	49	3	211	13.16
C2	82	11.94	49	4	219	13.69
C2	82	11.94	49	5	225	14.05
C2	82	11.94	49	1	204	12.74
C2	82	11.94	49	2	184	11.46
C2	82	11.94	49	3	187	11.67
C2	82	11.94	49	4	174	10.88
C2	82	11.94	49	5	204	12.75
C2	101	14.65	49	1	194	12.14
C2	101	14.65	49	2	206	12.83
C2	101	14.65	49	3	215	13.45
C2	101	14.65	49	4	231	14.45
C2	101	14.65	49	5	232	14.46
C2	101	14.65	49	1	189	11.80
C2	101	14.65	49	2	201	12.53
C2	101	14.65	49	3	213	13.29
C2	101	14.65	49	4	229	14.32
C2	101	14.65	49	5	232	14.49
C1	64	9.22	9	1	161	10.06
C1	64	9.22	9	2	189	11.83
C1	64	9.22	9	3	196	12.23
C1	64	9.22	9	4	196	12.26
C1	64	9.22	9	5	204	12.75
C1	64	9.22	9	1	187	11.70
C1	64	9.22	9	2	194	12.08
C1	64	9.22	9	3	198	12.39
C1	64	9.22	9	4	201	12.52
C1	64	9.22	9	5	205	12.77
C1	82	11.94	9	1.00	211	13.20
C1	82	11.94	9	2.00	212	13.25
C1	82	11.94	9	3.00	223	13.93
C1	82	11.94	9	4.00	224	14.00
C1	82	11.94	9	5.00	227	14.15
C1	101	14.65	9	1.00	198	12.39
C1	101	14.65	9	2.00	205	12.80
C1	101	14.65	9	3.00	215	13.44
C1	101	14.65	9	4.00	221	13.82
C1	101	14.65	9	5.00	220	13.71

C1	101	14.65	9	1.00	196	12.25
C1	101	14.65	9	2.00	203	12.69
C1	101	14.65	9	3.00	211	13.17
C1	101	14.65	9	4.00	212	13.25
C1	101	14.65	9	5.00	211	13.17
C2	64	9.22	9	1.00	166	10.37
C2	64	9.22	9	2.00	192	11.98
C2	64	9.22	9	3.00	198	12.35
C2	64	9.22	9	4.00	198	12.39
C2	64	9.22	9	5.00	200	12.48
C2	64	9.22	9	1.00	166	10.39
C2	64	9.22	9	2.00	206	12.84
C2	64	9.22	9	3.00	209	13.07
C2	64	9.22	9	4.00	213	13.31
C2	64	9.22	9	5.00	215	13.44
C2	64	9.22	9	1.00	192	11.97
C2	64	9.22	9	2.00	195	12.17
C2	64	9.22	9	3.00	204	12.73
C2	64	9.22	9	4.00	207	12.93
C2	64	9.22	9	5.00	208	13.00
C2	82	11.94	9	1.00	192	12.01
C2	82	11.94	9	2.00	199	12.45
C2	82	11.94	9	3.00	200	12.47
C2	82	11.94	9	4.00	206	12.84
C2	82	11.94	9	5.00	206	12.84
C2	82	11.94	9	1.00	191	11.93
C2	82	11.94	9	2.00	198	12.35
C2	82	11.94	9	3.00	203	12.67
C2	82	11.94	9	4.00	205	12.81
C2	82	11.94	9	5.00	211	13.15
C2	82	11.94	9	1.00	198	12.39
C2	82	11.94	9	2.00	202	12.60
C2	82	11.94	9	3.00	210	13.09
C2	82	11.94	9	4.00	212	13.24
C2	82	11.94	9	5.00	212	13.25
C2	101	14.65	9	1.00	201	12.52
C2	101	14.65	9	2.00	212	13.22
C2	101	14.65	9	3.00	220	13.72
C2	101	14.65	9	4.00	223	13.90
C2	101	14.65	9	5.00	239	14.91
C2	101	14.65	9	1.00	203	12.65
C2	101	14.65	9	2.00	209	13.04

