THE ECONOMIC FEASIBILITY FOR COMMERCIALIZING DRAG REDUCING AGENT FROM COCOA HUSK

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MASTER OF CHEMICAL ENGINEERING WITH ENTREPRENEURSHIP

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Thesis submitted in partial fulfillment of the requirements for the award of the degree of
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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion this thesis is satisfactory in terms of scope and quality for the award of the degree of Master of Chemical Engineering with Entrepreneurship.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

The development and application of Drag reduction agent (DRA) mostly related to gas, oil and petrochemical industry. Natural and non toxic DRA is needed to replace existing toxic synthetic polymer and artificial polymers used as flow improvers commercially. Generally, the drag reduction effectiveness of the cocoa husk mucilage was proven, with a maximum percentage drag reduction value of 54.55%.The cocoa bean husk mucilage concentration and the solution flow rate, showed a great effect on profile of drag reduction in the pipe. As concentration of cocoa bean husk mucilage increases, drag reduction increases in all conditions of experimental research. DRA is in demand for refinery industry as flow improver. As for commercialization strategy, 4P's or marketing mix, 4 P's stands for Promotion, Place, Price and Product and SWOT analysis were done for DRA. Economic analysis for DRA showing that DRA production is profitable. The DRA is niche player in the specialty and chemical business, focusing on value added product which is not widely or readily available in Malaysia. The operating cost is quite reasonable. The profit of the DRA production plant is quite impressive. Therefore, this plant is believed to be a profit making plant. This DRA production will recover back it capital cost at the 5 year after beginning operation, the DRA would cost just under RM 1.14 or under $1 per barrel of crude oil. DRA product is very unique and highly demand in the market.

ABSTRAK

Pembangunan dan aplikasi Drag reduction agent (DRA) kebanyakannya berkaitan dengan industri minyak, gas dan petrokimia. DRA yang asli dan bukan toksik diperlukan untuk menggantikan polimer yang sedia ada toksik sintetik dan polimer tiruan digunakan sebagai penambahbaik arus aliran komersial. Secara umumnya, keberkesanan DRA dari lendir sekam koko telah terbukti, dengan peratusan pengurangan nilai maksimum geseren 54.55%. Melalui ekstrak sekam koko dan kadar aliran media, menunjukkan kesan yang besar kepada profil pengurangan seretan di dalam paip. Dengan kepekatan ekstrak sekam koko ditingkatkan , pengurangan seret meningkat dalam semua keadaan penyelidikan eksperimen. DRA mempunyai permintaan yang tinggi, terutama untuk industri penapisan sebagai penambahbaik arus aliran. Strategi pengkomersilan, 4P atau campuran pemasaran dan analisis SWOT dilakukan untuk DRA. Analisis Ekonomi untuk DRA menunjukkan bahawa pengeluaran DRA menguntungkan. DRA adalah pemain khusus dalam perniagaan khusus dan kimia, memberi tumpuan kepada produk nilai tambah yang tidak meluas atau sedia ada di Malaysia. Kos operasi adalah agak munasabah. Keuntungan loji pengeluaran DRA adalah agak menarik. Oleh itu, kilang pembuatan DRA dipercayai untuk menjadi sebuah kilang memberikan keuntungan. Ini pengeluaran DRA akan mengembalikan kos modal pada 5 tahun selepas mula beroperasi, kos DRA hanya di bawah RM 1.14 atau di bawah $ 1 setong minyak mentah. DRA produk adalah sangat unik dan mempunyai permintaan yang sangat tinggi di pasaran.

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C	Concentration
% FI	Percentage flow increase
ΔP	Pressure drop
D	Diameter
D1	Main tank drain
D2	Collecting tank drain
F	Fanning friction factor
F1	Ultrasonic flow meter
Fp	Friction factor of the drag reduced flow
*F*s	Friction factor of the tap water
KKM 22	Cocoa clone.
Le	Length required for a fully developed velocity profile
Lp	Length of the pipe
P1	Section pipe one
P2	Section pipe two
P3	Section pipe three
P4	Pressure gauge
p1	Main pipe
p2	Bypass pipe
p3	0.0127 m pipe
p4	0.0254 m pipe
p5	0.0381 m pipe

p6	Circulation pipe
ppm	Part per million
PU1	Main pump
PU2	Recirculation pump
Q	Mass flow rate
Q	Volumetric flow Rate
R	Pipe radius
R	Radius at measuring position
Re	Reynolds number
Sc	Schmidt number
St	Stanton number
T1	Main tank
T2	Collecting tank
t1, t2, t3, t4, t5	Testing point
U	Streamwise velocity fluctuation
U	Velocity
U_{av}	Mean fluid velocity
U_m	Bulk mean velocity
V	Wall-normal velocity fluctuation
ν	Kinematics viscosity
v1	Pump valve
v2	Bypass valve
v3, v4, v5	Pipe valve
v6	Circulation valve
Wt	Weight
Θ	Temperature fluctuation

M	Dynamic viscosity
P	Density
Tw	Wall shear stress

LIST OF ABBREVATION

CPC	Caspian Pipeline Consortium
DR	Drag reduction
DRA	Drag reduction agent
DCFROR	discounted cash flow rate of return
FCI	Fixed capital investment
GRC	Grass root capital
MTA	Metric tonne annually
OECD	Organizations for Economic Co-operation and Development
NPV	Net present value
PBP	payback period
TCI	Total Capital Investment
TMC	Total module cost

CHAPTER 1

INTRODUCTION

1.0 Introduction

Recent developments have heightened mostly in application of Drag reduction agent (DRA) related to gas, oil and petrochemical industry. DRA is widely used in transportation of crude product or refining product and also important in the most of oil expansion project. The oil expansion project have correlate with the global energy issue.

In recent years, there has been an increasing demand for energy, between 2006 and 2030 , global primary energy demand is projected to increase by just over half, or at an annual rate of 1.6%. Over 70% of that increase in demand will be from developing countries, China alone accounting for nearly 30%. This represents a significant shift in the centre of gravity of global energy demand towards countries that are experiencing faster economic (and often population) growth than more advanced countries such as those in the Organizations for Economic Co-operation and Development (OECD).

The energy industry is known for being highly capital intensive, DRA as flow improver surely can help reduce the transportation costing. The term Drag Reducing Agents or DRA has become a common word in the flow improving research. This term DRA has been used to acknowledge the additive that will be used to reduce the drag in turbulent flow. Surfactants, fibers, and polymers are among the well known additives used as a DRA. Polymers maybe classified as the most successful drag reducing agent from the commercial point of view. The usage of polymers in pipelines improves the flow without changing the pipeline geometry, and also increase the toxicity level inside the pipeline. A more environmentally friendly solution is needed (Gareth *et al*., 2004). DRA is one of the factors of energy development, energy development can bring government revenues, create jobs and contribute to broader prosperity.

1.1 Problem Statement

Transportation of liquids (refinery product) through pipelines is the cheapest way for transporting in large quantities, but the problem is relating to energy loss during transportation. Thus, to reduce the energy loss forcing companies to install pumping station to support the flow of the product in the pipeline. With addition of pumping station, it will add up costing for transportation. This problem can be solved by using drag reducing agent (DRA). Drag Reduction Agent (DRA) is a special polymer that injected into a pipeline transporting fluids (crude, refined products). Drag reduction agent will allows pipelines to be operated at a lower pressure drop, reducing energy costs and optimizing production with less energy consumption in transporting fluids through pipelines.

1.2 Objective

The objective of the project is to merge the research study of extraction of new natural and environmentally friendly drag reducing agents using cocoa Husk waste with commercialization strategy.

1.3 Scope of study

In order to achieve the objective, the following scopes have been identified:

-Investigation of the DRA production process, the resources availability, the pricing from cocoa husk to capital cost involved in production and estimates the revenue and rate of return of the investment.

1.4 Rationale and Significance

This research was part of the effort in order to commercializing DRA from cocoa husk. The interest in replacing toxic synthetic polymer DRA is increase due to environment awareness. From this research, help to establish and provide new business opportunity for natural DRA since its preferable economic feasibility and environment friendly .

CHAPTER 2

LITERATURE REVIEW

2.0 Literature review

DRAs are long chain chemical additives that are used in crude oil, refined products or non-potable water pipelines. They are injected in small amounts, and are used to reduce the frictional pressure drop along the pipeline's length, they are also known as flow improvers. DRAs such as flexible polymers and surfactants can decrease the consumption of the system energy up to 90%, reduce pipe and pump size, and increase flow rate or system length, but they also decrease heat transfer (Gasljevic et al., 1995).

Daas (2001) reviewed the types of DRA's and mentioned that the first generation of DRA was in the form of gel, and nowadays, DRA's can be found in the form of slurries and even powders. The slurry form of DRA appears as a thick, viscous, highly viscoelastic but also highly thixotropic solution. Depending on its application and the nature of treated oil-water mixtures, DRA's are either oil-soluble or water-soluble. When oil percent is high in the liquid phase then oil-soluble DRA is to be injected into the pipeline, otherwise water soluble DRA is to be used. Vancko (1997) said that the first use of DRA's in oil fields was to reduce pressure loss while pumping fluids down hole into fractured tight formations

2.1 Marketing Strategy

2.1.1 Potential market for DRA

As to show the demand for DRA usage, can see the Druzhba pipeline system, which is the largest pipeline system in the world that use DRA. Under normal circumstances, almost all crude oil processed in Poland, the Slovak Republic, Hungary and eastern parts of Germany as well as a substantial proportion of the crude oil processed in the Czech Republic originates from Russia and is delivered to re- fineries in these countries via the Druzhba (Purvin & Gertz, 2010)

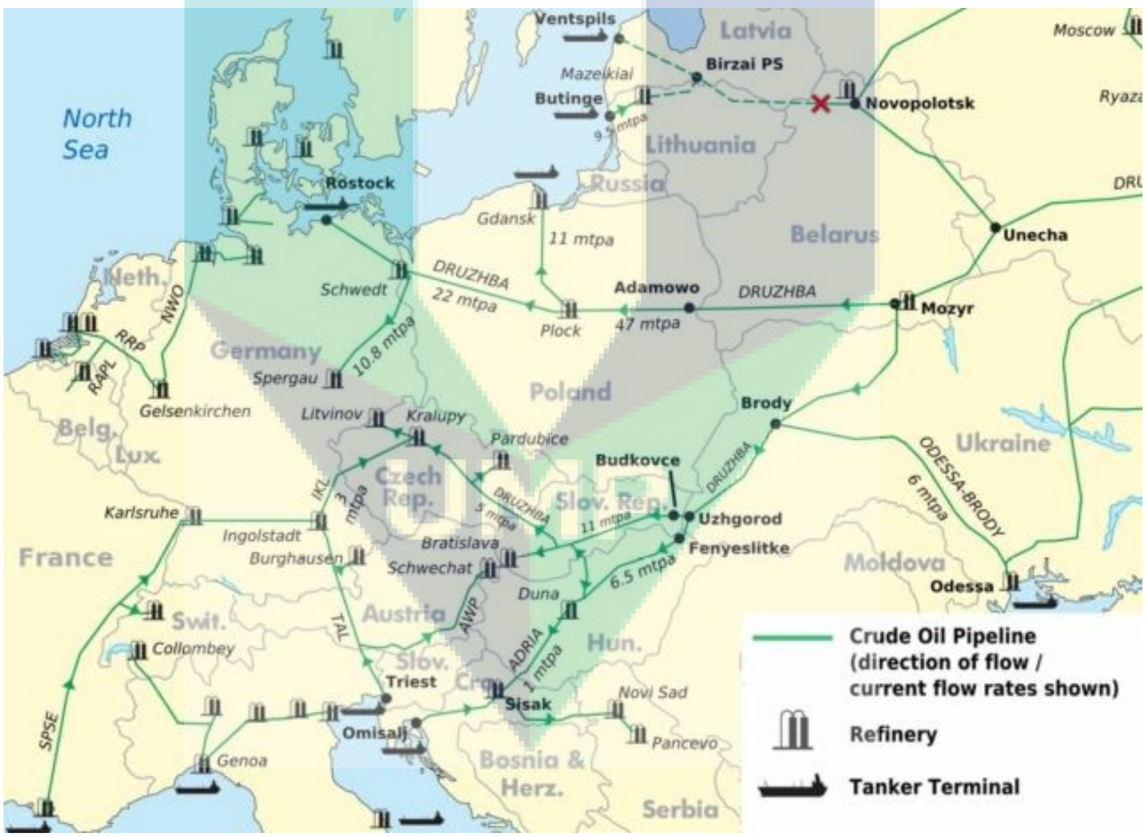

Figure 2.1 Current Flows in Central and Eastern Europe's Oil Pipeline Network

The Druzhba line begins in South Eastern Russia, where it collects oil from Western Siberia, the Urals and, to a smaller extent, the Caspian Sea. Most of the crude oil is blended to a common export blend referred to as Russian Export Blend (REB), or Urals Blend. The line runs to Mozyr in Belarus where it splits into two branches, the Northern and Southern Druzhba lines. The current flow through Belarus amounts to 64 million tons per year (MTA) of REB in addition to some crude exported to non-EU countries (mainly via Odessa). The Druzhba pipelines choose to use DRA as to help to improve the flow in their pipeline work. This option would be a very cost-effective solution (Purvin & Gertz, 2010).

