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Original Research Article

Survey of economic indices of the used motor oil industry equipped to acidic sludge recycling unit (A case study)

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Abstract

According to the database of Iranian industrial organizations, there are more than two hundred recycling units of used motor oil currently in Iran. With regard to the role of industrial sector for economic development and its priority for promoting other sectors to establish job opportunities, we need to survey the used motor oil industry through its indices. The objective of this study was survey of economic indices in used motor oil industry equipped to acidic sludge recycling unit. Therefore, the procedure of calculating the indices that would enable industries in specific sector regarding sustainability performance is presented. Present study was performed in site of case study industry. Based on the studies of technical and economical view-point, the indices values such as value-added percent, profit, annual income, breakeven point, value-added, output value, data value, variable cost of good unit and production costs were founded 56.34%, $2795396.8, $2775522.94, $260.83, $2955795.3, $2289986, $5245781.3, $535 and $2470258.36 respectively. The breakeven point about 6% and the time of return on investment about 0.26 (3.2 months) was indicated the economic success of this project.

Keyword: Acidic sludge, Economic indices, Industry, Recycling unit, Used motor oil

INTRODUCTION

Motor oil requirement is increasing day by day with the establishment of new industries, increase in number of vehicular transports and mechanization of agriculture. Used motor oil can be considered as a source of pollution or as a resource depending on the methods of utilization and management. Because of used motor oil basic properties it can be retrieved. There are different methods to recover of used motor oil. At present, there are eight kinds of common lubricant recycling technologies as follows: (1) acid/clay process; (2) distillation process; (3) solvent de-asphalting process; (4) TFE (Thin Film Evaporation) + hydro-finishing; (5) TFE + clay finishing; (6) TFE + solvent finishing; (7) solvent extraction hydro-finishing and (8) TDA (Thermal De-Asphalting) + clay finishing and TDA + hydro-finishing. But conventional acid-clay technique has been established to recover used motor oil collected from different sources in developing countries since 1930 (René and Serena, 2011). The efficiency recovery of used motor oil is between 62 to 66 percent using acid/clay technology. Also, are produced some of byproducts as acidic sludge, gasoline, spilled oil and etc in used motor oil reprocessing industries. Some byproducts are used so that heating of distillation and mixing tanks. Results of research Hassanpour et al. (2013) reported that environmental and health hazards of acidic sludge were decreased by modification and neutralization. Also, it was obtained bitumen 54/130 from acidic sludge recycling that can be used as suitable bitumen in construction and building materials

(Hassanpour et al., 2014; Damjan and Peter, 2005). The quality of produced motor oil from reprocessing industries would be same with refining or regenerative technologies using appropriate additives and quality control methods (Hassanpour et al., 2014). Regard to the number of reprocessing industries in developing countries and the world, quality of motor oil and quantity of produced acidic sludge as a suitable bitumen, it is necessary that focus on the performance of this industries and the sustainable development aspects. Based on the study of Damjan et al. (2005) many definitions of sustainability include the environmental performance, societal responsibility and economic evaluations. Economic estimates of indices concerns the impacts of the industry on the economic identity of its stakeholders on layout feasibility to establish (Damjan and Peter, 2005). Walter et al. (2004) were explained the knowledge economy as production and services based on knowledge-intensive activities that help to an accelerated step of technical, scientific advance and rapid obsolescence (Walter et al., 2000). The will follow societal responsibility the both quality of products and solving the environmental problems of industry. The research of Fagerberg (2000) reported that growth and development of industries have an important and significant role to achieve stable and rapid economic growth and development. Exports have a positive impact on the industries (Fagerberg, 2000; Williame, 2002). The economic benefit of any project is a vital requirement for its viability. Economic study describes the different components of the financial and economic aspects of recycling used motor oil and examines closely the associated costs. The major costs can be divided into organization and control costs incurred by the central office, collection cost and operational costs of the final storage facility prior to reprocessing costs. Cost estimates are based on a detailed evaluation that reflects typical investment costs, interest rates, overhead costs, transportation costs, materials, equipments and fixed, working costs and etc to establish and recover the used motor oil (Michel and Ana, 2000; Aminian, 2013).

