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Full Research Paper

Economical Assessment of Replacing and Refining Methods of Hydraulic Oil of Sugarcane Harvesters in Sugarcane Cultivation Industry of Khuzestan

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Abstract

Contamination due to hydraulic fluids exerts deleterious effects after a long time, however this factor is often ignored or its consecutive breakdowns and system failures are considered due to other factors. Therefore, in order to prevent the likelihood of occurring such problems, the following two strategies are presented: using oil change method to replace all of the hydraulic fluids from the discharge system with the new oil and using offline hydraulic oil filtration system for the removal of contaminated oil particles. In this regard, the present study aimed to investigate the economic status of cane sugar harvesting machines with an emphasis on hydraulic oil filtration process in seven units of sugarcane developmental company and affiliated industries in Khuzestan province, Iran. To perform this study, all statistics and data of the sugarcane and affiliated industries in seven companies during the crop year 2011-2016 were collected and classified. The results indicated that the application of the hydraulic filtration method led to the oil consumption saving (per liter) and in price (Iranian Rial) during the three crop-years of 2014-2016, as following: Imam Khomeini: 25500 L and 2882154363 Rials, Amir Kabir: 49000 L and 5847389466 Rials, Hakim Farabi: 82000 L and 9534396744 Rials, Dabal Khazaee: 73400 L and 6808230362 Rials, Dehkhoda: 31680 L and 3421979639 Rials, Salman Farsi: 73500 L and 7606675370 Rials and Mirza Koochak Khan: 75934 L and 8083068395 Rials.

Keywords: Economical assessment, Hydraulic oil, Oil replacing, Refining, Sugarcane harvester

Introduction

Maintenance costs related to farm machinery are those expenditures necessary to restore or maintain technical soundness and reliability of the machines (Ashtiani Iraqi *et al.*, 2005). The prediction of maintenance costs for mechanized agricultural units is of particular importance in several aspects: firstly, the machine is regarded as one of the main commodities in the agricultural industry that makes it possible to accurately measure the profitability by including the cost items. Secondly, to determine the break-even point for replacing the machine with a new one, it is necessary to estimate the useful lifespan of machines by analyzing the trend of changes in these costs; and thirdly, the possible undesirable causes of cost overruns become possible (Lazarus, 2002). Maintenance is usually described as activities that upgrade the system reliability and guarantee the operational performance of the equipment. Nowadays, maintenance is identified as one of the major issues in the machinery use. Thus, there has always been an attempt to select and run more effective ways to reduce maintenance costs, increase efficiency, and improve safety and timely performance (Bartholomew, 1981). The maintenance and inspection approaches and tools, which have been gradually introduced in the industry since the 1970s, include a wide variety of different methods such as vibration analysis, sound analysis, ultrasonic analysis, thermography, performance analysis, oil tribology analysis, engine circuit analysis and others (Dahunsi, 2008). These methods are mostly focused on the individual indicators for machinery system

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assessment and used to determine the health conditions of various components and parts of the machine. An effective lubrication program with oil analysis can provide longer equipment life, detect early signs of contamination and degradation, reduce equipment downtime and ultimately save you money. In addition, the erosion control and corrosion, wear related deteriorating factors, and optimum oil consumption are also of the benefits of oil analysis in the preventive maintenance (Macinan *et al.*, 2006). In oil analysis technique, oil sampling and testing should be investigated on a regular basis to increase the efficiency and accuracy of the oil analysis program. Thus, it is recommended to perform machine care oil analysis for hydraulic systems every 250 hours. However, depending on the equipment condition in special circumstances, the time can be changed and arranged. In mechanical systems, oil contamination leads to major and numerous problems such as machine failure, repairs, reduced shelf life of oil and so on. Furthermore, it directly effects on the equipment and production effectiveness and consequently imposes the significant unexpected costs. On the other hand, considering the oil contamination control schedule and clean oils, eliminating and controlling contaminated oil would achieve many benefits including minimizing the equipment failure, reducing the operational and maintenance costs, improving the operational efficiency of the equipment and increasing the oil shelf life. Oil contaminations are divided into two basic groups: physical and chemical. Physical contaminations refer to solid particles along with oil whose main consequence is the mechanical wear. On the other hand, chemical contaminations generally include water, some metals such as copper, and materials produced from oil usage. Therefore, in order to prevent the likelihood of problems occurring, the following strategies could be applied: Replace all of the hydraulic fluids from the discharge system with the new oil and use of offline hydraulic oil filtration system for removing the contaminated oil particles (Massoudi, 2011, Ranjbar *et al.*, 2003 and Saghafi, 2008). Prior to the emergence of maintenance and repairing systems, it was assumed that the machines and equipment were used until they were in service, and the maintenance and repairing teams were only involved in the repairing the machines once they had failed to resume their works (Bartelmous and Zimroz, 2009). Nowadays, the advancement of technology, as well as higher prices for agricultural machinery, preventive maintenance (PM) strategy, as a systematic and scheduled policy for identifying the maintenance tasks to prevent the abnormal wear and tear of machine components and lowering emergency machines breakdown, is planned and run based on the intermittent implementation procedures (Mirmoazi, 2004). Therefore, the main objective of the (PM) was to develop systematic conditions for monitoring the status of existing equipments and machines in order to achieve maximum efficiency and productivity and reducing the breakdown and failure with of the machines (Yeganeh Salehpour, 2002). It is obvious that the timeliness of harvesting process is limited based on climatic conditions and plant status, and the failure of harvesting machines during this period might cause to delayed harvest, which in turn increases loss and wastes (Scoma, 1990). The use of the offline filtration method has the following advantages over the oil change method: 1. Any future damages to the machine could be avoided which directly affects the expense reduction. 2. A large amount of oil would be recycled and reused, which is economically important. As a result, the offline oil filtration system plays a fundamental role in the smooth and continuous operation of hydraulic systems. The present study aimed to investigate the economic status of cane sugar harvesting machines with an emphasis on hydraulic oil filtration process in seven units of sugarcane developmental company and affiliated industries in Khuzestan province, Iran.