According to the *Oil & Gas Journal (OGJ)*, Malaysia held proven oil reserves of 4 billion barrels as of January 2011. Nearly all of Malaysia's oil comes from offshore fields

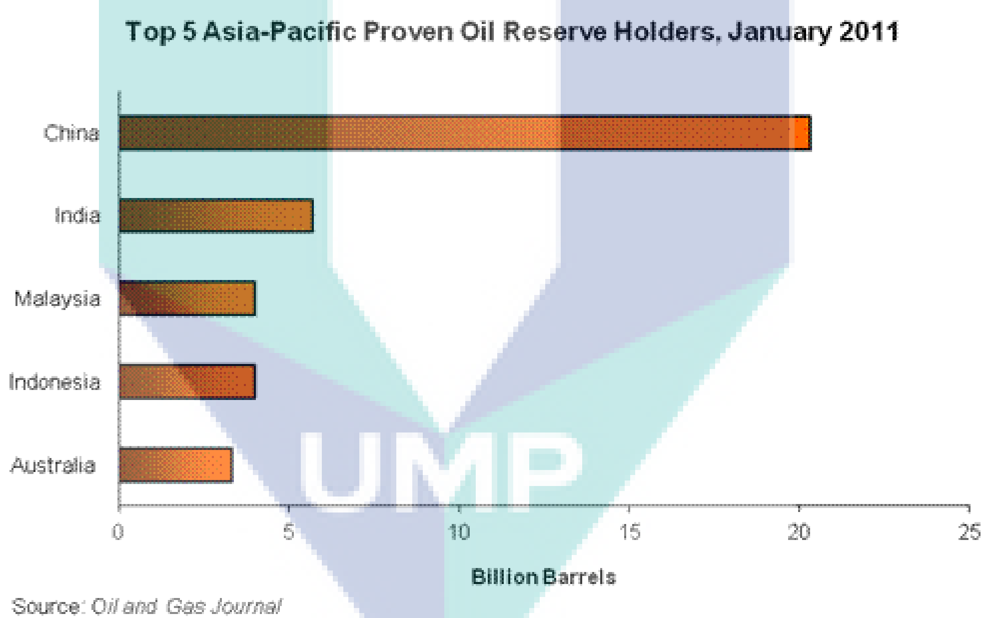

Figure 2.2 Figure Top 5 Asia-Pacific Proven Oil Reserves Holders

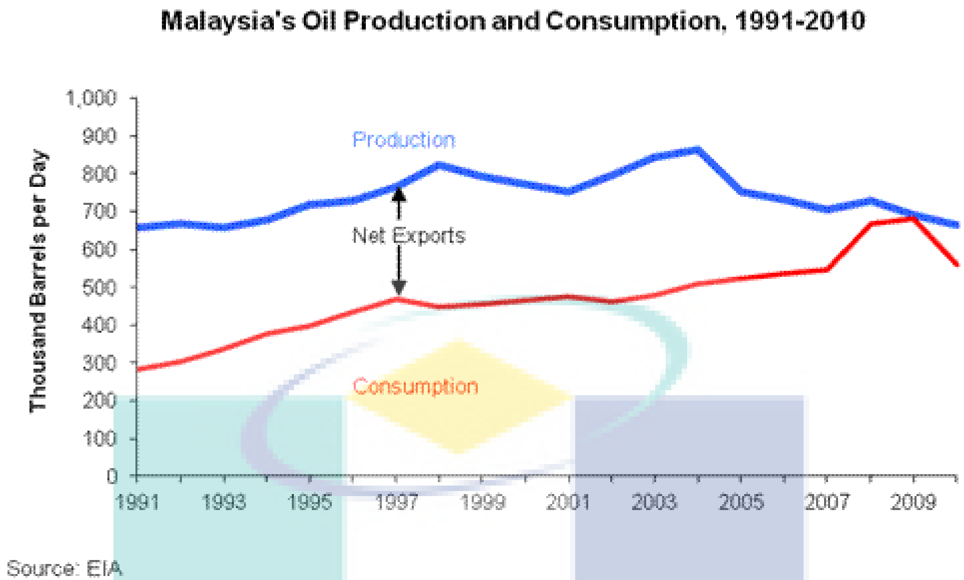

Figure 2.3 Figure showing Malaysia's Oil Production and Consumption, 1991-2010

Total oil production in 2011 was an estimated 630,000 barrels per day (bbl/d), compared with 665,000 in 2010, of which about 83 percent was crude oil

Malaysia's main oil pipelines connect oil fields offshore Peninsular Malaysia to onshore storage and terminal facilities. From the Tapis oil field runs the 124-mile Tapis pipeline, which terminates at the Kerteh plant in Terengganu, as does the 145-mile Jerneh condensate pipeline. The oil pipeline network for Sabah connects offshore oil fields with the onshore Labuan oil terminal. This network is currently expanding following the launch of development projects including the Kebabangan cluster, the Malikai, Gemusat/Kekap, and Kikeh oil fields. For Sarawak, there are a few other oil pipelines connecting offshore fields with the onshore Bintulu terminal. The majority of pipelines are operated by Petronas, although ExxonMobil also operates a number of pipelines connected with its significant upstream holdings located offshore Peninsular Malaysia.

An international oil products pipeline runs from the Dumai oil refinery in Indonesia to the Melaka oil refinery in Melaka City,Malaysia. An interconnecting pipeline runs from this refinery via Port Dickenson to the Klang Valley airport and to the Klang oil distribution center.(Energy Information Administration, 2011)

In Malaysia, the target market for DRA product is focusing on Petroleum and Gas Industry (Pipeline for refinery product) for example, Petronas and EssonMobil.

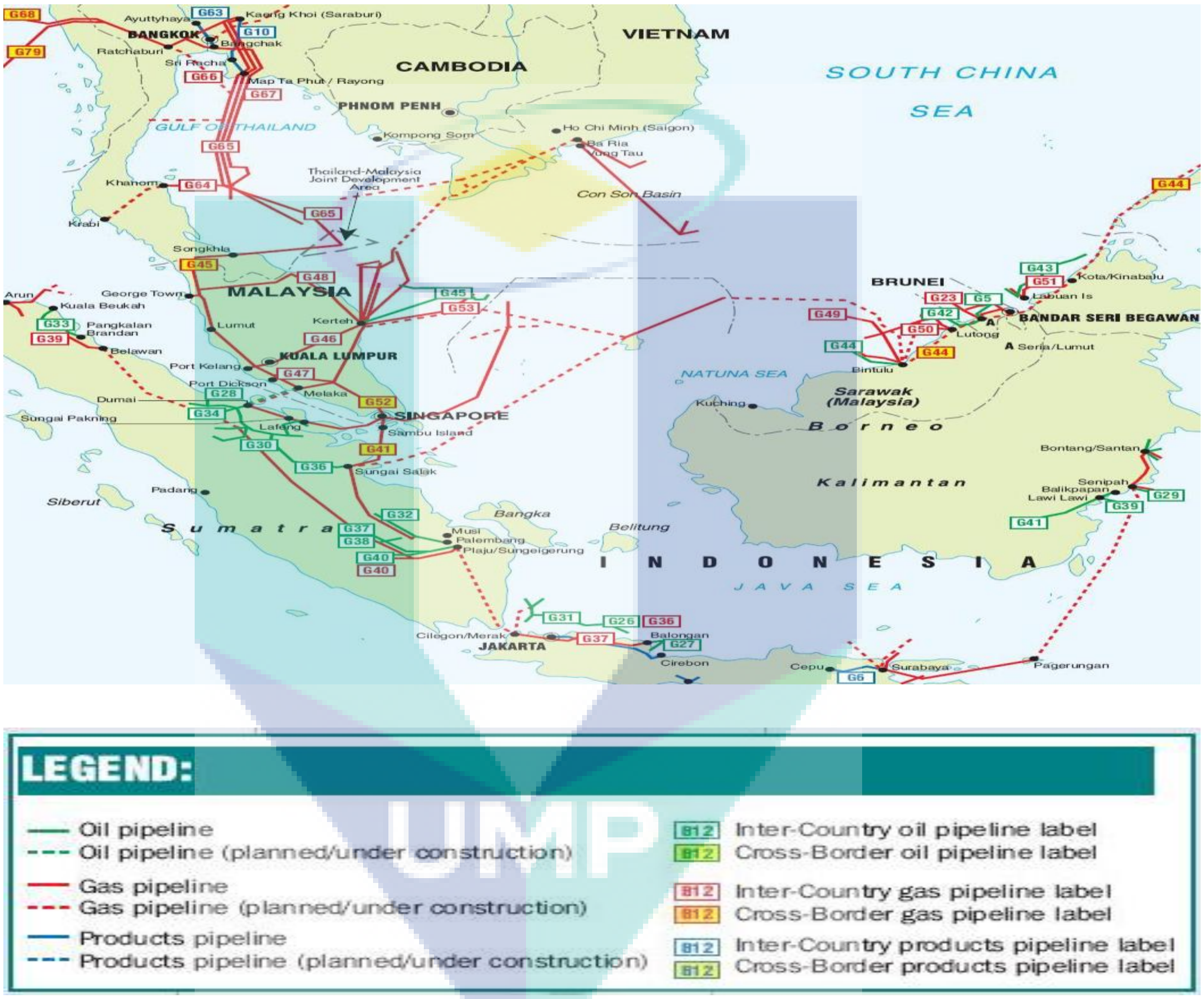

Figure 2.4 Pipeline for Oil & Gas in South East Asia

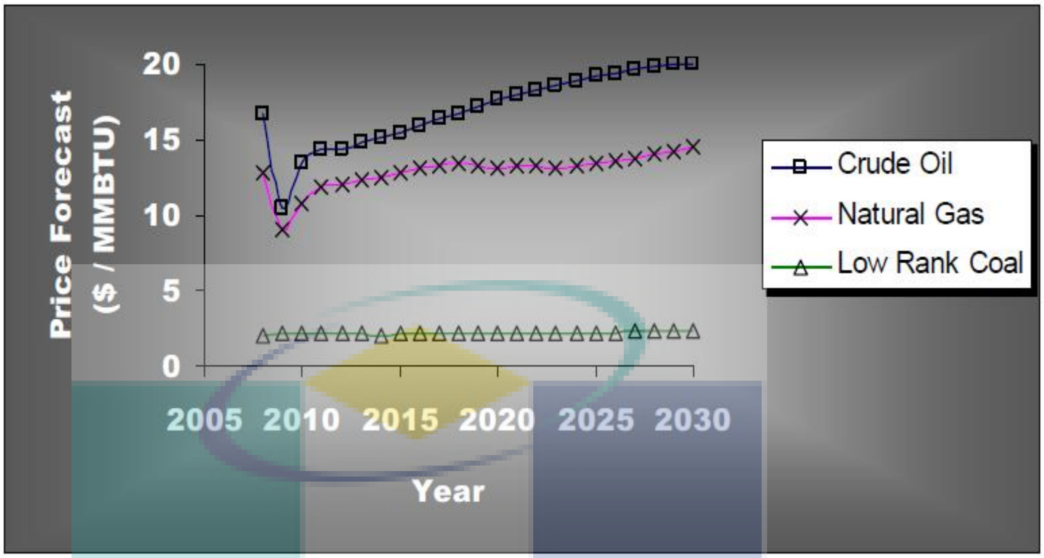

Figure 2.5 Projected Price Comparison for Crude Oil, Natural Gas and Low Rank Coal

As the price increasing, demand for DRA will increase to reduce the cost on pipeline transportation. DRA will ease the manufacturer costing in pipeline transportation because DRA can double up their production by improve the refinery product flow nearly by 50-55 %, it also reduce the pump power.

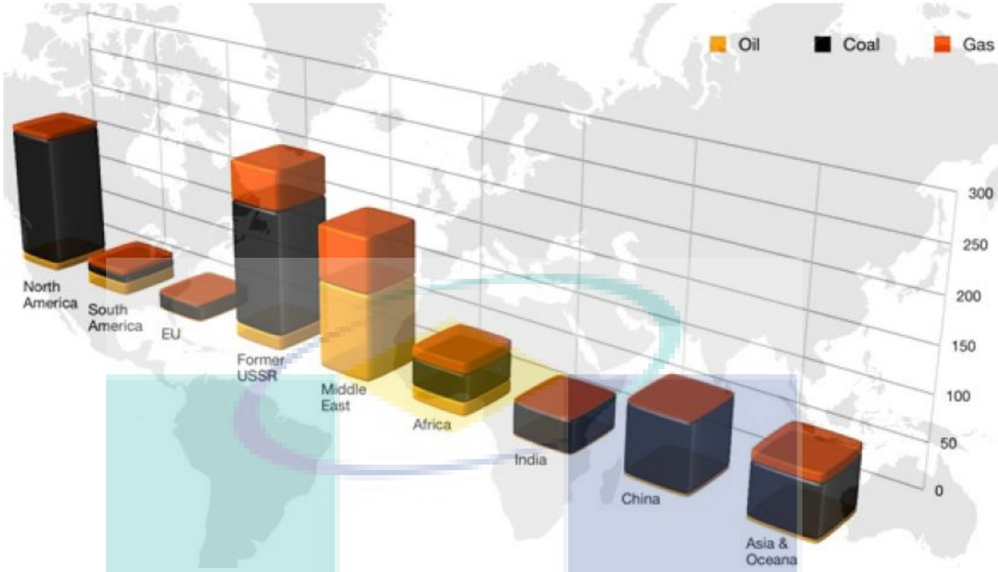

Figure 2.6 World proven reserves of Oil, Coal and Gas (Source Nitrogen and Syngas 2012 conference)

Based on the figure above, it's proven that growing of oil pipeline construction project due to the growing oil production. Thus DRA will be in demand to meet the expansion of oil pipeline constructions to help the refinery product flow. For examples, North Dakota System Expansion

The expansion is expected to increase system capacity from 110,000 bpd to 161,000 bpd and will consist of upgrades to existing pump stations, additional tankage as well as extensive use of drag reducing agents that are injected into the pipeline. The commercial structure for this expansion is a cost of service based surcharge that will be added to the existing transportation rates. Approval was received from the FERC in October 2008. The expansion is expected to be in-service in early 2010.

Furthermore, for Caspian Pipeline Consortium Expansion Project, Project Phase 1 involves refurbishment of the existing CPC facilities, including replacement of 88 km pipeline in Kazakhstan as well as construction of the third SPM and three tanks 100,000 cum each at the Marine Terminal, which will allow to achieve up to 35 MTA capacity in 2012 from the current level of 28 MTA (CPC is currently shipping 34-35 MTA per annum by using Drag Reducing Agent. Project Phase 2 aiming to increase the capacity up to 48 MTA by building five new PSs will be complete in 2013. Project Phase 3 targeting construction of another five new PSs and three tanks 100,000 cum each and the increase capacity up to the designed 67 MTA will be complete in 2014. Thus, from this pipeline expansion project, can conclude that DRA is in demand for the pipeline flow improver.

2.2 SWOT Analysis

Most management strategy includes a recommendation to perform a SWOT analysis.

SWOT stands for:

- Strengths (what are the positive attributes of the product ?)
- Weaknesses (what are the negative attributes of the product ?)
- Opportunities (where are the market opportunities for the product?)
- Threats (what are the main threats to the company/product?)

From the chart below can help in doing the SWOT analysis for the drag reduction agent product.

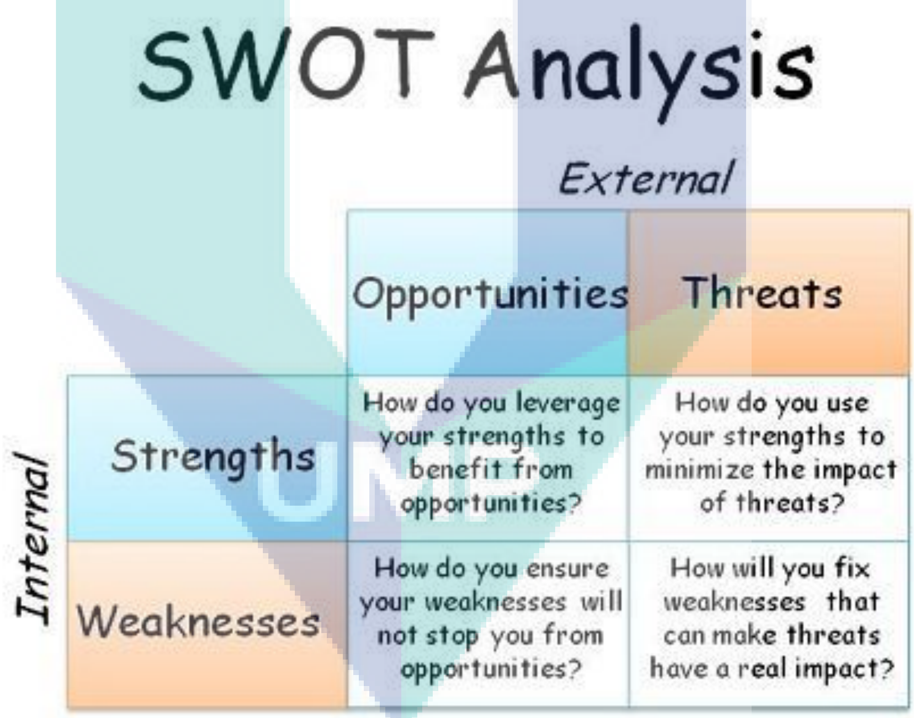

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Figure 2.7 SWOT analysis chart

As can be seen in figure above, a matrix can be made showing the possible combination of the internal and external factors. The Strength-Opportunities strategies are the ones that should be pursued because there is a good fit between the external opportunities and the internal strength of the product. With Weaknesses-Opportunities, must overcome internal weaknesses before pursue the opportunity. Strength- Threat strategies where must use the strength to overcome the threats. Weaknesses-Threat strategies are strategies where must find defensive position to prevent the threats from taking advantages of the weaknesses (Philip et.al, 2010).