In present research was used of economic indices such as value-added percent, profit, annual income, breakeven point, time of return on investment, value-added, output value. The most value-added has been devoted in the services sector > agriculture> mining and industry in Iran. The highest value-added with the lowest time of return on investment and breakeven level will follow the highest profit and annual income. Therefore, if this condition be ready in an industry it is the best state (Wiedmann et al., 2007; Daskalopoulos and Probert, 1997). Kasteren et al. (2007) have studied on the conceptual design of a production process with economic indices such as the raw material price, plant capacity, production price and capital cost in the conversion of waste cooking oil to biodiesel (Van Kasteren and Nisworo, 2007). Marchetti et al. (2008) have studied the economic indices such as evaluate productivity, raw material consumption, economic competitiveness and environmental impacts of each process (Marchetti and Errazu, 2008). Bradley et al. (2007) have studied on the relationship between oil prices and some of key macro-economic variables. Also, investigate on the crude oil prices with output, prices of consumer, unemployment, and stock (Bradley and Thompson, 2007). The main objective of present study was survey of economic indices in used motor oil industry equipped to acidic sludge recycling unit. To achieve to this aim, was estimated and surveyed requirements of a used motor oil industry as a case study in Isfahan province, Iran.

METHOD

In current study were determined a working shift of 8 hours per day, for 270 working days per year. Treatment capacity of used motor oil was estimated about 100 barrels (220 liters) and acidic sludge as byproduct was about 15 barrels per day. The required electrical energy and water were calculated on 300 working days per year. The required water was calculated 100 L/person – day. Total daily required water for the fire fighting was calculated by a factor of 1.5. The salaries of the staff were computed for 14 months including 23% of total salaries for insurance costs and pensions with $ 100 transportation costs per month, for each individual. In present research was neglected from get a loan. Finally, economic evaluation was performed with empirical equations 1 to 11 and professional experiences (Santana et al., 2010; Thomas et al., 2006).

$$Q = MC'T \qquad \text{equation (1)}$$

$$W = 0.75(\sum e) \times A \qquad \text{equation (2)}$$

$$C = 0.005 \times P \qquad \text{equation (3)}$$

$$V = p - ((\sum)e + A' + F + Cf) \qquad \text{equation (4)}$$

$$\%V = V \times 100 / p \qquad \text{equation (5)}$$

$$Qp = V - ((\sum)I + L + D + S) \qquad \text{equation (6)}$$

$$Cv = Cvd / Cp \qquad \text{equation (7)}$$

$$Ph = Tf / Cv - Cs \qquad \text{equation (8)}$$

$$Cpi = Cvp + Cfp \qquad \text{equation (9)}$$

$$Ai = Ts - Cpi \qquad \text{equation (10)}$$

$$Vt = If / Ai \qquad \text{equation (11)}$$

In equations 6 to 16, Q, M, C', T, W, e, A, C, P, V, A', F, C_f, Q_p, I, L, D, S, C_v, C_{vd}, C_p, P_h, T_f, C_s, C_{pi}, C_{vp}, C_{fp}, A_i, T_s, V_t and I_f, are the required heating rate (kj), flow rate (m^3/h), thermal capacity, temperature ($k^{\cdot}$), required electrical energy, sum of electrical energy consumption (facilities, manufacturing line apparatus, building and campus), area (m^2), selling costs, selling price, value-added, initial materials (Additives, materials, boxes and barrels), maintenance, unforeseen costs, profit, insu-