C2	101	14.65	9	3.00	216	13.46
C2	101	14.65	9	4.00	218	13.58
C2	101	14.65	9	5.00	221	13.79
C2	101	14.65	9	1.00	208	12.98
C2	101	14.65	9	2.00	211	13.20
C2	101	14.65	9	3.00	223	13.94
C2	101	14.65	9	4.00	225	14.02
C2	101	14.65	9	5.00	219	13.66
C1	64	9.22	16	1.00	206	12.86
C1	64	9.22	16	2.00	216	13.47
C1	64	9.22	16	3.00	219	13.67
C1	64	9.22	16	4.00	218	13.62
C1	64	9.22	16	5.00	224	13.96
C1	64	9.22	16	1.00	200	12.46
C1	64	9.22	16	2.00	208	12.96
C1	64	9.22	16	3.00	207	12.93
C1	64	9.22	16	4.00	210	13.10
C1	64	9.22	16	5.00	209	13.04
C1	64	9.22	16	1.00	194	12.14
C1	64	9.22	16	2.00	205	12.77
C1	64	9.22	16	3.00	205	12.80
C1	64	9.22	16	4.00	206	12.85
C1	64	9.22	16	5.00	209	13.07
C1	82	11.94	16	1.00	216	13.50
C1	82	11.94	16	2.00	223	13.90
C1	82	11.94	16	3.00	227	14.17
C1	82	11.94	16	4.00	230	14.37
C1	82	11.94	16	5.00	233	14.52
C1	82	11.94	16	1.00	213	13.32
C1	82	11.94	16	2.00	223	13.90
C1	82	11.94	16	3.00	228	14.26
C1	82	11.94	16	4.00	229	14.27
C1	82	11.94	16	5.00	232	14.50
C1	82	11.94	16	1.00	205	12.80
C1	82	11.94	16	2.00	211	13.16
C1	82	11.94	16	3.00	212	13.24
C1	82	11.94	16	4.00	214	13.35
C1	82	11.94	16	5.00	212	13.24
C1	82	11.94	16	1.00	212	13.22
C1	82	11.94	16	2.00	208	13.00
C1	82	11.94	16	3.00	218	13.61
C1	82	11.94	16	4.00	217	13.56

C1	82	11.94	16	5.00	219	13.69
C1	101	14.65	16	1.00	218	13.58
C1	101	14.65	16	2.00	230	14.33
C1	101	14.65	16	3.00	234	14.58
C1	101	14.65	16	4.00	239	14.92
C1	101	14.65	16	5.00	237	14.80
C1	101	14.65	16	1.00	215	13.43
C1	101	14.65	16	2.00	219	13.70
C1	101	14.65	16	3.00	229	14.28
C1	101	14.65	16	4.00	226	14.13
C1	101	14.65	16	5.00	232	14.49
C1	101	14.65	16	1.00	175	10.90
C1	101	14.65	16	2.00	217	13.53
C1	101	14.65	16	3.00	220	13.73
C1	101	14.65	16	4.00	235	14.66
C1	101	14.65	16	5.00	234	14.63
C1	101	14.65	16	1.00	217	13.55
C1	101	14.65	16	2.00	218	13.63
C1	101	14.65	16	3.00	224	13.96
C1	101	14.65	16	4.00	230	14.36
C1	101	14.65	16	5.00	232	14.50
C2	64	9.22	16	1.00	201	12.53
C2	64	9.22	16	2.00	206	12.87
C2	64	9.22	16	3.00	216	13.49
C2	64	9.22	16	4.00	218	13.64
C2	64	9.22	16	5.00	223	13.93
C2	64	9.22	16	1.00	189	11.79
C2	64	9.22	16	2.00	193	12.04
C2	64	9.22	16	3.00	197	12.29
C2	64	9.22	16	4.00	198	12.39
C2	64	9.22	16	5.00	202	12.60
C2	64	9.22	16	1.00	181	11.28
C2	64	9.22	16	2.00	187	11.65
C2	64	9.22	16	3.00	184	11.50
C2	64	9.22	16	4.00	192	11.97
C2	64	9.22	16	5	188	11.73
C2	64	9.22	16	1	201	12.54
C2	64	9.22	16	2	210	13.11
C2	64	9.22	16	3	212	13.23
C2	64	9.22	16	4	214	13.35
C2	64	9.22	16	5	220	13.71
C2	82	11.94	16	1	208	12.96

C2	82	11.94	16	2	213	13.32
C2	82	11.94	16	3	216	13.47
C2	82	11.94	16	4	217	13.53
C2	82	11.94	16	5	224	13.96
C2	82	11.94	16	1	211	13.2
C2	82	11.94	16	2	215	13.4
C2	82	11.94	16	3	218	13.6
C2	82	11.94	16	4	222	13.83
C2	82	11.94	16	5	226	14.11
C2	82	11.94	16	1	192	11.97
C2	82	11.94	16	2	198	12.34
C2	82	11.94	16	3	203	12.65
C2	82	11.94	16	4	206	12.85
C2	82	11.94	16	5	208	12.97
C2	82	11.94	16	1	198	12.36
C2	82	11.94	16	2	201	12.57
C2	82	11.94	16	3	206	12.84
C2	82	11.94	16	4	207	12.92
C2	82	11.94	16	5	205	12.8
C2	101	14.65	16	1	217	13.52
C2	101	14.65	16	2	224	13.97
C2	101	14.65	16	3	227	14.16
C2	101	14.65	16	4	224	14
C2	101	14.65	16	5	229	14.27
C2	101	14.65	16	1	202	12.62
C2	101	14.65	16	2	201	12.56
C2	101	14.65	16	3	205	12.81
C2	101	14.65	16	4	205	12.8
C2	101	14.65	16	5	211	13.16
C2	101	14.65	16	1	203	12.68
C2	101	14.65	16	2	207	12.92
C2	101	14.65	16	3	213	13.27
C2	101	14.65	16	4	218	13.61
C2	101	14.65	16	5	216	13.5
C2	101	14.65	16	1	209	13.03
C2	101	14.65	16	2	210	13.08
C2	101	14.65	16	3	218	13.58
C2	101	14.65	16	4	216	13.46
C2	101	14.65	16	5	217	13.55
C1	64	9.22	10	1	198	12.39
C1	64	9.22	10	2	203	12.69
C1	64	9.22	10	3	205	12.82