Strengths are the core competencies of the business. They are the factor that makes the business succeed because the product performs in these areas better than the competitors. Strengths analysis must be done to determine which areas that the product is proficient. Weaknesses is the areas where needs improvement. Opportunities are factors that exist in the business environment, if utilized; opportunities help the business grow and prosper. Opportunities, then, also are factors that exist outside the business but if recognized and taken advantage of, help the business grow. Threats are factors that exist in the environment that may impede the growth of the business, directly or indirectly(Newell, 2005).

2.3 Financial Strategy

Normally corporate managers must issue a lot of report to the public. Most of stockholders, analysts, government entities and other interested parties may pay particular attention to annual reports. An annual report provides four basic financial statements: the balance sheet, the income statement, the statement of cash flow and the statement of retained earnings. The financial strategy is important in commercialization strategy as the investor will look at the financial status of the company before make any investment(Marcia. *et al*, 2009).

2.3.1 Balance Sheet

The balance sheet or in accounting texts, the statement of financial position for the business list all assets and liabilities.

The balance sheet formula

Assets= Liabilities + Equity

Table 2.1 The basic balance sheet

Total assets		**Total Liabilities and Equity**	
Current assets		Current liabilities	
Cash and marketable securities		Accrued wages and taxes	
Accounts receivable		Notes payable	
Inventory		Long term debt	
Fixed assets			
Gross plant and equipment		Stockholders' equity	
Less: Depreciation		Preferred stock	
Net plant and equipment		Common stock and paid-in-surplus	
Other long term assets		Retained earnings	

Figure above illustrate a basic balance sheet, the left sides of the balance sheet lists assets of the firm and the right side lists liabilities and equity. Both assets and liabilities are listed in descending order of liquidity, that is, the time and effort it takes to convert the account to cash. The most liquid assets called current assets appear first on the asset side of the balance sheet. The least liquid, called fixed asset, appear last. Similarly, current liabilities those obligation that the firm must pay within a year, appear first on the right side of the balance sheet. Stockholders' equity, which never matures appears last on the balance sheet.

Managing balance sheet will need to monitor a number of issues underlying items reported on the balance sheet. These include the accounting method for fixed asset depreciation, the level of net working capital, the liquidity position, the method for financing the assets- equity or debt, the difference between the book value reported on the balance sheet and the true market value.(Philip et.al, 2010)

2.3.2 Income Statement

The income statement is like a motion picture, it show what has happened during the accounting period with regard to the revenues (income) and expenditures (expenses) of the business. The normal accounting period is 1 year. For external reporting, corporation typically generates quarterly income statements. They often issue quarterly to stockholders and other creditors and investor.

A proforma financial statement is developed to project the future condition of a business based on forecast. It projects future income and expense as determined by a forecast of future operation.

Table 2.2 The basic income statement

Net sales (all credit)	
Less: Cost of goods sold	
Gross profits	Operating income
Less Depreciation	
Earnings before interest and taxes (EBIT)	
Less : Interest	
Earnings before taxes (EBT)	Financing and tax considerations
Less : Taxes	
Net income before preferred dividends	
Preferred dividends	
Net Income	

The income statement then shows various expenses (cost of goods sold, depreciation, interest and taxes) subtracted from revenues to arrive at profit or income measures. The top part of the income statement report the firm's operating income. First subtract the cost of goods sold (the direct cost of producing the product) from net sales to get gross profit. Next deduct the depreciation from gross profits to get operating profit or earnings before interest and taxes (EBIT). The (EBIT) figures represent the profit earned from the sale of the product without any financing cost or tax considerations (Marcia. *et al*, 2009). The bottom part of the income statement summarizes financial tax structure. First subtract interest expense from EBIT to get earnings before taxes (EBT).

Clearly, income statement and balance sheet are the most common financial documents available to the public.

2.3.3 Economic Analysis

Project cash flow represents both benefits and the cost of the project. These cash flows should estimate for the entire project life cycle, including the development and production phases. There are basically two cash flow streams: investment cost and net revenues in the production phase. The first cash flow stream typically is comprised of development phase cost and production phase capital cost. The latter, in the case of a product development project, for example, may including building a manufacturing plant and product launch cost.

The second stream, commonly referred to as project payoff, is a net cash flow, which is the difference between the revenues and the cost associated with those revenues in the production phase of the project. The crux of the project valuation lies in estimating these two cash flow streams over the entire project life cycle and discounting them back today's value using the appropriate discount rate. (Prasad Kodukula, 2006)

Discount rate is the rate that is used to convert the future value of the project cash flows to today's value. It is adjusted for the risk perceived to be associated with the project, the higher the risk, the higher the discount rate.

2.4 Raw material Availability

Cocoa serves as an important crop around the world: a cash crop for growing countries and a key import for processing and consuming countries. Cocoa travels along a global supply chain crossing countries and continents. The complex production process involves numerous parties including, farmers, buyers, shipping organizations, processors, chocolatiers, and distributers. Cultivation of cocoa at the farm level is a delicate process as crops are susceptible to various conditions including weather patterns, diseases, and insects. Unlike larger, industrialized agribusinesses, the vast majority of cocoa still comes from small, family-run farms, who often confront outdated farming practices and limited organizational leverage. Based on the Cocoa World Foundation, 2012, a steady demand from worldwide consumers draws numerous global efforts and funds committed to support and improve cocoa farm sustainability.

Cocoa production is an important economic activity in many agricultural countries, and Malaysia is one of those countries. So far, it has been only the cocoa beans that have been utilized and little or no attention is given to the other parts that, together with the beans, from the cocoa pod. Cocoa pod husks are a non-utilized part of the cocoa pods. It has been estimated that husks could be collected from the farmers at low or no cost, (Simpson et al, 1985).

Because cocoa husk causes pollution as well as host pests when left to lie in estates or at processing plants, therefore, farmers have to find ways of disposing of this cocoa husk, among others, as animal feeds. The usage of cocoa husk as animal feed has been investigated primarily with ruminant rather than monogastric animals. The result is a reduced need for new materials as well as fewer materials discarded into landfills. Using alternative materials such as cocoa husk, not only helps protect and restore our natural resources, but also creates employment, which is healthy for our economy (Ridzwan et al, 1993).

Large numbers of agricultural wastes were tested in order to choose the most suitable one in the present work. The most important category adopted in choosing the suitable leave to extract the mucilage from is that it must be an agricultural waste.

Waste is simply a choice: whether we can embrace a new approach to developing our social and economic potential, or whether we are genuinely constrained by the structures and assumptions of the past. Waste has always been the shadow side of the economy. In production and consumption, it is that which is rejected as useless and barren.

Malaysia is the seventh largest supplier of chocolate in the world, The bulk of the cocoa products in the State is exported as cocoa beans and processed cocoa butter and cocoa powder.

Cocoa wastes, such as the husks, pulp and by-products from cocoa butter, are being commercially processed to produce a variety of 'added-value' products such as cattle feed, fertilizers, food products , and for more added value, by making drag reducing agent from the cocoa husk.

CHAPTER 3

METHODOLOGY

3.0 Introduction

The experimental setup and procedures are explained by Muhammed, (2011). The experimental works were carried out to obtain the data for the pressure drops of aqueous solution with additives.

3.1 Materials and Apparatus

3.1.1 Cocoa Husk

The choice of cocoa husk was base on two reasons; the first one was because of its availability in the Malaysian market and consider as a waste, so the cost of the raw material will be low, and the second because it contains high percentage of mucilage that can be work as DRA after extraction.

A mature cocoa fruit collected from Malaysian cocoa board - Cocoa Research & Development Centre – Jengka, located in Jengka city. The mature fruit has a reddish yellow color, and smooth surface. A pod has a rough leathery rind of 3 cm (1½ inch) thick, it is filled with slimy pinkish pulp, sweet but inedible, enclosing from 30 to 50 large almondlike seeds that are fairly soft and pinkish or purplish in color. Figure 3.1 and 3.2 shows snapshots for samples of the selected cocoa fruits, and cocoa husk wastes

Figure 3.1: Mature cocoa pod

Figure 3.2 : Cocoa pod husk after removing the seeds

3.1.2 Ethanol

Ethanol of a laboratory grade (95% purity) Fluka was used to extract the mucilage from the husk of the cocoa. Ethanol was chosen as the solvent in the present work due to its good ability to extract the mucilage without destroying the bonds. The specifications of the ethanol used are shown in Table 3.1

Table 3.1 Specifications of Ethanol

Properties	
Molecular formula	C_2H_6O
Molar mass	46.07 g mol^{-1}
Density	0.789 g/cm^3
Boiling point	78.4 C

3.1.3 Calcium Chloride

Calcium chloride with 99 % laboratory grade has been used for the extraction process of the mucilage as a dryer compound for ethanol vapors. Table 3.2 showing specifications of Calcium Chloride.

Table 3.2 Specifications of Calcium Chloride

Properties	
Molecular formula	$CaCl_2$
Molar mass	110.98 g/mol (anhydrous)
Appearance	white solid
Density	2.15 g /cm^3 (anhydrous)
Melting point	772 °C (anhydrous)
Boiling point	1935 °C (anhydrous)

3.1.4 Anti Oxidant

TRITON® X-100 from amresco® company has been added as an anti oxidant, with the following specifications listed in Table 3.3.

Table 3.3 Specification of anti oxide triton®

Properties	
Grade	Reagent Grade TX-100, octoxynol 9
Molecular Weight	647
Molecular Formula:	$C_{34}H_{62}O_{11}$
pH (5%, Water) @25C	6.0 - 8.0

3.1.7 Autoclave

As shown in Figure 3.3 an autoclave type 500 E steam sterilizer has been used in the extraction of the mucilage. The manufacturer is H+P Labortechnik AG company from Germany. The specifications of the autoclave are listed in Table 3.4.

Table 3.4 Specification of 500 E autoclave

Properties	
Max pressure	2.5 bar
Max temperature	150 °C
Volume	202 L
Electricity power	6.2 KW
Frequency	50 Hz

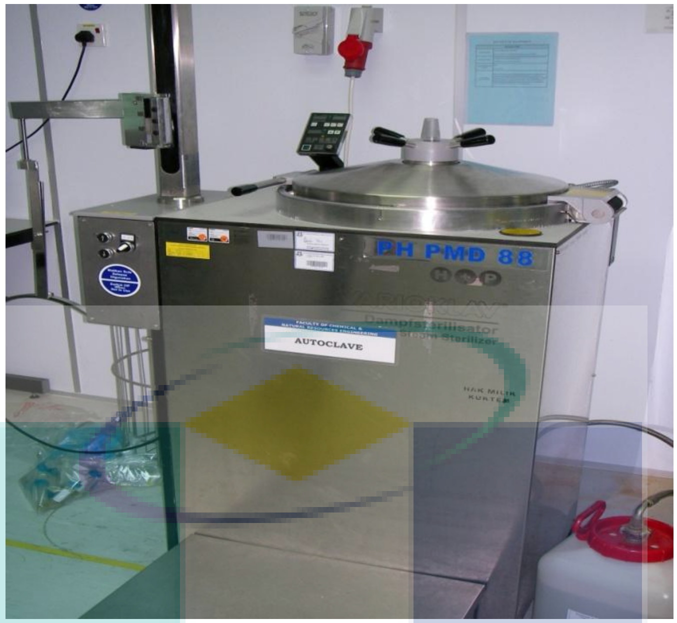

Figure 3.3: Autoclave 500 E in biotechnical laboratory in UMP

3.2 Preparation of the Mucilage

Fresh and mature cocoa fruits were collected from (Malaysian cocoa board branch in Jengka city). The fruit of the clone KKM 22 was chosen for its high mucilage content. The procedure of extracting the mucilage consists of the following steps:

3.2.1 Physical Treatment:

The first step is drying the fruits in the oven at 35 °C for 5 hours to drive out the water that reduces the efficiency of the extraction by ethanol. Then cut the cocoa husks into two pieces, and removes the seeds and juice from the husks. The final step is making the husk into cubic pieces, each piece is of about 1cm^{3}as shown in Figure 3.4.

Figure 3.4: Cocoa pod husk after been cut to small cubic pieces.

3.2.2 Extraction:

Ethanol is used to extract the mucilage from the cut up husks. The extraction carried out using 5 L round bottom flask, and reflex condenser for 1 hour, and as shown in Figure 3.5.

After preliminary extraction of the husks with ethanol and acetone mixture, mater-soluble mucilage was extracted by heating a water suspension (50 ml/g) of the husk in an autoclave at a pressure of 0.25 MPa for 30 minutes. After filtration of insoluble material, the filtrate was poured into two volumes of 95% ethanol; the water-soluble polysaccharide was dried by washing with ethanol, and placed over calcium chloride in a vacuum desiccator. Figure 3.6 shows the mucilage after extraction.

5 % of (TRITON® X-100) antioxidant had been added to the mucilage and kept in cool and dark place.

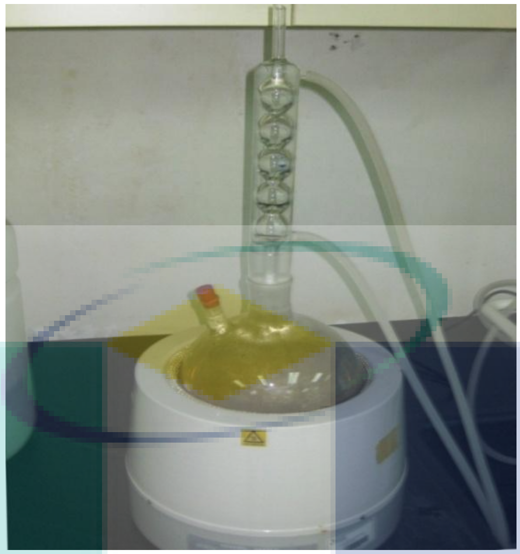

Figure 3.5: Preliminary extraction of mucilage.

Figure 3.6: Cocoa husk mucilage.