Materials and Methods

One of the most important sources of the sugar production is sugarcane. Sugar is among the eight human food sources (wheat, rice, corn, sugar, cattle, sorghum, millet and cassava). Also, sugarcane is mainly used for livestock feed, electricity generation, fiber and fertilizer and in many countries sugarcane is a renewable resource for the biofuel production (Haroni *et al.*, 2018). This study was focused on the performance of sugar cane harvesting machines known as the A7000 (Austoft) sugar cane harvester manufactured by Australia in seven sugarcane developmental companies and affiliated industries development company, which were taking care of sugar cane harvesting operations in Khuzestan province. The purpose of this study was to compare the economic efficiency of two offline replacements and filtration techniques for hydraulic oil with an emphasis on the hydraulic oil filtration process. The quantity of hydraulic oil used in each harvester was 480 (L) and the working temperature of hydraulic oil of the sugarcane harvesters in sugarcane development corporations is adjusted from 80 to 100 degrees Celsius, which is replaced each 1000 (h). The offline refinery device of hydraulic oil (filtration) has been formed by two separated pumps and a filter with a debit of 300 L min^{-1} (see Figure 1). This device, which is performed in the offline mode, is similar to a dialysis machine. The machine is connected to a hydraulic oil tank (reservoir) and then, its electric motors start working. While the oil is passing through the pump, the filters are blocked by the oil particles. By allowing the oil to pass the machine's filters by repeating the process, the device will reach to National Aerospace Standard (NAS) (the number of particles is in one milliliter of oil, and the higher its amount, the higher the level of contamination in the oil will be.) which, regarding the hydraulic oil of sugarcane harvester, the number of particles in 5-15 µm sizes available in the oil should not be more than 256000, fitting the pumps and hydro-motors (because moving and disposing the components of hydraulic systems can easily pass these particles). The device filtration components include one magnetic filter made of metal in 100 µm size, one filter made of paper in 10 µm size, two fiberglass filter in 10 µm size that are used for absorbing the tank water to reduce the water boiling point that the available water starts evaporating in lower temperature and one filter in 5 µm size is installed in device output route.

Fig.1. Representation of offline refinery device of hydraulic oil (filtration)

In order to collect data on the criteria such as the oil consumption (demand) price for sugar cane harvesting machines during the cropping years of 2011-2013 (oil replacement technique) and 2014-2016 (offline oil filtration technique), the researcher directly visited the sugarcane developmental companies and affiliated industries development companies operating in Khuzestan province. In this study, fixed costs included purchase costs of equipment required for offline oil filtration, building and facilities. The annual depreciation cost (D) of offline refinery device of hydraulic oil (filtration) was computed by using the formula (1):

$$D = {P - S}/{L} \quad (1)$$

Where P is the list price of the equipment (rial)
S= 0.1*P (is the salvage value) (rial)
M=10 (is the estimated life of the equipment in years)
The usance cost (I) of offline refinery device of hydraulic oil (filtration) was computed as:

$$I = {(P + S)}/{2} * i \quad (2)$$

Where P is the list price of the equipment (rial)
S= 0.1*P (is the salvage value) (rial)
And i: is the interest rate.