C1	64	9.22	10	4	209	13.04
C1	64	9.22	10	5	210	13.08
C1	64	9.22	10	1	198	12.33
C1	64	9.22	10	2	203	12.65
C1	64	9.22	10	3	208	13
C1	64	9.22	10	4	208	12.99
C1	64	9.22	10	5	214	13.35
C1	64	9.22	10	1	193	12.03
C1	64	9.22	10	2	199	12.41
C1	64	9.22	10	3	201	12.55
C1	64	9.22	10	4	204	12.75
C1	64	9.22	10	5	206	12.88
C1	64	9.22	10	1	196	12.25
C1	64	9.22	10	2	200	12.48
C1	64	9.22	10	3	204	12.71
C1	64	9.22	10	4	206	12.85
C1	64	9.22	10	5	207	12.9
C1	82	11.94	10	1	197	12.32
C1	82	11.94	10	2	201	12.53
C1	82	11.94	10	3	206	12.85
C1	82	11.94	10	4	208	12.98
C1	82	11.94	10	5	209	13.03
C1	82	11.94	10	1	197	12.29
C1	82	11.94	10	2	206	12.87
C1	82	11.94	10	3	207	12.93
C1	82	11.94	10	4	209	13.07
C1	82	11.94	10	5	209	13.06
C1	82	11.94	10	1	201	12.55
C1	82	11.94	10	2	207	12.95
C1	82	11.94	10	3	209	13.05
C1	82	11.94	10	4	213	13.27
C1	82	11.94	10	5	213	13.32
C1	82	11.94	10	1	195	12.15
C1	82	11.94	10	2	202	12.64
C1	82	11.94	10	3	208	13.01
C1	82	11.94	10	4	210	13.14
C1	82	11.94	10	5	212	13.26
C1	101	14.65	10	1	196	12.22
C1	101	14.65	10	2	202	12.6
C1	101	14.65	10	3	206	12.86
C1	101	14.65	10	4	208	12.99
C1	101	14.65	10	5	212	13.22

C1	101	14.65	10	1	206	12.84
C1	101	14.65	10	2	215	13.42
C1	101	14.65	10	3	223	13.93
C1	101	14.65	10	4	225	14.02
C1	101	14.65	10	5	227	14.14
C1	101	14.65	10	1	203	12.67
C1	101	14.65	10	2	213	13.32
C1	101	14.65	10	3	218	13.62
C1	101	14.65	10	4	220	13.72
C1	101	14.65	10	5	222	13.89
C1	101	14.65	10	1	205	12.78
C1	101	14.65	10	2	213	13.28
C1	101	14.65	10	3	214	13.38
C1	101	14.65	10	4	218	13.59
C1	101	14.65	10	5	220	13.74
C2	64	9.22	10	1	189	11.82
C2	64	9.22	10	2	190	11.84
C2	64	9.22	10	3	194	12.11
C2	64	9.22	10	4	196	12.23
C2	64	9.22	10	5	198	12.36
C2	64	9.22	10	1	183	11.43
C2	64	9.22	10	2	188	11.76
C2	64	9.22	10	3	191	11.9
C2	64	9.22	10	4	193	12.03
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C2	64	9.22	17	2	202	12.59
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C2	82	11.94	17	3	217	13.54
C2	82	11.94	17	4	224	13.96
C2	82	11.94	17	5	223	13.95
C2	101	14.65	17	1	214	13.37
C2	101	14.65	17	2	216	13.49
C2	101	14.65	17	3	219	13.69
C2	101	14.65	17	4	219	13.66
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C2	101	14.65	17	2	207	12.94
C2	101	14.65	17	3	213	13.32
C2	101	14.65	17	4	217	13.52
C2	101	14.65	17	5	221	13.81
C1	64	9.22	18	1	199	12.44
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C1	64	9.22	18	3	211	13.15
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C1	64	9.22	18	1	198	12.38
C1	64	9.22	18	2	206	12.83
C1	64	9.22	18	3	214	13.37
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C1	64	9.22	18	5	214	13.35
C1	64	9.22	18	1	191	11.91
C1	64	9.22	18	2	196	12.25
C1	64	9.22	18	3	201	12.53
C1	64	9.22	18	4	203	12.68
C1	64	9.22	18	5	204	12.73
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C1	64	9.22	18	2	201	12.55
C1	64	9.22	18	3	204	12.72
C1	64	9.22	18	4	206	12.89
C1	64	9.22	18	5	209	13.02
C1	82	11.94	18	1	204	12.71
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C1	82	11.94	18	3	225	14.07
C1	82	11.94	18	4	232	14.49
C1	82	11.94	18	5	227	14.2
C1	82	11.94	18	1	213	13.29
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C1	82	11.94	18	3	224	14
C1	82	11.94	18	4	231	14.42
C1	82	11.94	18	5	236	14.74
C1	82	11.94	18	1	199	12.45
C1	82	11.94	18	2	208	12.98
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C1	101	14.65	18	4	231	14.4
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C1	101	14.65	18	4	227	14.15
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C2	64	9.22	18	4	203	12.7