3.3 Mucilage Tests

Some of the basic tests have been done to the mucilage after preparation in order to predict the ability of mucilage to act as DRA and also to see the effects of the additive on water properties for different concentrations. The viscosity of the solution was measured as well as surface tension, conductivity, and pH. All of the experiments were conducted at 25 °C.

3.4 Experimental Rig Description

The experimental Rig is described by Muhammed, (2011). The drag reduction experimental work was carried out in a built up closed loop liquid circulation system. This system was designed and constructed in such a way to provide flexibility in experimental work and to save time.

The rig is shown in Figure 3.7, while Figure 3.8 shows the schematic diagram of the experimental rig. The rig consists mainly of two storage tanks with maximum capacity 0.45 m^3. The tank's dimensions were 0.9 m for both length and width, and 0.55 m for its depth. The first tank (main tank) is used as a storage for the solution, and to prepare the DRA solution, and to deliver it to the testing sections through the pump1, while the second tank (collecting tank) is used to collect the solution from the tubes. The system works as a closed loop.

Precision pump1, model CPM-158 with maximum load equal to 9 m^3/hr is used as the main solution circulation pump for the pressure drop testing section in the system. As shown in Figure 3.7, pump1 and main tank are connected with the test section. The test section consists of three galvanized iron pipes used for pumping the liquid with 0.0127, 0.0254 and 0.0381 m inner diameters. The height of the pipes is 1.80 m from the discharge section.

The flow originates in a vertical pipe of 0.0381 m diameter, the altitude is 0.90 m, and the pipe is connected to the pump with flexible plastic tubing to prevent the vibration of the pump. The vertical pipe is connected to a horizontal pipe with the same diameter by an elbow.

The horizontal pipe splits to three pipes; the first pipe is 0.0127 m diameter pipe splits after 1.4 m, and to 0.0254 m after 1.85 m, while the main pipe still has the same diameter of 0.0381 m. After 2.3 m from the elbow the three pipes are connected to three vertical pipes have the same diameters by an elbow too.

These vertical pipes are connected to the test section pipes by elbow. The length of the pipes in the test section is 4.90 m for the 0.0381 m inner diameter pipe, 4.20 m for the 0.0254 m inner diameter pipe, and 3.60 m for the 0.0127 m inner diameter pipe. To close the loop, we connect three vertical pipes to the test section pipes by elbow, and these vertical pipes pour out in the collecting tank.

Before the start of the pressure drop measurement sections, certain length is left before the first pressure drop tab for each pipe. This horizontal part equals to 50-time diameters (50 D.) for each pipe, which is equal to 0.7 m, 1.27 m and 2 m for p3, p4 and p5, respectively. This is to ensure fully developed turbulent flow before the testing section. The testing sections has 5 pressure gauge intakes (t1, t2, t3, t4, and t5), with a distance of each part is equal to 0.5 m as shown in Figure 3.8.

After the test sections, all pipes deliver the solution to the collecting tank which is connected to a small centrifugal pump that delivers the solution to the main tank for a complete liquid circulation system. The reason behind the usage of a second tank and not completing pipe circulation to the first tank is to control the temperature of the transported liquid. The main pump can supply high shearing rates on the transported liquid, which might increase its temperature if the circulation was continued for long time. This might affect the experimental results, so to avoid that, the liquid is transported first to the second tank and after certain time (depending on the flow rate the experiment is running with) it will be pumped back to the main tank.

Each tank is connected from the bottom to a draining pipe (d) with 0.0125 m I.D. After each experiment or run, the liquid inside the tank is drained through the draining pipe.

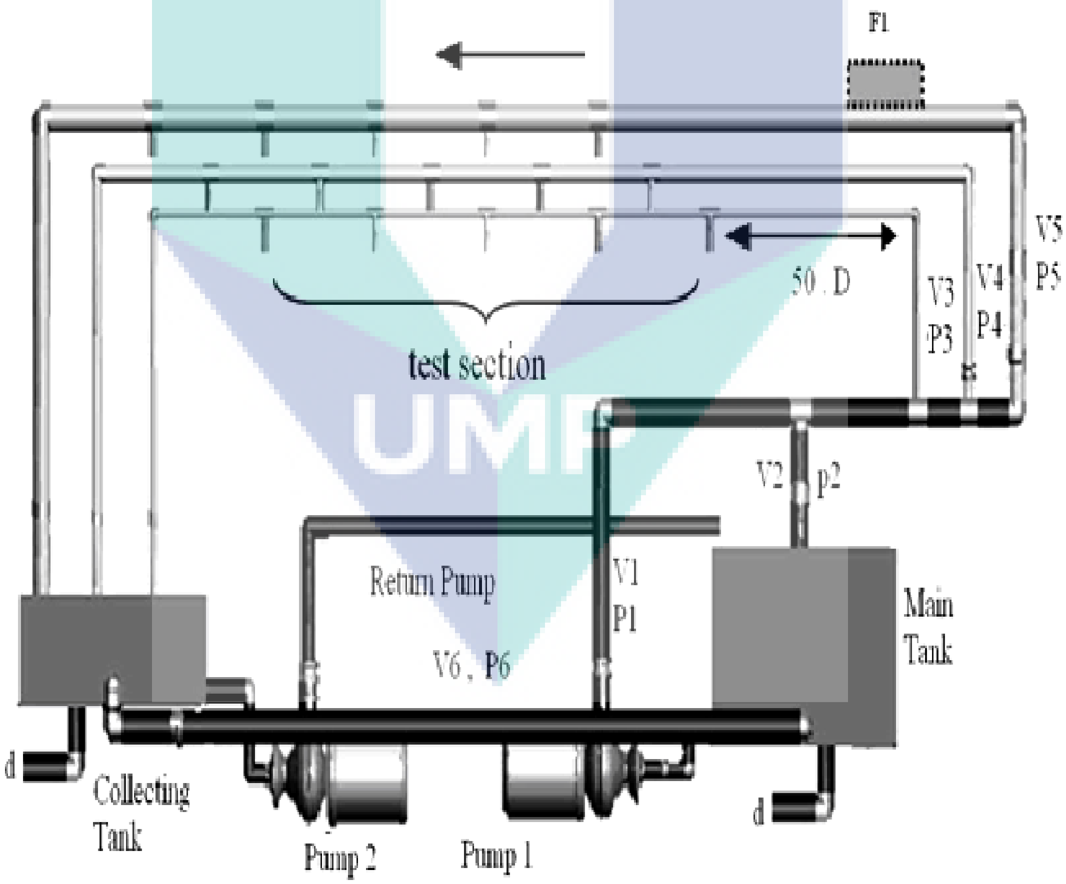

Figure 3.7: The schematic diagram of the pipes flow system

Table 3.5: The symbol description of the schematic diagram

Symbol	Description	Symbol	Description	Symbol	Description
p1	Main pipe	p4	0.0254 m pipe	P4	Pressure gauge
v1	Pump valve	p5	0.0381 m pipe	t1	Testing point 1
v2	Bypass valve	v5	0.0381 m pipe valve	t2	Testing point 2
p2	Bypass pipe	F1	Ultrasonic flow meter	t3	Testing point 3
v3	0.0127 m pipe valve	v6	Circulation valve	t4	Testing point 4
p3	0.0127 m pipe	p6	Circulation pipe	t5	Testing point 5
v4	0.0254 m pipe valve	d	drain		

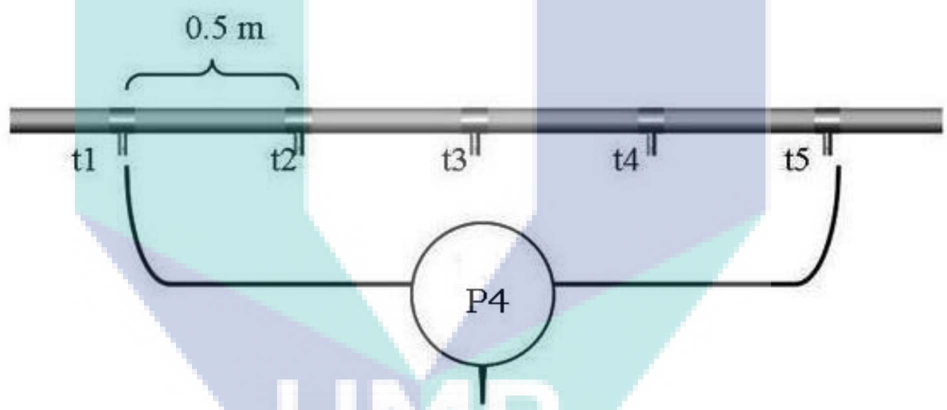

Figure 3.8 : A schematic diagram of the test section

Figure 3.9: Drag reduction experimental rig in the common Laboratory (UMP)

For each one of the three pipes, different flow rates and concentrations are used, and as listed below:

For 0.0127 m diameter pipe the range of the flow rate increases from 0.5 to 2.5 m^3 /hr, by increasing step of 0.5 m^3 /hr. The concentrations were 100, 200, and 300 ppm, and for 0.0254 m diameter pipe the range of the flow rate increases from 4.0 to 7.0 m^3 /hr, by increasing step of 0.5 m^3 /hr. The concentrations were 100, 200, and 300 ppm, while for 0.0381 m diameter pipe the range of the flow rate increases from 4.0 to 8.0 m^3 /hr, by increasing step of 1.0 m^3 /hr. The concentrations were 100, 200, and 300 ppm, and the test sections for the three pipes were 0.5, 1, 1.5, and 2 m.

Since it is very important in the drag reduction researches to avoid any disturbance to the main flow that might be caused by inserting certain measurement instrumentations, portable minisonic flow meter was used to measure the flow rate of fluid in pipes. The manufacturer of this flow meter is Ultraflux Corporation. This flow meter can measure the flow rate using ultrasonic wave without any interference with the flow inside the pipe. The ultrasonic flow meter was highly sensitive to small changes in the flow rate and its accuracy can detect small changes in the volumetric flow rate as low as 0.001 m^3 /h.

Figure 3.10 shows a photo for the portable ultrasonic flow meter used. It can be seen clearly that the system consists of a hand held control unit and two probes with support and cables. Several parameters were set on the flow meter before the experiments began such as the probe distance, which depends on the inner diameter of pipes. The probe distance for 0.0127 m pipe was 33 mm in W mode, for 0.0254 m was 27 mm in V mode and for 0.0381 m was 17 mm also in V mode. The operation mode either V or W is a measurement for the transit time for wave calculation.

Figure 3.10: A portable mini sonic P flow meter

Baumer Bellows differential pressure gauges are used for the pressure drop measurements in the testing sections. Due to the differences in the maximum pressure drop readings for each pipe diameter in the same flow rate, the differential pressure manometer maximum reading were different also. The maximum differential pressure reading range for the 0.0127 m I.D. pipe was 0.25 Bar and for the 0.025 and 0.0381 m I.D. was 0.016 Bar. The reason behind that is to ensure the accuracy during the pressure drop readings. Each gauge has two outlet stainless steel tubes to be connected to the flexible tubes from the testing tabs in the pipe sections. It is very important to make sure that these flexible tubes are empty from air to ensure accurate reading. The measurement mechanism of this gauge depends on two stainless steel bellows mounted on a force balance to enable direct reading of the actual differential pressure..

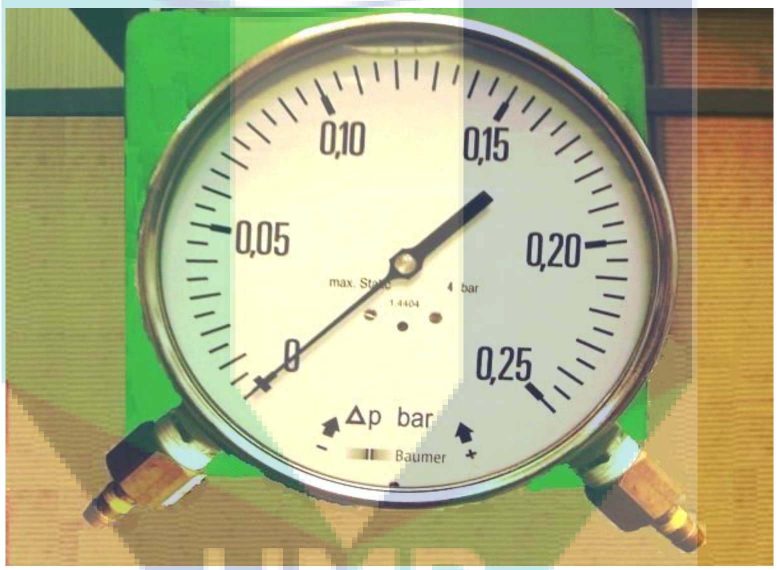

Figure 3.11: A 0.25 bar Baumer differential pressure gauge

3.5 Experimental Calculations

3.6.1 Velocity and Reynolds Number Calculations

The average velocity (V) and Reynolds number (Re) was calculated using the solution volumetric flow rate readings (Q), density (ρ), viscosity (μ) and pipe diameter (D), for each run as follows:

$$Re = \frac{\rho . V . D}{\mu} \qquad \text{Equation 3.1}$$

3.6.2 Percentage Drag Reduction Calculations

Pressure drop readings through testing sections before and after drag reducer addition, were needed to calculate the percentage drag reduction % DR as follows:

$$\%Dr = \frac{\Delta P_b - \Delta P_a}{\Delta P_b} \qquad \text{Equation 3.2}$$

where: ΔP_a is pressure drop after drag reducer addition.

ΔP_b is pressure drop before drag reducer addition.

Drag reduction also can be calculated as in the following Equation:

$$\% \, DR = \left(1 - \frac{f_p}{f_s}\right) \times 100$$

Equation 3.3

where: fs is friction factor of the solvent.

fp is friction factor of the polymer solution.

3.6.3 Friction Factor Calculations

Fanning friction factor was calculated using the following equation:

$$f = \frac{\Delta P.D / 4L}{\rho.V^2 / 2}$$

Equation 3.4

where: f is fanning friction factor.

ΔP is pressure drop across the pipe.

D is diameter of the pipe.

L is length of pipe used.

ρ is fluid density.

V is mean fluid velocity in the flow direction averaged across the pipe's cross section.

3.6 Commercialization of DRA

3.6.1 Marketing Mix or 4P's

As to take product of DRA from cocoa husk to commercialization, marketing strategy is important. One of the methods to do marketing strategy is 4P's strategy, 4 P's stands for Promotion, Place, Price and Product.