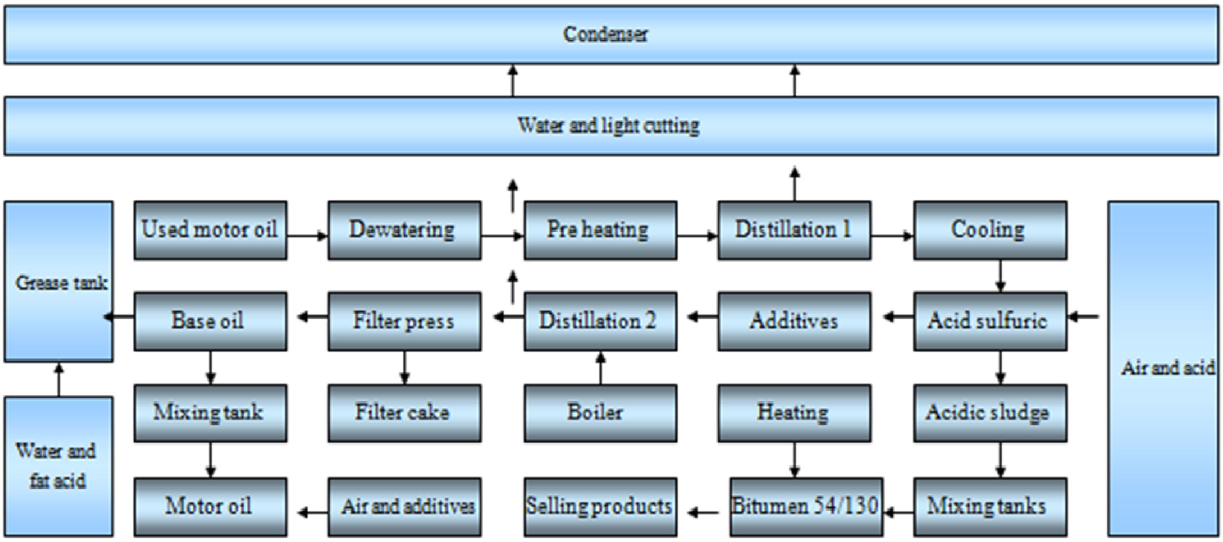

Figure 1 the diagram of used motor oil reprocessing industry

rance, cost of interest and fees, depreciation, salary, variable costs of good unit, variable project costs, production capacity, breakeven point, total fixed costs, selling cost of good unit, manufacturing costs, variable manufacturing costs, fixed manufacturing costs, annual income, total selling price, time of return on investment and fixed capital respectively (Evelina, 2005; Johnson et al., 2008).

RESULT AND DISCUSSION

With regard to the role of industrial sector for economic development and its priority for promoting other sectors to establish job opportunities, we need to survey this sector through its indices. Figure 1 represents the layout of recycling unit of used motor oil reprocessing industry in the case study industry.

The study of Zhang et al. (2003) indicates that in the future, the motor oil price will increase because the motor oil production cannot supply the requirements due to oil shortage. The consumption of motor oil is high in the developed countries due to the high population growth in the developing countries. Therefore, it will increase motor oil consumption and used motor oil production in the near future (Zhang et al., 2003). The study of Hassanpour et al. (2012) showed that the best management method in order to compensate motor oil consumption is the used motor oil recovery in Iran (Hassanpour and Jonidi, 2013; Hassanpour and Mohammadi, 2012). According to the database of Iranian industries organization (2000), there are more than two hundred recycling units of used motor oil currently in Iran (Brumberg and Ahram, 2007). In the other hand, the results of case study the Hassanpour et al. (2014) in a used motor oil industry using business excellence model showed that performance of the industry was in sustainable development state. Based on another experimental study of Hassanpour et al. (2013) were selected the bentonite soil and SBS (Styrene-Butadiene - Styrene) polymer in weight percentages of 2 and 4 per 50 g of acidic sludge respectively the suitable additives to recover of acidic sludge to polymer bitumen in used motor oil industry as case study (Jonidi and Hassanpour, 2014). Grease, motor oil and bitumen 54/130 are products of used motor oil reprocessing industry (Jonidi et al., 2014). Therefore, the requirements of used motor oil reprocessing industry as case study were estimated according to Table 1.

The equipments cost which contributes to the capital cost was calculated from the data of DACE price book (DACE (Dutch Association of Cost Engineers)). Other requirements were estimated using empirical equations 1 to 11, professional experiences and based on collected data in site of industry and observations. Some of byproducts are produced from recycling processes of used motor oil and acidic sludge such as spilled oil and gasoline that are used to supply required energy for heating of mixing and distillation tanks. The costs of energy consumption include the water, fuel, petroleum and electrical costs (Hassanpour, 2010-2014). The costs of additives, barrels and required materials include the bentonite soil, SBS polymer, barrels (220 L) , used motor oil, acid sulfuric, Cao, additives as polymer for base oil, fat acid, drums 4.5 liters for motor oil, drums 1 kg for grease, boxes with 24 empty spaces for grease and 6 empty spaces for motor oil. There are a list from costs that are called fixed and working capitals (Table 2).