C2	64	9.22	18	5	206	12.84
C2	64	9.22	18	1	193	12.04
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C2	64	9.22	18	4	199	12.45
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C2	82	11.94	18	3	218	13.58
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C2	101	14.65	18	5	219	13.69
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C1	64	9.22	16	4	212	13.25
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C1	64	9.22	16	3	203	12.67
C1	64	9.22	16	4	210	13.14
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C1	82	11.94	16	4	218	13.58
C1	82	11.94	16	5	220	13.75
C1	101	14.65	16	1	221	13.78
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C1	101	14.65	16	3	234	14.58

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C1	101	14.65	16	4	220	13.74
C1	101	14.65	16	5	223	13.93
C2	64	9.22	16	1	202	12.59
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C2	64	9.22	16	3	203	12.65
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C2	64	9.22	16	4	203	12.66
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C2	82	11.94	16	1	202	12.58
C2	82	11.94	16	2	205	12.8
C2	82	11.94	16	3	217	13.53
C2	82	11.94	16	4	219	13.69
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C2	82	11.94	16	4	204	12.71
C2	82	11.94	16	5	205	12.77
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C2	101	14.65	16	5	211	13.16
C2	101	14.65	16	1	202	12.58
C2	101	14.65	16	2	208	12.97
C2	101	14.65	16	3	212	13.21
C2	101	14.65	16	4	214	13.39
C2	101	14.65	16	5	216	13.51
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C1	64	9.22	36	3	191	11.92
C1	64	9.22	36	4	179	11.18
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C1	64	9.22	36	1	184	11.48
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C1	64	9.22	36	1	173	10.81
C1	64	9.22	36	2	180	11.22
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C1	101	14.65	36	4	221	13.78

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C1	82	11.94	12	3	208	13.01
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C1	101	14.65	12	1	212	13.25
C1	101	14.65	12	2	217	13.53
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C1	101	14.65	12	4	223	13.95
C1	101	14.65	12	5	227	14.17
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C1	101	14.65	12	3	222	13.83
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C2	64	9.22	12	2	187	11.69
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C2	64	9.22	12	1	183	11.44
C2	64	9.22	12	2	189	11.8
C2	64	9.22	12	3	192	11.99
C2	64	9.22	12	4	199	12.45
C2	64	9.22	12	5	191	11.92
C2	64	9.22	12	1	177	11.06
C2	64	9.22	12	2	183	11.41
C2	64	9.22	12	3	189	11.8
C2	64	9.22	12	4	188	11.72
C2	64	9.22	12	5	189	11.79

C2	82	11.94	12	1	198	12.36
C2	82	11.94	12	2	204	12.73
C2	82	11.94	12	3	209	13.03
C2	82	11.94	12	4	211	13.18
C2	82	11.94	12	5	214	13.35
C2	82	11.94	12	1	192	11.98
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C2	82	11.94	12	4	197	12.3
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C2	82	11.94	12	2	192	11.98
C2	82	11.94	12	3	194	12.13
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C2	82	11.94	12	5	200	12.49
C2	101	14.65	12	1	191	11.95
C2	101	14.65	12	2	201	12.55
C2	101	14.65	12	3	206	12.84
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C2	101	14.65	12	1	190	11.85
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C2	101	14.65	12	3	198	12.33
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C2	101	14.65	12	5	205	12.81
C2	101	14.65	12	1	192	11.98
C2	101	14.65	12	2	199	12.45
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C1	101	14.65	37	2	214	13.33
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C1	101	14.65	37	4	218	13.6

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C2	82	11.94	37	5	215	13.42
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C2	101	14.65	37	5	215	13.43

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