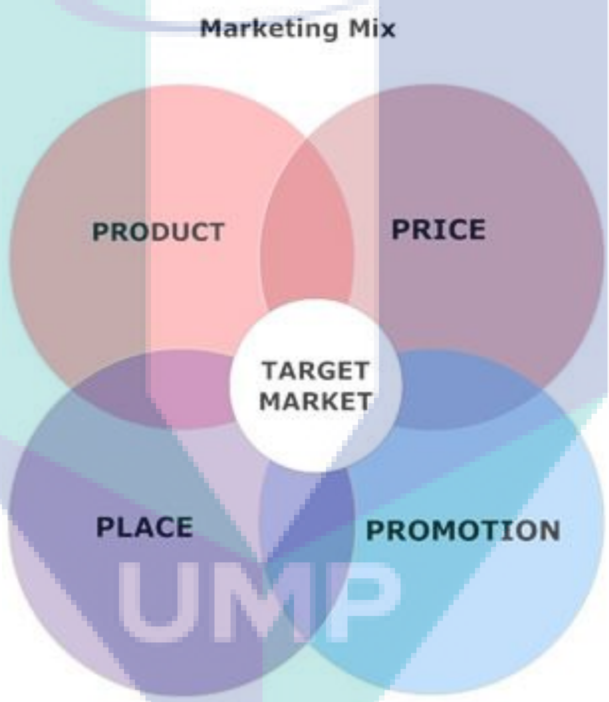

Figure 3.12: The marketing mix or the 4Ps

As the product is the item being sold to the customer, the thing that will bring in money, its features and design need careful consideration. If the firm is manufacturing the product, thus need to determine what product features will appeal to their target market

There are lots of different pricing strategies but all most at least cover costs unless the price is being used to attract customers to the business (loss leader). A product is worth as much as people are prepared to pay for it. The amount target market are prepared to pay for the product depends on its features and the target market's budget. Also need to consider competitor pricing.

The Place element of the marketing place is about where the product is made, where is it stored and how is it transported to the customer. The place for each of these things should ensure that the product gets to the right place at the right time without damage or loss

A successful product or service means nothing unless the benefit of such a service can be communicated clearly to the target market. Promotion is any activity to raise awareness of a product or to encourage customers to purchase a product(“Marketing Mix: Product, Price, Place and Promotion", 2010). The Marketing mix strategy for DRA products were discussed in chapter result and discussion.

3.6.2 SWOT analysis

Asses the product of company’s market position, which is an examination of the product of firm’s internal strengths and weaknesses, external opportunities and threats. Without explicit planning, these elements may go unrecognized (Newell, 2005). The SWOT analysis procedure is listed below:

List all the strength of the product first; the strength is the good point of the DRA that will attract customer as it will give benefit to the customer. Next, list all the weaknesses of DRA that will not give benefit to customer or the manufacturer, beside that the suggestions plan of how to overcome each weakness must be listed together. Opportunity for the DRA product need to be listed as to enhance the strength of the product. The threat of DRA that will affect the business or the product need to be listed also with the suggestions plan of how to overcome each threat.

3.6.3 Economic analysis

Economic analysis is carrying out to determine the profit margin.

3.6.3.1 Economic Analysis for 1 kilogram of DRA

The cost for 1 kilogram DRA will be calculated to estimate the cost required to produce 1 kilogram of DRA from cocoa husk. The cost involved is raw material, operating labor and plant overhead. Cost of the DRA will be compared with competitor or the commercial DRA to see the differences between them. Price margin between the competitors also will be discussed later.

3.6.3.2 Economic Analysis for 820 MTA of DRA from Cocoa Husk.

The analysis comprises of fixed capital cost and manufacturing cost. After the cost estimation, cash flow analysis will be conducted to give overall economic feasibility of the production of DRA from cocoa husk and find out the payback period ,the discounted break even period and net present value (NPV) that were very concerned by the investor.

The cost for the raw material involve for producing DRA will be calculated with the annually consumption of raw material. The DRA sales price will be calculated to get the sales revenue. The formula for sales revenue is:

Sales revenue= Total production capacity x Price for DRA

The labor cost involved is calculated by referring to the typical labor requirement for process equipment (Peters, 2004).

Grass root capital (GRC), is the total cost of a completely new facility in which we start the construction on essentially undeveloped land, a grass field. The formula for GRC is;

Grass root capital (GRC)= auxiliary facilities + the total module cost.

Total module cost, TMC = Contingency & Fee + total bare module cost

The bare module method is the cost of each equipment used in the plant

Auxiliary facilities = 35% of bare module cost

Next, to calculate the Fixed and Total Capital Investment,

Fixed capital investment = direct cost + indirect cost

Direct cost:

- Purchased Equipment Installation
- Instrumentation and Control (installed)
- Piping (installed)
- Electrical and Material (installed)
- Building
- Yard improvement
- Land

Indirect cost:

- Engineering and Facilities
- Construction and Expenses
- Legal Expenses
- Contingency

Total capital investment formula:

Total capital investment = Fixed capital investment +working capital.

For manufacturing cost,

Manufacturing cost = direct production cost + fixed charges + plant overhead cost.

Direct production cost:

- Raw material
- Operating labor
- Direct supervisory and clerical labor
- Utilities
- Maintenance and repairs
- Laboratory charges
- Patent

Fixed charges:

- Depreciation
- Local taxes
- Insurance

General expenses = Administrative cost + Distribution and selling costs + research and development cost.

Total product cost formula:

Total product cost: manufacturing cost + general expenses

As for cash flow analysis, it can be analyzed with payback period. After all the calculation has been carried out, the final step is to determine the payback period (PBP). To solve that particular step, the value can be obtained by using graphical method.

CHAPTER 4

RESULT AND DISCUSSION

4.0 Result and Discussion

Based on the research study by Mohammed (2011), there are several effect of using the cocoa husk mucilage in improving the flow in pipelines are discussed. The effects of pipe diameter, testing section length, addition concentrations and liquid velocity are presented graphically.

4.1 Basic Tests of the Mucilage

Mucilage and samples of the circulated water solutions were tested to show the concentration range effect on the apparent physical properties of the transported liquid. The results of the tests are shown in Table 4.1. The test results show that, within the concentration range adopted in the present work (100 to 300 ppm), the value of the pH reduces from 6.6 to 5.0 when adding 300 ppm, which can be considered as an acceptable range for the drag reduction operation. Such finding is highly supported by the results mentioned by (Interthal and Wilski, 1985) that the drag reduction is highly dependent on the pH of the solution. Moreover, the results show that DR starts to increase sharply after pH = 5, so the pH range of 5 to 6.6 is in the active range.

The viscosity of the prepared solution was slightly affected by the addition of the mucilage. This is an acceptable agreement with the concept of drag reduction which indicates that the addition of minute quantities of some special soluble polymers could significantly decrease resistance to flow without affecting viscosity or density of the fluid. (Marhefka et al., 2006).

Typically, the presence of mucilage (in the concentration range used) reduced the surface tension relative to pure water, Sabadini and Alkschbirs (2002) studied the effect of adding PEO to water and they mentioned that the presence of PEO reduces the surface tension from approximately 72 mN m^{-1} (at 25 °C) to 62 mN m^{-1} for the entire PEO concentration range. The results of the pre chemical tests are listed on Table 4.1 (Muhammed, 2011).

Table 4.1: Results of the chemical tests for the mucilage

Property	**Mucilage**	**Water**	**100ppm**	**200ppm**	**300ppm**	**400ppm**
Conductivity(μs)	550	4	12.3	17	24.4	38.8
pH	3.4	6.6	5.8	5.5	5.3	5.0
Surface tension (mN. m^{-1})	53	72	58.38	52.54	46.70	42.81
Viscosity (cP)	724	1.002	1.0554	1.0815	1.0976	1.1437

4.2 Effect of Mucilage Concentration on Drag Reduction

One of the most important factors controlling the drag reduction performance and efficiency is the additive concentration. The concentration must be controlled in a way to ensure controlling the apparent physical properties of the transported liquid to ensure the delivery of the liquid within the same properties. In the present work, three addition concentrations were investigated (100, 200 and 300 ppm). The purpose behind that is to show the effect of the additive in improving the flow in pipelines without changing the apparent physical properties of the transported liquid, especially the viscosity.

Selected samples from the experimental data results are shown in Figures (4.1, 4.2, 4.3).Figure 4.1, shows the effect of changing the addition concentration on the % DR for the water flowing in 0.0127 m pipe diameter and 0.5 m length. This figure shows that, the % DR increases by increasing the mucilage concentration for all the Reynolds numbers investigated. The same behavior can be observed in Figure 4.2 for the flow of water in 0.0254 m pipe diameter and 2.0 m pipe length, where the % DR increases by increasing the additive concentration.

Increasing the additive concentration means increasing the number of mucilage molecules involved in the drag reduction operation. Increasing the concentration will increase the turbulence spectrum that is under the drag reducer effect which will enable more molecules will interfere within the turbulent structures formed during the flow of the liquid in turbulent mode through the pipe, and that will lead to improve the flow without changing the apparent physical properties of the transported liquid. High extensional viscosity has been suggested as the cause of drag reduction in diluted mucilage solutions (Landahl 1972; Hoyt 1986; Bewersdorff 1993) since it can be quite large compared to that of the Newtonian solvent. The presence of the mucilage molecules will lead to increase the stretching resistance, and that will reduce the possibility for the vortex to complete its shape and absorb more energy from the main flow. That will result in the reduction of energy dissipation or drag reduction (Muhammed, 2011).

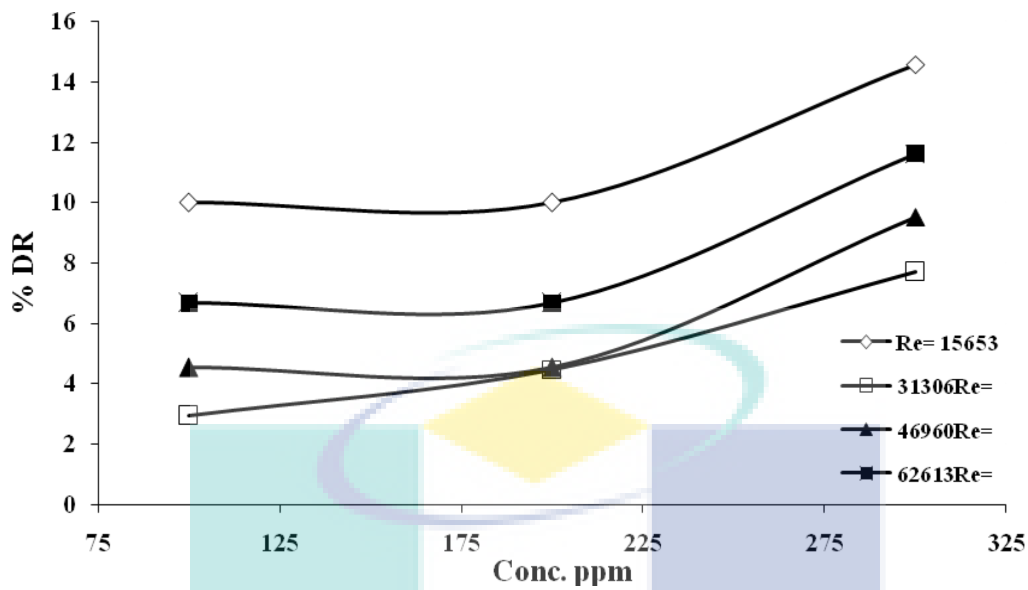

Figure 4.1: The drag reduction versus mucilage concentration in 0.0127 m pipe diameter at 0.5 m length.

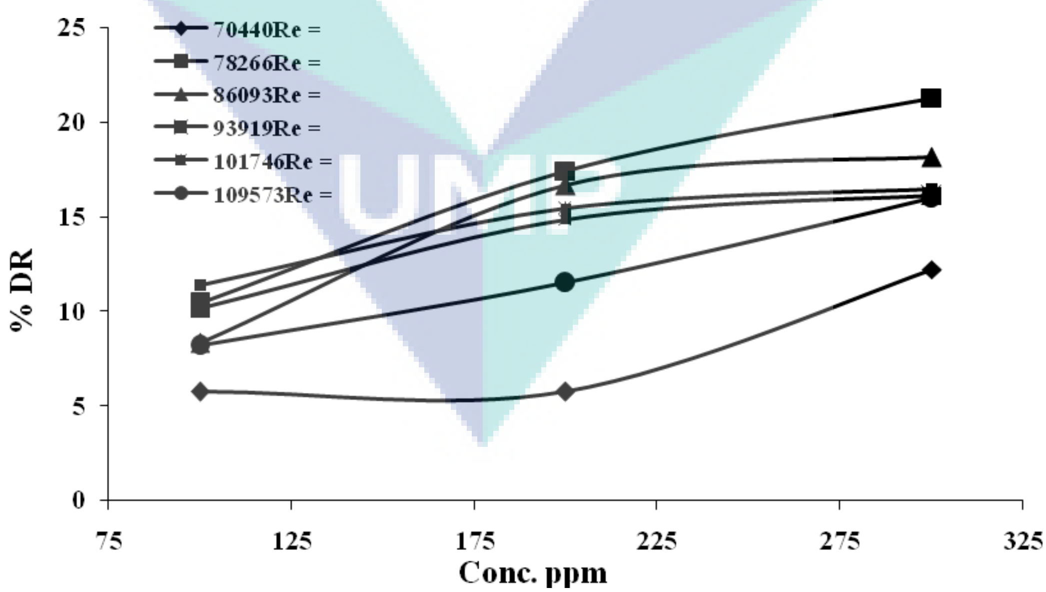

Figure 4.2: The drag reduction versus mucilage concentration in 0.0254 m pipe diameter at 2.0 m length

A slightly different behavior can be seen in Figure 4.3 for the liquid flowing in 0.0381 m pipe diameter and 2.0 m length. This figure shows that, the % DR increases when the addition concentration increases from 100 to 200 ppm. Further increase in the addition concentration up to 300 ppm, the % DR didn't show a noticeable increase in most cases and tends to decline. This behavior highlights the complex relation between the % DR and the operation conditions in the drag reduction system such as the pipe geometry and liquid flow rate. These results agree with the results presented by Kim and Kim (1991), they explained this behavior from the additive flocculants attraction to pipe surfaced. That, since the polymer additives are flocculants, they are adsorbed onto the surface of solids. This adsorption leads to a decrease in the effective concentration of polymer in the pipe and resulting decrease in drag reductions (Muhammed, 2011)

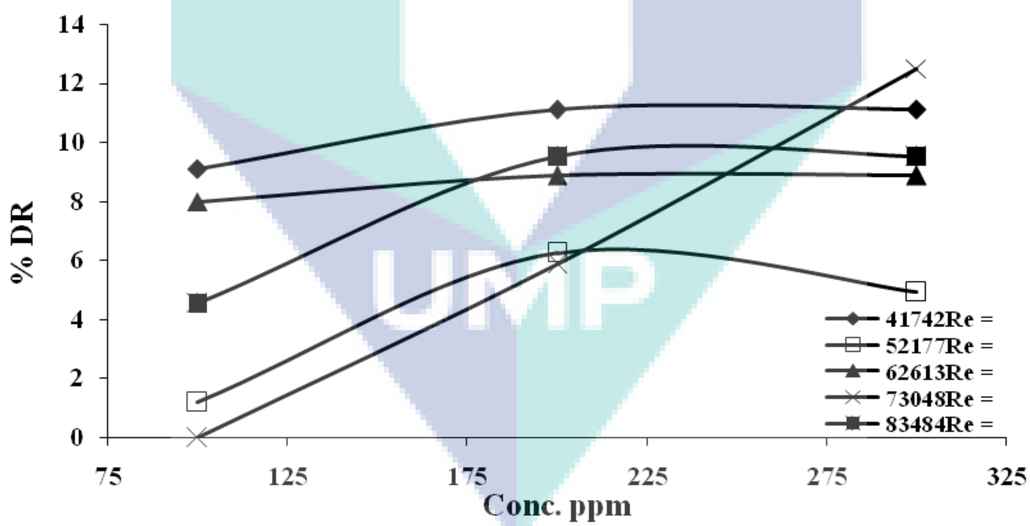

Figure 4.3**:** The drag reduction versus mucilage concentration in 0.0381 m pipe diameter at 2.0 m length

4.3 Commercialization strategy

4.3.1 Marketing Strategy

New product introduction really need good marketing strategy, for this new Drag reduction agent from cocoa husk that is from natural polymer and environmental friendly really need exposure to let customer know about this great product. Firstly, the marketing team involves with the Green Technology Exhibition & Conference Malaysia, which involved in the seminar and conference, demonstration of the product to show the effectiveness in improving pipeline flow. During the conference also done the business matching and can build business networking.. Then advertisement: to expose the DRA in newspaper/magazine and digital advertisement board. To demonstrate the effectiveness of the product, can also provide free product trial and free testing (Pipe flow performances testing)

Furthermore, use the internet help in the marketing, for example using the very famous social network Facebook, Twitter, YouTube and all other forms of social networking, because big business is paying attention with the social networking. Many companies, including chemical firms - are using social media to spread their message and extend their presence further than traditional marketing could ever do. Website education also is one way of marketing, from this website can give information and knowledge to the customer about the DRA and how it can improve the pipeline flow. As for price strategy, to compete with the competitor of DRA manufacturer, the DRA can be sell at lower price compare to the competitor as long as still reasonable and can make profit.