The investment rates to establish an industry unit are

Table 1. Requirements of used motor oil reprocessing industry

Main annual material and equipments	Total annual rates	Total cost $
Acidic sludge	891 m^3	-
Bentonite soil	330.32 tons	103.225
SBS polymer	35.64 tons	66825
Barrels (220 L)	4050 Number	36450
Used motor oil	5770 m^3	1154000
Acid sulfuric	411.3 tons	154237.5
Cao	22.5 tons	1406.25
Additives as polymer for base oil	66 tons	144375
Fat acid	112.5 tons	249600.5
Drums 4.5 liters for motor oil	700000 Number	284375
Drums 1 kg for grease	787500 Number	123046.8
Boxes with 24 empty spaces for grease	34453 Number	10766.6
Boxes with 6 empty spaces for motor oil	122500 Number	15312.5
Bitumen 54/130	891 tons	417656.25
Motor oil	3000 tons	4687500
Grease	750 tons	703125
Required energy for heating of mixing tanks to 180 °C and distillation tanks	60324098 KJ	The will be compensated of spill oil and by-product as gasoline
Required electrical energy	287820 (kwh)	3598
Required water	16980 m^3	1171.6
water supply facilities		15625
Split AC (Internal wiring, transformers and emergency power generators)		13125
Fire extinguishers (Total)	54 Number	3402
Stoves (Total)	9 Number	270
Cooler (Total)	8 Number	240
Ventilation system (Total)	14 Number	280
Office equipment, furniture and etc	-	2500
Lab equipments (for the oil and bitumen quality control)	-	5000
Transportation (a vehicle weighing 4 tons, car and fork)	7 Number	85000
Staffs salary (6 persons for acidic sludge recycling unit+27 persons for used motor oil industry)	33 Persons	110000
Required fuel (stoves)	2360 L	332
Petroleum expenses (Transportation vehicle and cars)	44400 L	9712.5
Required land	20000 m^2	100000
Construction of infrastructure (buildings)	2284 m^2	228400
Pavement and asphalt	5542 m^2	53688
landscaping	2000 m^2	2000
ground tank 2*15*12	1 Number	28000
Mixing tanks equipped with heating to 180 °C	2 Number	3150 With 5% cost of installation
Propeller mixers with power 3.5 hp	5 Number	945 With 5% cost of installation
Sewage pumps with power 10 hp	2 Number	840 With 5% cost of installation
Stainless steel vacuum pumps with power 7.5 hp	4 Number	1260 With 5% cost of installation
Gear pumps with power 5.5 hp	13 Number	2730 With 5% cost of installation
Condenser	4 Number	840 With 5% cost of installation
Sedimentation tank 20 m^3	7 Number	26250 With 5% cost of installation
Distillation tanks	4 Number	104864.55 With 5% cost of installation
Mixing tanks	5 Number	12796.87 With 5% cost of installation
Grease cooking chamber	1 Number	3062.5 With 5% cost of installation
Filter presses with 20 blades (62*62)	1 Number	17187.5 With 5% cost of installation

Table 2. Fixed and working capital

fixed capital		
Description		Costs $
Required land, landscaping, buildings, pavement and asphalt		384088
Investment in facilities		11692
Investment in equipment and the installations costs		201926.42
Investment in transportation cars (a vehicle weighing 4 tons, car and fork)		85000
Unforeseen costs	3% investment (fixed and working capitals)	33049.43

Table 2. Continue

Costs before of the operation			-
Total cost			725766.85
working capital			
Description	Time		Cost $
Additives and barrels and required materials*	45 days		373416.4
Energy consumption (water, fuel, petroleum and electrical costs) *	65 days		3566.35
Staffs salary *	68 days		20493.15
Other costs	-	5% costs (∑*)	19873.8
Cost of sales	20 days		1591.3
Total cost			418941

Table 3. Depreciation costs, maintenance, operational and non-operational fixed annual capital

Description	**%Rate**	**Capital value $**	**Costs of maintenance $**
Landscaping, buildings, pavement and asphalt	2	284088	5681.76
Facilities and equipments	10	11692	1169.2
Equipments without installations costs	5	193230.124	9661.5
Office equipment, furniture, etc	10	2500	250
Transportation cars (a vehicle weighing 4 tons, car and fork)	10	85000	8500
Unforeseen cost	5	32481.5	402.8
		Total cost	1624.075
			Depreciation costs of fixed capital
Description	Depreciation rate	Capital value $	Cost of depreciation$
Equipments without installations costs	10	193230.124	19323.0124
Landscaping, buildings, pavement and asphalt	5	284088	14204.4
Office equipment, furniture and etc	20	2500	500
Transportation cars (a vehicle weighing 4 tons, car and fork)	10	85000	8500
Facilities and equipments	10	11692	1169.2
Costs before of the operation	20	10011	2002.2
Unforeseen cost	10	32481.5	3248.15
Total cost			48946.97