Due to lack of availability to the working life and dilapidated price of the machine in this study, they were considered to be 10 years and 10% of a new machine price, respectively (Almasi, 2008). Moreover, variable costs include labor and transportation in the offline filtration cycle or oil replacement. Oil consumption costs involved expenses related to ordering, supplying, purification, replacement and hydraulic oil analysis (Determination of the Exact Amount of Water in the Oil (water contamination), Determination of the Uncleanness Level of Oil, Determination of the Si Amount, Viscosity Measurement of oil and Measurement of the Total acid number (TAN)). These data were extracted and calculated from different types of warehouses and purchase orders of subsidiaries supervised by Sugarcane developmental Company. Then the amount of hydraulic oil consumption for each company was received from the technical offices of the company and affiliated service centers. To remove the effects of inflation on the prices of various years, all prices were calculated based on the prices of 2016 fiscal years. Finally, oil consumption level, oil savings due to the use of hydraulic oil filtration technique, Rial savings, the cost-benefit and the break-even point analysis of offline hydraulic oil filtration have been calculated and evaluated.

Results and Discussion

According to previous studies, it was expected that applying offline hydraulic oil filtration in preventive maintenance programs would lead to the removal of suspended contaminants in oil to protect and extend equipment life. It was also estimated that it would increase as well as increases the oil shelf life and consequently would reduce oil consumption and costs. Therefore, this section investigated the economic comparison of two offline replacements and filtration techniques for hydraulic oil in sugarcane developmental companies and analyzed their results.

Economic evaluation of two offline replacements and filtration techniques

Based on the results obtained from the seven sugarcane developmental companies and affiliated industries development companies in Khuzestan province including Imam Khomeini, Amir Kabir, Hakim Farabi, Dabal Khazaee, Dehkhoda, Salman Farsi and Mirza Koochak Khan, the offline hydraulic oil filtration program was implemented and planned on a regular basis from the 2014 cropping year. Data on oil consumption and harvester status in all seven companies have been shown in Table 1. As can be seen from data in Table 1, the use of offline hydraulic oil filtration technique during the studied years, reduced the amount of oil consumed per hour from 0.95, 1.99, 3.47, 3.73, 1.35, 2.46 and 4.20 (L h^{-1}) in 2014 to 0.88, 1.88, 3.06, 3, 1.25, 2.33 and 4 in 2016 in seven studied companies. In addition, the amount of oil usage per hectare was declined from 2.07, 3.97, 7.33, 8.45, 3.01, 5.36 and 9.21 (L ha^{-1}) in 2014 to 2, 3.85, 6.7, 6.45, 2.9, 5.2 and 6 in 2016. In addition, the amount of oil usage per ton was declined from 0.027, 0.06, 0.095, 0.095, 0.037, 0.06 and 0.1 (L ton^{-1}) in 2014 to 0.023, 0.045, 0.075, 0.071, 0.034, 0.056 and 0.064 in 2016. In addition, the amount of sugarcane yield (ton ha^{-1}) was increased from 76.67, 66.17, 77.16, 88.95, 81.35, 89.33 and 92.1 in 2014 to 86.96, 85.56, 89.33, 90.85, 85.29, 92.86 and 93.75 in 2016.

Table 1- Hydraulic oil consumption of sugarcane harvester in sugarcane developmental companies

Sugarcane development company	Year description	2011	2012	2013	2014	2015	2016
Imam Khomeini	Oil consumed (L h^{-1})	1.23	1.05	1.07	0.95	0.92	0.88
	Oil consumed (L ha^{-1})	2.51	1.77	2.28	2.07	2.02	2
	Oil consumed (L ton^{-1})	0.033	0.027	0.030	0.027	0.024	0.023
	Sugarcane yield (ton ha^{-1})	76.1	65.56	76	76.67	84.17	86.96
Amir Kabir	Oil consumed (L h^{-1})	2.15	1.93	2.24	1.99	1.92	1.88
	Oil consumed (L ha^{-1})	4.54	4	4.48	3.97	3.9	3.85
	Oil consumed (L ton^{-1})	0.082	0.07	0.078	0.06	0.05	0.045
	Sugarcane yield (ton ha^{-1})	55.37	57.14	57.44	66.17	78	85.56
Hakim Farabi	Oil consumed (L h^{-1})	3.5	3.45	3.08	3.47	3.08	3.06
	Oil consumed (L ha^{-1})	8.96	7.23	6.78	7.33	6.74	6.7
	Oil consumed (L ton^{-1})	0.12	0.095	0.095	0.095	0.078	0.075
	Sugarcane yield (ton ha^{-1})	75	76.11	71.37	77.16	86.41	89.33
Dabal Khazaee	Oil consumed (L h^{-1})	3.41	3.88	3.50	3.73	3.65	3
	Oil consumed (L ha^{-1})	7.94	7.84	7.90	8.45	8.35	6.45
	Oil consumed (L ton^{-1})	0.095	0.095	0.095	0.095	0.093	0.071
	Sugarcane yield (ton ha^{-1})	83.58	82.53	83.16	88.95	89.78	90.85
Dehkhoda	Oil consumed (L h^{-1})	1.5	1.46	1.2	1.35	1.3	1.25
	Oil consumed (L ha^{-1})	3.62	3.03	2.62	3.01	2.95	2.9
	Oil consumed (L ton^{-1})	0.048	0.038	0.037	0.037	0.035	0.034
	Sugarcane yield (ton ha^{-1})	75.42	79.74	70.81	81.35	84.29	85.29
Salman Farsi	Oil consumed (L h^{-1})	2.93	3.03	1.84	2.46	2.4	2.33
	Oil consumed (L ha^{-1})	5.9	6.4	4.20	5.36	5.3	5.2
	Oil consumed (L ton^{-1})	0.072	0.1	0.06	0.06	0.058	0.056
	Sugarcane yield (ton ha^{-1})	81.94	64	70	89.33	91.38	92.86
Mirza Koochak Khan	Oil consumed (L h^{-1})	4.64	4.7	4.11	4.20	4.15	4
	Oil consumed (L ha^{-1})	7.9	7.4	7.3	9.21	6.3	6
	Oil consumed (L ton^{-1})	0.12	0.15	0.1	0.1	0.068	0.064
	Sugarcane yield (ton ha^{-1})	65.83	49.33	73	92.1	92.65	93.75