4.3.2 SWOT Analysis:

4.3.2.1 The Strengths of DRA

The strength of DRA is listed as below.

- Environmental friendly natural product
- High demand as to replace existing artificial, high cost and toxic DRA
- Utilize waste to make valuable product
- Improve the pipeline flow performance by 55%.
- Cheap and can double up the customer production
- Save energy cost for customer as pump power will reduce when using DRA in the pipeline.
- The product easy to handle.
- DRA not subject to denaturation at high temperature and pressure.
- DRA will not react with the end product.
- DRA will not freeze or become gel at less or ambient condition.
- DRA will not produce hammering.
- The product is unique and superior to its competition.
- A successful merger between technology and customer needs was made.

4.3.2.2 SWOT Analysis: Weaknesses

The weaknesses of DRA are listed below with the suggestion to overcome the weaknesses.

Table 4.2: The weaknesses of DRA

Weaknesses	How to overcome
• New product need to compete with existing DRA manufacturer local company such as Delcom Services Sdn. Bhd and Duro Kimia Sdn Bhd, also International Company.	Marketing team shall come out with marketing strategy to compete with the competitors
• Less exposure of product to the customer	Expose the product by following the marketing strategy
• Less business connection	Make good connection or relationship with the customer , supplier and the product distributor

4.3.2.3 SWOT Analysis: Opportunity

The opportunities of the DRA are listed below;

- Market for this natural DRA is focusing on Petroleum and Gas Industry (Pipeline for refinery product).
- Increased Global Demand for Oil. With the US and global economies beginning to recover and accelerate, the demand for energy increases. In addition, emerging nations such as India and China are accelerating their thirst for oil as their manufacturing sectors build new facilities to address expanding economies.
- New Drilling Discoveries and Techniques. Recent and emerging technological advancements are enabling crude oil discoveries and supplies to be made in harsher climates and from more unconventional sources such as shale and oil sands. Cold, remote oil fields stand to benefit from viscosity reduction technology, making them more competitive.
- Oil and Gas Price Increases. As demand outpaces readily available supplies, new pipelines and pipeline flow improver (DRA) will be required to prevent supply shortages. Greater price increases accelerate demand for additional pipelines and/or flow improver (DRA) to improve delivery throughput capacities
- Furthermore, this new business on natural DRA ,meet the objective for facilitate the growth of the green technology industry and enhance its contribution to the national economy
- Besides that, this new business can increase capability and capacity for innovation in green technology development and enhance Malaysia’s competitiveness in green technology in the global arena.

4.3.2.4 SWOT Analysis: Threat

The threats involved in DRA product are listed below;

Table 4.3: The Threat involve for DRA product.

Threat	How to overcome
• Need to compete with well established company	• Emphasizing the benefit of natural DRA compared to toxic synthetic of DRA existing in market. • Marketing team shall do effective marketing strategy for the product
• Raw material shortage	• Ensure the raw material supply is sufficient before run the production • To have backup raw material supplier • Enough storage space for the raw material
• Delay of shipping for the raw material	• Ensure the schedule for each shipping and alert with any changes of the schedule. • Prepare with back up plan to encounter any delaying of raw material.
• Delay of delivering of product to the customer.	• Ensure the schedule for each shipping and alert with any changes of the schedule. • Prepare with backup plan to encounter any delaying of product to customer.
• Other new natural DRA emerge in market from competitors	• Ensure the quality of the DRA and marketing strategy that can compete with any new DRA

4.3.3 Competition

There are many specialty manufacturers, all of whom seem to have carved out a specific niche of expertise, and upon whom these major manufacturers depend for products. In competition, it seems that the line is drawn at the level of quality performance It is extremely important that to seize this opportunity and begin to exclusively market this product. The DRA manufacturer that utilized waste from cocoa husk is not in the market yet, beside natural DRA is still new and existing manufacturer for DRA is toxic synthetic polymer and artificial polymers used as flow improvers commercially.

Competitors for DRA manufacture is listed below

- Delcom Services Sdn. Bhd (local company)
- Duro Kimia Sdn Bhd
- Flowchem company (non-local company)
- Shandong Deshi Chemical Group Co., Ltd
- Quanzhou Jasmine Chemical Co., Ltd.
- Texokem, Texas, United States
- Aras Sepehr Afza Co.,Iran
- NUR chemicals & engineering industries, Jordan.
- Pasargad Additive Chemical Industries,Iran
- Chemland Group. INC, China

4.4 Economic Analysis for 1 kilogram of DRA

The cost for 1 kg DRA involved the raw material cost, labor cost and plant overhead cost. The calculation is show as below:

Table 4.4: Costing for 1 kg of DRA

	Cost for 1 Kg of DRA
Raw material	17.83
Operating labor	0.35
Plant Overhead	0.20
Total	RM 18.38

From the research study by Mohammed(2011), to get maximum % of drag reduction (DR), the DRA concentration needed is 300 ppm.

The laboratory tank capacity is 0.45 m^3 =450L

Conversion unit:

Assume 1ml = 1g 450 L= 450000 ml =450000 g

From the Part per million formula below we can get the amount of DRA needed (X).

300 ppm = (X/ 450000g) x 1 000 000 ppm

X= 135 g of DRA needed.

So, to transfer 450 L of medium with 54 % DR will only need 135 g of DRA.

Thus the cost for 135 g is (0.135kg) x price for 1 kg DRA (RM24) = RM3.24 only for capacity of 450L.

One Barrel crude oil = 158.987 L

Cost for DRA for 1 barrel of crude oil:

(158.987L/450 L) x RM 3.24 = RM1.14

Thus, the DRA would cost just under $1, (around $0.37) per barrel of crude oil.

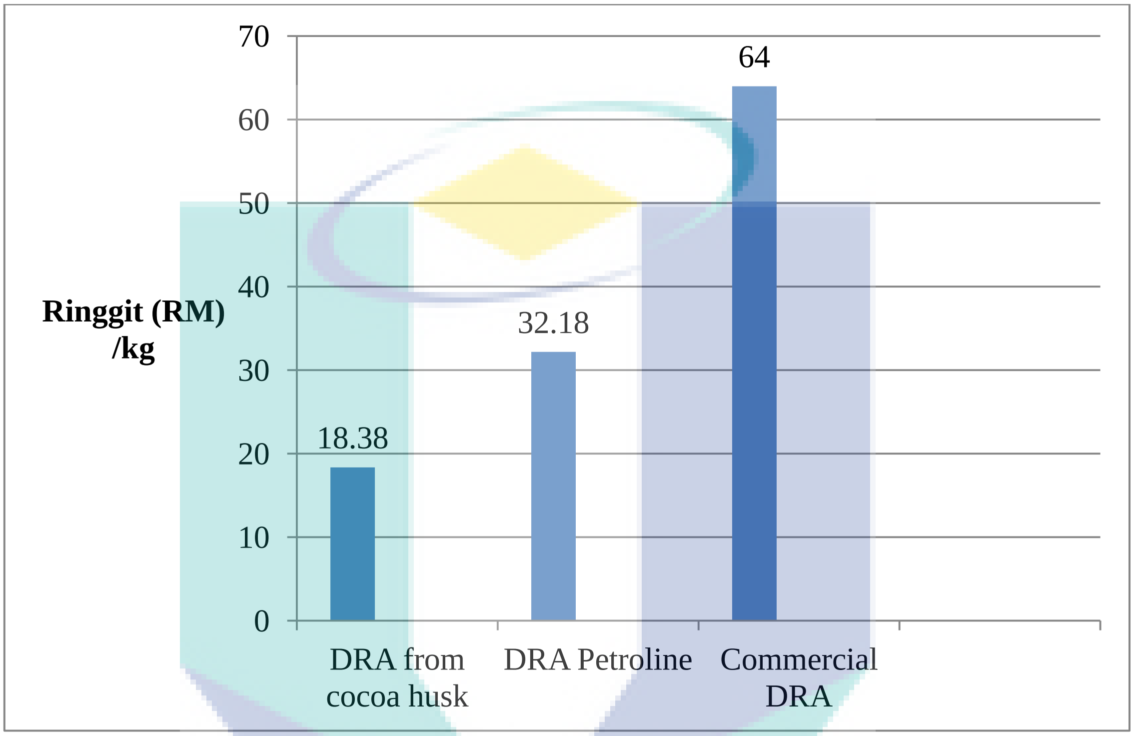

Figure 4.4: Comparison in term of pricing between DRA from cocoa husk, DRA from Petroline and commercial DRA

Comparison in term of pricing between DRA from cocoa husk, DRA from Petroline and commercial DRA is shown in figure above. Based on the figure above, clearly showed that price for DRA from cocoa husk is much lower compared to DRA Petroline and Commercial DRA. The price is cheaper because he main raw material from waste which is cocoa husk, The price for DRA is collected from the alternative pipeline strategy (Ewell, 2006).

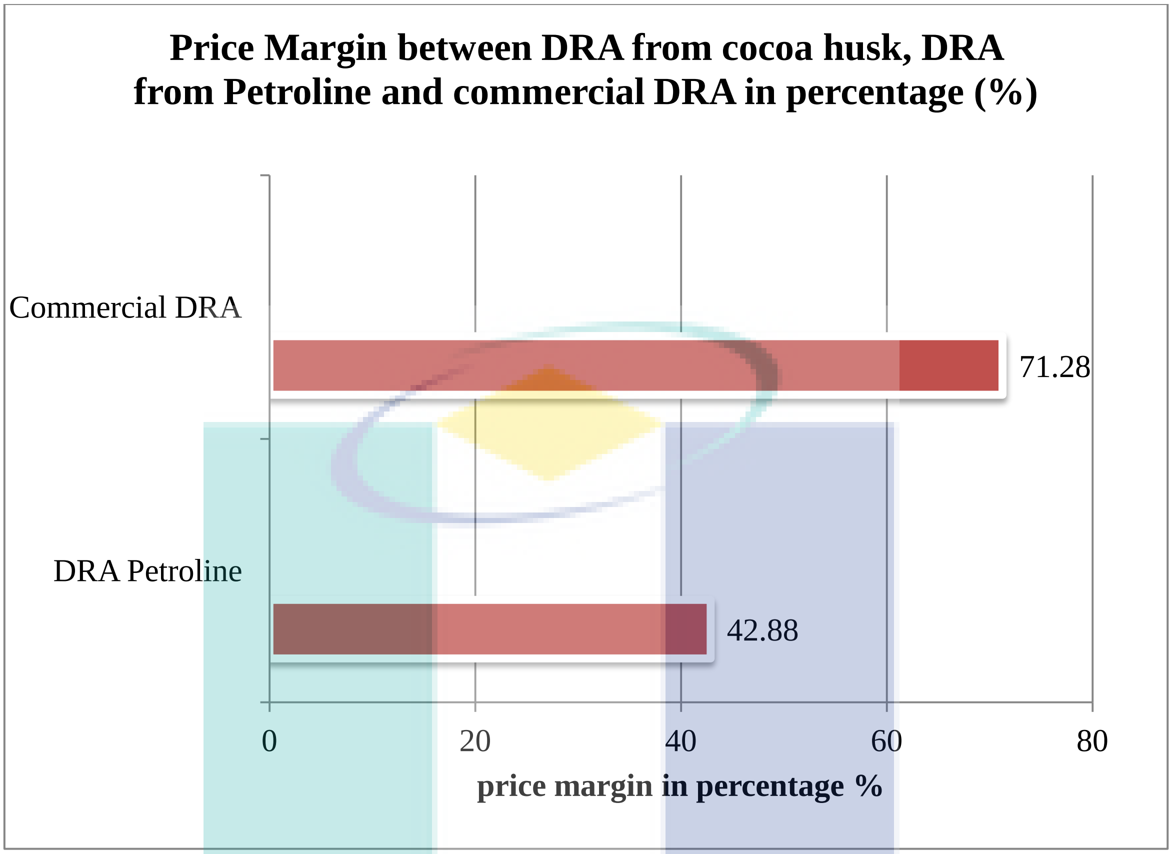

Figure 4.5: Price Margin between DRA from cocoa husk, DRA from Petroline and commercial DRA in percentage (%)

From the figure above, the price margin for DRA Petroline is 42.88% and price margin for commercial DRA is 71.28 %. Based on the price margin, this outcome may be explained by the fact that the price for DRA from cocoa husk is much lower compared to others due to low cost of raw material and the effectiveness of the DRA as a flow improver.

4.5 Economic Analysis for 820 MTA of DRA from Cocoa Husk.

Next, the economic analysis for DRA product can be done by calculate the cost involved and make cash flow analysis. The most concern factor in economic analysis, like payback period (PBP), the discounted break even period and net present value (NPV) is determined.

Example; Assume DRA production capacity is 820 MTA (metric tonne annually).