Table 4. Total fixed and variable manufacturing costs

Description	**%Fixed cost**	**Cost $**	**%Variable cost**	**Cost $**
Additives, barrels and required materials	-	-	100	2240498.4
Maintenance	10	162.4075	90	1461.66
Energy consumption (water, fuel, petroleum and electrical costs)	20	2962.82	80	11851.3
Unforeseen cost	-	33049.43	-	-
Staff salary	85	93500	15	16500
Depreciation of fixed capital	100	48946.97	-	-
Interest and fees	100	-	-	-
Insurance (0.2% of total investment)	100	1451.53	-	-
Unforeseen costs of working capital	-	-	-	19873.8
	Total cost	180073.16		2290185.2

estimated by fixed and working capital (Table 2). In an industry are calculated costs for depreciation, maintenance, operational and non-operational. Table 3 shows the depreciation costs, maintenance, operational and non-operational fixed annual capital.

Table 3 represents the depreciation costs, maintenance, operational and non-operational fixed annual capital. Total costs of manufacturing are equaled with sum from fixed and variable manufacturing costs. Table 4 shows total fixed and variable manufacturing costs. In current study was neglected from get a loan and interest and fees.

Economic studies need to estimate the total fixed and variable manufacturing costs (Table 4). Table 5 shows total manufacturing price.

Table 5 shows that total manufacturing price is equal with 2465681.8 for three products. The required selling price is the price of the products which is required to

Table 5. Total manufacturing price

Description	Cost $
Additives, barrels and required materials	2240498.4
Staffs salary	110000
Energy consumption	14814.1
Maintenance cost	1624.075
Depreciation of fixed capital	48946.97
Cost of insurance	1451.53
Cost of interest and fees	-
Unforeseen costs*	48346.7
Total cost	2465681.8

*(2% total manufacturing costs)

Table 6. Economic indices

Economic indices	Cost $
Data value	
Grease	703125
Bitumen 54/130	417656.3
Motor oil	4125000
Total value of annual selling of products	5245781.3
Output value	
Additives, barrels and required materials	2240498.4
Maintenance	1624.075
Energy consumption	14814.1
Unforeseen costs of fixed capital	33049.43
Total cost	2289986
Value- added	2955795.3
Value- added percent	56.34 %
Profit	2795396.8
Variable cost of good unit	535
Breakeven point (6%)	260.83
Production cost	2470258.36
Annual income	2775522.94
Time of return on investment	0.26 (3.2 months)

cover all costs (variable, fixed and overhead), recover the total investments and provide the specified return of the employed capital. According to Table 6 data value (selling annual value of products) was obtained US$ 5245781.3 which is more than the total annual manufacturing price US$ 2465681.8. Table 6 represents economic indices.

Rates of profit, Value- added, breakeven point, time of return on investment and investment rate are main economic indices. According to Table 6, the time of return on investment will take about 3.2 months, which this is least time so. If it be prepared the selling market and export of bitumen 54/130, the will follow high profit as well as environment protection, business and sustainable development aspects. Van kasteren et al. (2007) have been studied on the conceptual design of a production process with sensitive key factors such as the raw material price, plant capacity, glycerol price and capital cost in the conversion of waste cooking oil to biodiesel for three plant capacities (125,000; 80,000 and 8000 tons biodiesel/year) with the existing alkali, acid catalyzed and a supercritical trans-esterification processes. The economic assessment shows that biodiesel can be sold at US$ 0.17/L (125,000 tons / year), US$ 0.24/L (80,000 tons / year) and US$ 0.52/L for the smallest capacity (8000 tons / year). The study of zhang et al. (2003) was showed that for three biodiesel plants with capacities 100,000 (1994), 7800 (1996) and 10,560 (1999) tons / year the breakeven prices $/ton 340,763, 420 were founded respectively, on the economic feasibilities of three continuous processes to produce biodiesel, including both alkali- and acid-catalyzed processes, using waste cooking oil and the standard process using virgin vegetable oil as the raw material. It was obtained $/unit 260.83 breakeven point in present study. The analysis of breakeven point determines the relationship between costs and incomes. Using of this method in current study indicates the time of return on investment clearly. Based on the breakeven point is shown fixed and variable costs of project at contrast with the available incomes. The breakeven point shows the lowest level of production which at this level profitability starts and at this level incomes of industry covers the fixed and variable costs. In an industry is vital the knowing of a breakeven budget to determine an expected market price for products at some point in the future or to evaluate the choice of retained ownership or sale of their products. Therefore, industries owners use breakeven budgets to estimate the profit potential of a barrel of bitumen or other products, to determine the price which they can afford to pay for costs, and to evaluate the effect on expected profit of changes in selling or products prices (Kolmakov et al., 2007). Moosavi et al. (2013) have reported that the value-added will increase almost equal to the average annual growth rate of 18 percent for industries sector since 2009 to 2025 years in Iran (Moosavi and Rajabi, 2013). In the present study was obtained the value-added growth percent about 56.34% per year. Therefore, the will follow a positive impact on total value-added of industries sector.