The DRA production capacity is 820 MTA .The process involve for the production is raw material physical treatment, cutting, mixing, extraction, filtration, washing, mucilage retrieve and packaging. The raw materials involve in DRA and the cost for the raw material for producing DRA is listed below

Table 4.5: Cost for the raw material for producing DRA

Raw material	kg	price/kg	Annually consumption (RM)
Cocoa Husk	10000	0.05	55000.00
Ethanol	83333	1.36	12466616.80
Anti-Oxidant (Triton X)	4666	2.44	1252354.40
Total			13773971.20

The sales income of DRA product is calculated below.

	annually (kg)	price/kg	sales income
Production of DRA	820000	24	19680000

Table 4.6: The labor for each equipment in the plant is listed below

Equipment	no of unit	operator per unit	operator per shift
Oven	2	0.5	1
Cutter	2	0.5	1
Mixer	1	0.5	0.5
Extractor	2	0.5	1
Filter	1	0.5	0.5
Storage tank	4	0	0
Heat exchanger	2	0.5	1
Pump	7	0.1	0.7
Total			5.7

Source: Typical labor requirement for process equipment (Peters, 2004)

Total operator per shift= 5.7 = 6 people

Total operator per day = 6x 2= 12 people

The operating labor cost annually;

= 12 operator x 12 month x RM 1300/ operator

= RM187200.00

4.5.1 Grass Root Capital

The term grass root refers to a completely new facility in which we start the construction on essentially undeveloped land, a grass field. The term total module cost refers to the cost of making small to moderate expansions or alterations to an existing facility. The bare module method is used to calculate the cost of each equipment used in the plant.. To calculate the grass roots capital cost, contingency and fee costs (18% of bare module cost), auxiliary facilities (35% of bare module cost) is added to the initial bare module cost.

Table 4.7: Bare module cost summary

Equipment	no of unit	Price/unit	Price (RM)
Oven	2	41250	82500
Cutter	2	12650	25300
Mixer	1	54615	54615
Extractor	2	366400	732800
Filter	1	35019	35019
Storage tank	5	48790	243950
Heat exchanger	2	20973	41946
Waste Treatement	1	17500	17500
Pump	7	11253	78771
Total Bare module cost, TBM			1312401
Contingency & Fee	0.18 TBM		236232.18
Total module cost, TMC			1548633.18
Auxiliary facilities	0.35 TBM		459340.35
Grass root capital (GRC)	TMC +0.35 TBM		2007973.53

4.5.2 Fixed and Total Capital Investment

Fixed capital is the total cost for installed the process equipment with some auxiliaries that completed the operation of the process. It is includes the cost of direct and indirect cost for the set up of the plant.

Then, the working capital is the additional investment needed, in order to start up the plant and operate to its point when income is earned. Working cost is most likely to be recovered at the end of the plant. Working capital consists of the total amount of money invested in raw materials and supplies carried in stock, finished products in stock and semi-finished products in the process of being manufactured, account receivable, cash kept on hand for monthly payment of operating expenses, in example salaries, wages and raw material purchases.

For most chemical plant use in an initial working capital amounting to 12% of the fixed capital investment whereas start up cost is 8% out of fixed capital cost. For the capital investment that have been calculated are includes all equipment cost, waste treatment cost, the direct cost in setting up the plant, indirect cost and also cost for working and start up cost. Table below show the summary of fixed and total capital investment..

Table 4.8: Summary of Fixed and Total Capital Investment

Items	Specification	Cost (RM)
DIRECT COST		
Grass root capital (GRC)		2007973.53
Onsite		
Purchased Equipment Installation	10% GRC	200797.35
Instrumentation and Control (installed)	6% GRC	120478.41
Piping (installed)	12% GRC	240956.82
Electrical and Material (installed)	8% GRC	1606378.82
		2168611.41
Offsite		
Building	18% GRC	361435.24
Yard improvement	3% GRC	60239.21
Services Facilities land	8% GRC	160637.88
Land	2 % GRC	40159.47
		622471.79
INDIRECT COST		
Engineering and Facilities	8 % GRC	160637.88
Construction and Expenses	5 % GRC	100398.68
Legal Expenses	2 % GRC	40159.47
Contingency	10 % GRC	200797.35
		501993.38
Fixed capital investment (FCI)		3293076.59
Working capital	12%FCI	395169.19
Start up	8% FCI	263446.13
Total capital Investment (TCI)		3951691.91

Source: The specification factor is based on typical percentages of fixed-capital investment values for direct and indirect cost segments for multipurpose plants. (Peters, 2004)

4.5.3 Manufacturing Cost and Total Production Cost

Total production cost consists of manufacturing cost and general expenses. Manufacturing cost consists of direct production cost fixed charges and plant overhead. This is another equally important part is the estimation of costs for operating the plant and selling the products.

Table 4.9: Manufacturing cost summary

Cost	Specification	Cost RM/year
Raw material		13773971.20
Utilities	Water	158934.00
	Steam	237495.00
	Electricity	476302.00
Maintenance and repairs	3% FCI	98792.30
Operating supplies	0.5% FCI	164653.83
Operating labor	12 operator/day	187200.00
Direct Supervision & Clerical Labor	25% Operating Labor	46800.00
Laboratory charges	15% operating labor	28080.00
Rates (Local authority taxes)	1.0 % FCI	32930.77
Insurance	0.05* FCI	164653.83
Plant Overhead	50% Operating Labor	93600.00
TOTAL MANUFACTURING EXPENSES, AME		15463412.92
General Expenses		
Administration cost	10% overhead	9360.00
Distribution & selling expenses	8% FCI	263446.13
Research and Development	5% FCI	164653.83
Total general expenses AGE		437459.96

Source: The specification factor is from summary of the predesigned estimates for capital investment cost, and total product cost. (Peters, 2004)

Table 4.10: Total Production Cost Summary

Cost	Specification	RM/year
Total Production Cost, APC	AME+ AGE	15900872.88
Depreciation, AD	10% FCI	329307.66
Total expenses	APC+AD	16230180.54
Revenue from sales, AR	RM 24/kg of DRA	19680000.00
Net annual profit , ANP	Revenue- ATE	3449819.46
Income taxes	30% net annual profit	1034945.84
Net annual profit after taxes, ANNP	ANP- income taxes	2414873.62
Rate of return (%)	(ANNP+ AD)/ TCI x 100%	79.52

4.5.4 Cash Flow Analysis

After all the calculation has been carried out, the final step is to determine the payback period (PBP). To solve that particular step, the value can be obtained by using graphical method. For the plant, the total operating period is 20 year with 3 year at the beginning as the start up operation period. The capital investment used in the first year of the plant is 10% from Total Capital Investment (TCI), while it is increased to 25% of TCI. In the third year operation, capital investment to the plant account of 65% of TCI plus the working capital. (Prasad Kodukula, 2006). As the new plant, the production of DRA in the beginning is expected not to achieve the target as desired. Therefore, an assumption of 85% of the targeted value is set before it is back to normal production glow in second year and so on. From the graph, the payback period is around 5 years.

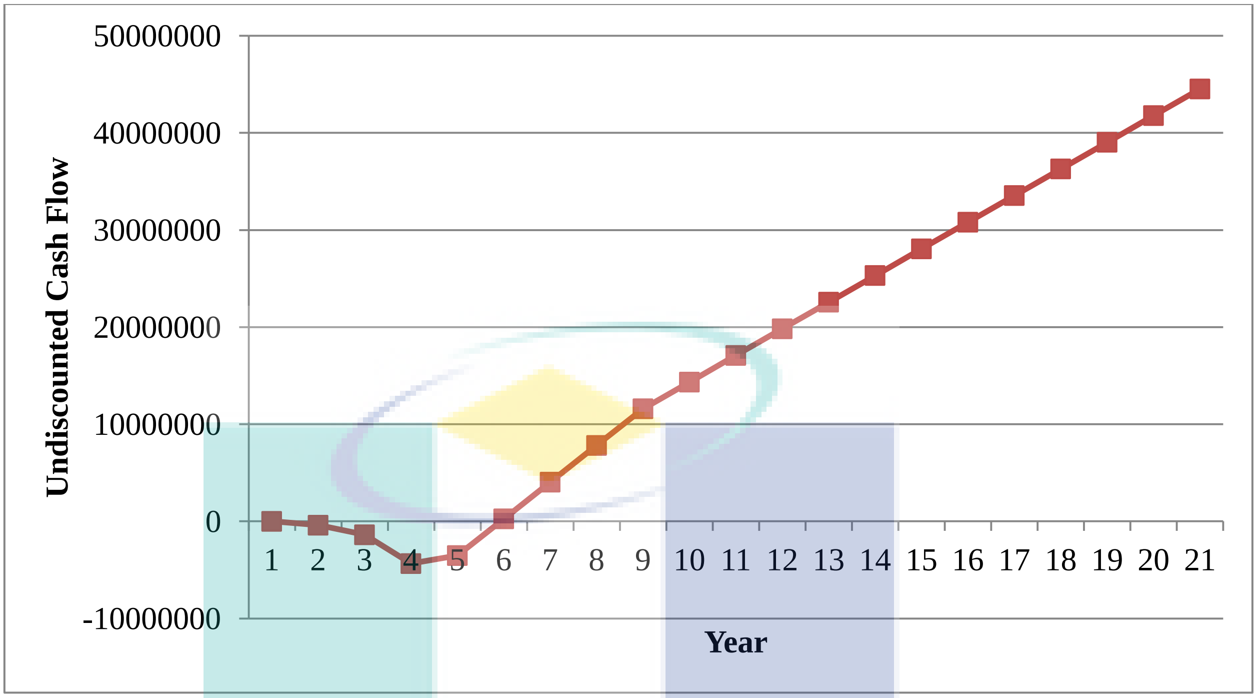

Figure 4.6: Cash Flow Analysis

Discounted break even point is the time from the decision to proceed until discounted cumulative cash flow become positive. Meanwhile, net present value is the final cumulative discounted cash flow value at project conclusion. In discussion economic attractiveness, used these three parameters above which is rate of return, pay back period and net present value.

The net present value (NPV) is the total of the present value of cash flows minus the present value of all capital investment. An earning rate is incorporated into the present value factors by the discount rate used. Thus, the net present value is the amount of money earned over and above the repayment of all investment and the earnings on the investment at the discount rate used in the present value factor calculations. The appropriate discount rate to use for discrete compounding is the minimum acceptable rate of return originally selected as the evaluation standard. If the present value is positive, then the project provides a return at a rate greater than the discount (earning) rate used in the calculations. In making comparisons of investment, the larger the net present value, the more favorable is the investment.

When net present value equals to zero, the discounted break even point is called discounted cash flow rate of return (DCFROR). This rate of return is equivalent to the maximum interest rate (which is normally, after taxes). This is because money could be borrowed to finance the project under conditions where the net cash flow to the project over its life would be just sufficient to pay all principal and interest accumulated on the outstanding principal. Figure 24 show the cumulative discounted annual cash flow for different rate of return versus time. From figure 25 obtained the DCFROR value, which is 27%. This is the maximum interest rate that the project can pay, where the net present value equal to zero. If the interest rate is higher than 27%, profit could not be achieved after 20 years of plant lifetime.