The research of Richard et al. (2006) to decline four water quality indicators (sediment yield, surface runoff, nitrate in surface runoff and edge-of-field erosion) so that growth switchgrass showed that was produced between 527,000 and 1.27 million metric tons of switchgrass per year on cropland in the Delaware basin in Kansas. The break-even price per Mg was calculated around $41 without used nitrogen to slightly less than $ 25 at 224 kg N $haKh^{-1}$ used. The most rates of break-even had a $ 30 Mg^{-1} or less (Richard et al., 2006). The economic analysis of Haenlein (2014) has reported the breakeven point 30, 37, 38% of total milk production in commercial factories with three types of classification (840.44, 991.16 and 982.87 liters) such as large, medium and small respectively. These breakeven points show that the small Livestock owners can cover its total costs in compare with livestock owners of medium and large easily (Haenlein, 2014). Cutler (2004) based on research on the oil extraction costs reported that the decrease in the oil rates and energy return on investment has been raised the energy costs of extraction of petroleum in the US. Energy return on investment covers the ratio of energy delivered to energy costs (Cutler, 2004). The results research of Greene et al. (2005) represent that a feebate rate of $ 500 per 0.01 gallon per mile produces a 16 percent increase in fuel economy and 29% around $ 1000 so. Saving fuel for 3 years declines unit sales about 0.5 %. But sales will follow increase, because the added value of implementation fuel economy technologies outweighs the decrease in sales (Greene et al., 2005). Gonzalez et al. (2011) were studied on the technical and financial performance of high yield Eucalyptus biomass. Results showed that a cost of $ 0.49 L^{-1} of ethanol, cash cost of $ 0.46 L^{-1} and CAPEX of $ 1.03 L^{-1} of ethanol.

The main costs include the biomass, enzyme, tax, fuel (gasoline), depreciation and labor. Profitability of the process is very depend on biomass cost, carbohydrate percentage in biomass and enzyme cost (Gonzalez et al., 2011). Haas (2005) has been studied on the production cost of soap-stock biodiesel and biodiesel produced from soy oil. Results of this research showed that cost of soap-stock biodiesel is US$ 0.41/L and about 25% less respectively (Haas, 2005). The research of song et al. (2006), represent that based on evaluation the costs of raw material and the potential market indicate that the petroleum-based succinic acid process will be replaced by the fermentative succinic acid production system in the close future (Song and Yup, 2006). Based on the calculations Banat et al. (2008), on the key factors such as membrane lifetime and plant lifetime to treatment water, the estimated cost of potable water produced by the compact unit was $15/$m^3$, and $18/$m^3$ for water produced by the large unit (Banat and Jwaied, 2008; Zhang et al., 2003). The assessment of Iranian industry organization (2000) has reported the breakeven point percent, time of return on investment and value-added percent 22.5%, 0.9 (11 months), 36.3% respectively, for used motor oil reprocessing industries without acidic sludge recycling unit. The results of research show that reprocessing project of used motor oil is an economic project. These results of studies are in good agreement with the findings of present study.

CONCLUSION

The study of economic indices represent the confidence of performance the industries, excellence business and job opportunities. Economic indices are criteria to study of economic cycle of industry sector as main base of sustainable development. The results of this research showed that these industries have important role in economic cycle of country due to available numbers, products and success economic.

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