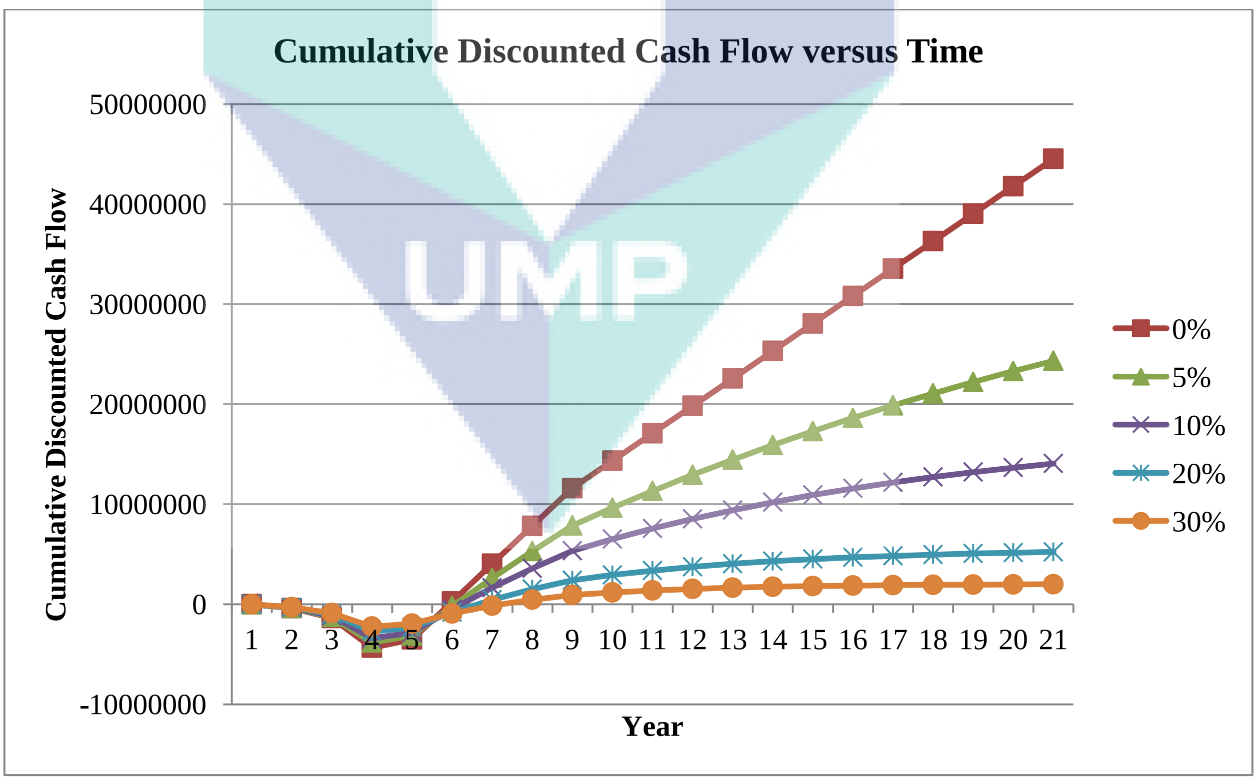

Figure 4.7: Cumulative Discounted Cash Flow versus time

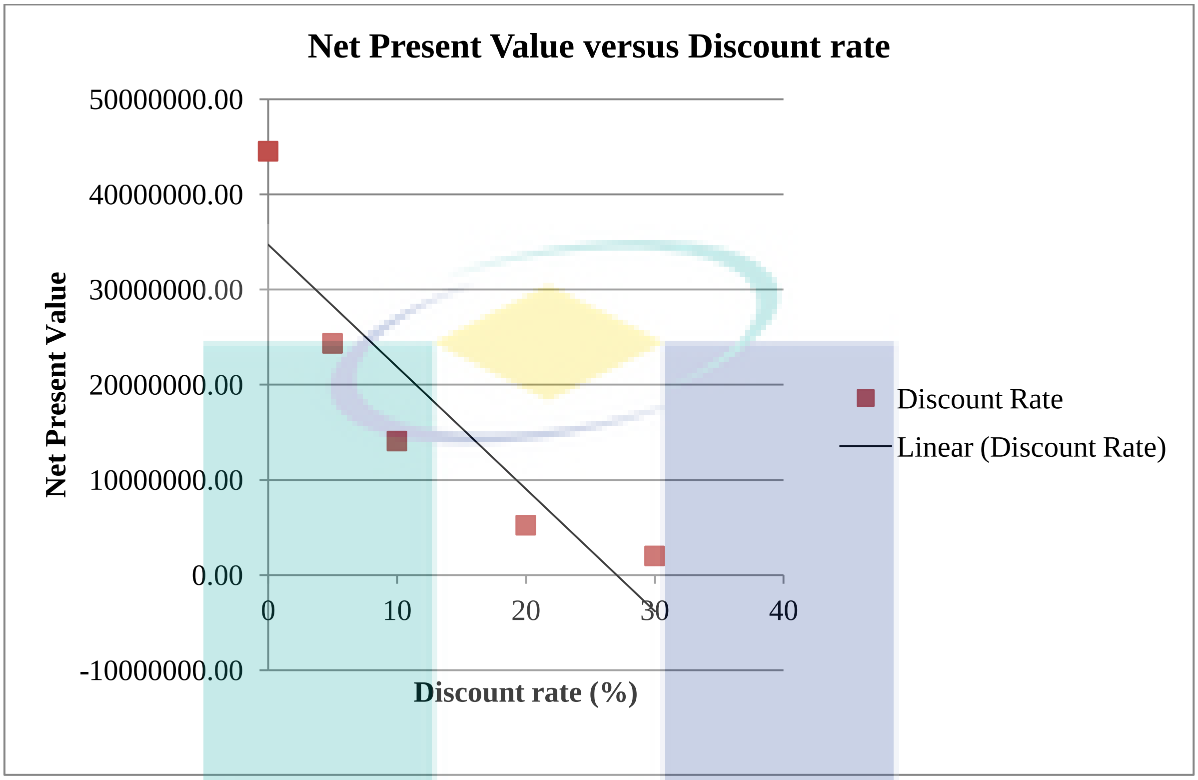

Figure 4.8 : Net Present Value versus Discount Rate

When net present value equals to zero, the discounted break even point is called discounted cash flow rate of return (DCFROR). This rate of return is equivalent to the maximum interest rate (which is normally, after taxes). This is because money could be borrowed to finance the project under conditions where the net cash flow to the project over its life would be just sufficient to pay all principal and interest accumulated on the outstanding principal. When the net present value is favorable, the DCFROR will necessarily be favorable and be the actual earning rate of the investment The two methods net present value and DCFROR are nearly always used together. Figure 24 show the cumulative discounted annual cash flow for different rate of return versus time. From figure 25, obtained the DCFROR value, which is 27%. This is the maximum interest rate that the project can pay, where the net present value equal to zero. If the interest rate is higher than 27%, profit could not be achieved after 20 years of plant lifetime.

4.5.5 Proforma Balance Sheet

In the basic balance sheet, the left sides of the balance sheet lists assets of the firm and the right side lists liabilities and equity. Both assets and liabilities are listed in descending order of liquidity, that is, the time and effort it takes to convert the account to cash. As the table showing that the amount of total asset and total liabilities and equity is balance.

Table 4.11: Proforma Balance Sheet for year 1,2 and 3 (RM)

	Year 1	Year 2	Year 3		Year 1	Year 2	Year 3
Assets				**Liabilities and Equity**			
Current asset				Current liabilities			
Cash and marketable securities	2601376	7598433	14463002	Accrued wages and taxes	4510816	7520814	8238700
Account receivable	4456334	11945035	19433735	Account payable	11038584	15067324	17763770
Inventory	33311299	33311299	33311299	Notes Payable	8800797	9560768	13640034
Total	40369009	52854767	67208037	Total	24350197	32148906	39642504
Fixed assets				Long term debt	4000970	4000970	4000970
Gross plant and equipment	3931559	3594561	3257563	**Total debt**	28351167	36149876	43643474
Less: Depreciation	336998	336998	336998	Stockholder's equity			
Net plant and equipment	3594561	3594561	3594561	Preferred stock	3000000	3000000	3000000
Other long-term assets	366674	366674	366674	Common stock and paid-in surplus	6500884	6500884	6500884
Total	8229791	7892794	7555796	Retained earnings	10746750	15096800	21619474
Total assets	48598801	60747561	74763832	Total	20247634	24597684	31120358
				Total liabilities and equity	48598801	60747560	74763832

4.5.6 Proforma Income Statement

The proforma financial statement is developed to project the future condition of a business based on forecast. It projects future income and expense as determined by a forecast of future operation of DRA manufacturing.

Table 4.12: Proforma Income Statement for year year 1,2 and 3 (RM).

Income statement	Year 1	Year 2	Year 3
Net sales (all credit)	40800000	41480000	42500000
Less: cost of good sold	33311299	33311299	33311299
Gross profit	7488701	8168701	9188701
Less: depreciation	333414	333414	333414
Earnings before interest and taxes	7155286	7835286	8855286
Less: interest	307754	105698	85698
Earnings before taxes (EBT)	6847532	7729588	8769588
Less: taxes	190556	247722.8	247722.8
Net Income	**6656976**	**7481866**	**8521866**
Less: preferred stock dividends	3000000	3000000	3000000
Net income available to common stock holders	3656976	4481866	5521866

CHAPTER 5

CONCLUSION

5.0 Conclusion

The product is Drag reduction agent from Cocoa Husk. The DRA is flow improver in pipeline for refinery product. The DRA is niche player in the specialty and chemical business, focusing on value added product which is not widely or readily available in Malaysia.

The operating cost is quite reasonable. The profit of the DRA production plant is quite impressive. Therefore, this plant is believed to be a profit making plant. This DRA production will recover back it capital cost at the 5 year after beginning operation. , the DRA would cost just under RM 1.14or under $1 per barrel of crude oil. DRA product is very unique and highly demand in the market.

5.1 DRA Performance

(i) A new environmentally friendly drag reducing agent has been introduced in the present work. This drag reducing agent solved two problems. Firstly, it can replace the existing toxic synthetic polymer and artificial polymers used as flow improvers commercially. Secondly, the present work utilized agricultural waste (cocoa husk) to be used successfully in a valuable commercial application.

(ii)The efficiency of the cocoa husk mucilage as drag reducing agent was found to increase by increasing the liquid velocity until reaching certain range of Re where the value of the % DR start to decrease. This was due to the complex relation between the parameters controlling the degree of turbulence and the mucilage molecules interacting within the liquid flow structures inside the pipe.

The % DR was found to increase by increasing the addition concentration of the new flow improver. This can be considered normal because increasing the addition concentration means increasing the number of mucilage molecules involved in the drag reduction operation.

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Appendix

Cash Flow Analysis for DRA production for 20 years plant (RM).

Total capital investment	3951691.9	Year 1 :10% of TCI, loaned by bank and etc
annual total production cost	15900872.87	Year 2 :25% of TCI, loaned by bank and etc
		Year 3 :65% of TCI, loaned by bank and etc + working capital

YEAR	CAPITAL INVESTMENT	SALES INCOMES	DEPRECIATION	TOTAL PRODUCTION COST	CASH INCOME	NET PROFIT	FEDERAL INCOME TAX	NET PROFIT AFTER TAXES	NET CASH INCOME	SUMMATION NET CASH INCOME
0	0								0	0
1	-395169.19								-395169.19	-395169.19
2	-987922.98								-987922.98	-1383092.17
3	-2963768.93								- 2963768.93	-4346861.10
4		16728000.00	329307.66	15900872.88	827127.12	497819.46	0.00	497819.46	827127.12	-3519733.98
5		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	0.00	3449819.46	3779127.12	259393.14
6		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	0.00	3449819.46	3779127.12	4038520.27
7		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	0.00	3449819.46	3779127.12	7817647.39
8		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	0.00	3449819.46	3779127.12	11596774.51
9		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	14340955.79
10		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	17085137.07
11		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	19829318.35
12		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	22573499.64
13		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	25317680.92
14		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	28061862.20
15		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	30806043.48
16		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	33550224.77
17		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	36294406.05
18		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	39038587.33
19		19680000.00	329307.66	15900872.88	3779127.12	3449819.46	1034945.84	2414873.62	2744181.28	41782768.61
20		19680000.00	329307.66	15900872.88	3779127.12	344s9819.46	1034945.84	2414873.62	2744181.28	44526949.89

Cumulative Discounted Cash Flow for Discounted Factor 0%, 5%, 10%, 15%,20%, 30%.

YEAR	NET CASH INCOME A(NCI)	Discounted Factor (fd= 5%)	Discounted Cash Flow, i= 5%, A(NCI) x fd	Cumulative Discounted Cash Flow, i= 5%	Discounted Factor (fd= 10%)	Discounted Cash Flow, i= 10%, A(NCI) x fd	Cumulative Discounted Cash Flow, i= 10%
0	0			0			0
1	-395169.1907	0.9524	-376359.1372	-376359.1372	0.9091	-359248.3113	-359248.3113
2	-987922.9768	0.907	-896046.1399	-1272405.277	0.8264	-816419.548	-1175667.859
3	-2963768.93	0.8638	-2560103.602	-3832508.879	0.7513	-2226679.597	-3402347.457
4	827127.1209	0.8227	680477.4824	-3152031.397	0.683	564927.8236	-2837419.633
5	3779127.121	0.7835	2960946.099	-191085.2975	0.6209	2346460.029	-490959.6036
6	3779127.121	0.7462	2819984.658	2628899.36	0.5645	2133317.26	1642357.656
7	3779127.121	0.7107	2685825.645	5314725.005	0.5132	1939448.038	3581805.695
8	3779127.121	0.6768	2557713.235	7872438.24	0.4665	1762962.802	5344768.496
9	2744181.282	0.6446	1768899.255	9641337.495	0.4241	1163807.282	6508575.778
10	2744181.282	0.6139	1684652.889	11325990.38	0.3855	1057881.884	7566457.663
11	2744181.282	0.5847	1604522.796	12930513.18	0.3505	961835.5395	8528293.202
12	2744181.282	0.5568	1527960.138	14458473.32	0.3186	874296.1565	9402589.359
13	2744181.282	0.5303	1455239.334	15913712.65	0.2897	794989.3175	10197578.68
14	2744181.282	0.5051	1386085.966	17299798.62	0.2633	722542.9316	10920121.61
15	2744181.282	0.481	1319951.197	18619749.81	0.2394	656956.999	11577078.61
16	2744181.282	0.4581	1257109.445	19876859.26	0.2176	597133.847	12174212.45
17	2744181.282	0.4363	1197286.293	21074145.55	0.1978	542799.0576	12717011.51
18	2744181.282	0.4155	1140207.323	22214352.88	0.1799	493678.2127	13210689.72
19	2744181.282	0.3957	1085872.533	23300225.41	0.1635	448673.6397	13659363.36
20	2744181.282	0.3769	1034281.925	24334507.33	0.1486	407785.3386	14067148.7

YEAR	NET CASH INCOME A(NCI)	Discounted Factor (fd= 20%)	Discounted Cash Flow, i= 20% , A(NCI) x fd	Cumulative Discounted Cash Flow, i= 20%	Discounted Factor (fd= 30%)	Discounted Cash Flow, i= 30%, A(NCI) x fd	Cumulative Discounted Cash Flow, i= 30%
0	0	S		0			0
1	-395169.1907	0.8333	-329294.4866	-329294.4866	0.7692	-303964.1415	-303964.1415
2	-987922.9768	0.6944	-686013.7151	-1015308.202	0.5917	-584554.0253	-888518.1668
3	-2963768.93	0.5787	-1715133.08	-2730441.282	0.4552	-1349107.617	-2237625.784
4	827127.1209	0.4823	398923.4104	-2331517.871	0.3501	289577.205	-1948048.579
5	3779127.121	0.4019	1518831.19	-812686.6813	0.2693	1017718.934	-930329.6452
6	3779127.121	0.3349	1265629.673	452942.9915	0.2072	783035.1395	-147294.5058
7	3779127.121	0.2791	1054754.379	1507697.371	0.1594	602392.8631	455098.3573
8	3779127.121	0.2326	879024.9683	2386722.339	0.1226	463320.985	918419.3423
9	2744181.282	0.1938	531822.3325	2918544.672	0.0943	258776.2949	1177195.637
10	2744181.282	0.1615	443185.2771	3361729.949	0.0725	198953.143	1376148.78
11	2744181.282	0.1346	369366.8006	3731096.749	0.0558	153125.3156	1529274.096
12	2744181.282	0.1122	307897.1399	4038993.889	0.0429	117725.377	1646999.473
13	2744181.282	0.0935	256580.9499	4295574.839	0.033	90557.98232	1737557.455
14	2744181.282	0.0779	213771.7219	4509346.561	0.0254	69702.20457	1807259.66
15	2744181.282	0.0649	178097.3652	4687443.926	0.0195	53511.53501	1860771.195
16	2744181.282	0.0541	148460.2074	4835904.134	0.015	41162.71923	1901933.914
17	2744181.282	0.0451	123762.5758	4959666.71	0.0116	31832.50287	1933766.417
18	2744181.282	0.0376	103181.2162	5062847.926	0.0089	24423.21341	1958189.63
19	2744181.282	0.0313	85892.87414	5148740.8	0.0068	18660.43272	1976850.063
20	2744181.282	0.0261	71623.13147	5220363.931	0.0053	14544.1608	1991394.224

YEAR	Cumulative Cash Flow , i= 0%	Cumulative Discounted Cash Flow, i= 5%	Cumulative Discounted Cash Flow, i= 10%	Cumulative Discounted Cash Flow, i= 20%	Cumulative Discounted Cash Flow, i= 30%
0	0	0	0	0	0
1	-395169.1907	-376359.1372	-359248.3113	-329294.4866	-303964.141
2	-1383092.167	-1272405.277	-1175667.859	-1015308.202	-888518.167
3	-4346861.098	-3832508.879	-3402347.457	-2730441.282	-2237625.78
4	-3519733.977	-3152031.397	-2837419.633	-2331517.871	-1948048.58
5	259393.1441	-191085.2975	-490959.6036	-812686.6813	-930329.645
6	4038520.265	2628899.36	1642357.656	452942.9915	-147294.506
7	7817647.386	5314725.005	3581805.695	1507697.371	455098.357
8	11596774.51	7872438.24	5344768.496	2386722.339	918419.342
9	14340955.79	9641337.495	6508575.778	2918544.672	1177195.64
10	17085137.07	11325990.38	7566457.663	3361729.949	1376148.78
11	19829318.35	12930513.18	8528293.202	3731096.749	1529274.1
12	22573499.64	14458473.32	9402589.359	4038993.889	1646999.47
13	25317680.92	15913712.65	10197578.68	4295574.839	1737557.46
14	28061862.2	17299798.62	10920121.61	4509346.561	1807259.66
15	30806043.48	18619749.81	11577078.61	4687443.926	1860771.19
16	33550224.77	19876859.26	12174212.45	4835904.134	1901933.91
17	36294406.05	21074145.55	12717011.51	4959666.71	1933766.42
18	39038587.33	22214352.88	13210689.72	5062847.926	1958189.63
19	41782768.61	23300225.41	13659363.36	5148740.8	1976850.06
20	44526949.89	24334507.33	14067148.7	5220363.931	1991394.22