Statistical analysis

According to Table 2, because $P < 0.05$, the hypothesis of the equal consumption of hydraulic oil (L ha^{-1}) in the harvesters before and after the hydraulic oil refining method with the confidently of 99% is rejected and with 99% confidence, the use of hydraulic oil refining method has been effective in reducing the consumption of hydraulic oil (L ha^{-1}) in harvesters.

Table 2- The t-test results to compare the oil consumption (L ha^{-1}) before and after using the hydraulic oil refining of harvesters in sugarcane developmental companies

Variable	Stage	Average	The standard deviation	Degrees of freedom	t	p-value
Oil consumption (L ha^{-1})	Before oil refining (oil replacing)	5	2	6	3	0.01
	After oil refining	5	2			

Figure 2 shows a comparison of oil consumption (L ha^{-1}) in seven Imam Khomeini, Amir Kabir, Hakim Farabi, Dabal Khazaee, Dehkhoda, Salman Farsi and Mirza Koochak Khan companies, which used offline hydraulic oil filtration technique for operating sugarcane harvester. Further, the downward oil consumption trend observed in all these seven sugar cane companies indicated that the use of offline hydraulic oil filtration technique had a greater impact on reducing oil consumption in harvester machines. As evident from Figure 2, Mirza Koochak Khan company was in a sufficiently favorable situation compared to other studied companies in terms of reduced oil consumption. This can be attributed to different reasons including: 1) Proper overhaul of sugarcane harvesters, checking and replacing hydraulic hoses correctly, pressing the hoses connections properly, using a suitable hose according to the standards of the manufacturer company and considering the quality of the parts. In addition, when a pump is uninstalled (opened) during machine's service, the inputs are blocked using the blinders to stop the oil leak in the hose. 2) Controlling the oil intake and exhaust by the maintenance group and creating sensitivity of the mechanics regarding oil frugality. 3) Encouragement and promotion of every personnel whose machine would consume the minimum amount of oil. 4) Expert and experienced staff. 5) Efficient management. 6) Training courses for offline hydraulic oil filtration technique. 7) Timely delivery of services for sugar cane harvesting machines in this unit.

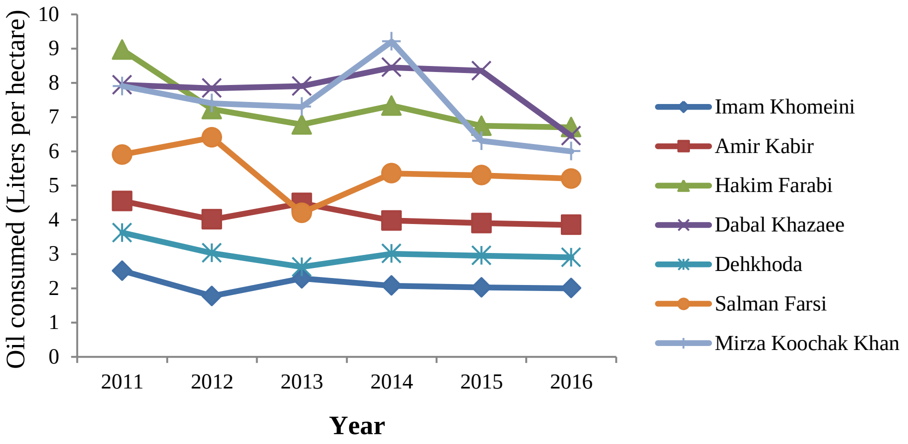

Fig.2. Comparison of oil consumption (L ha^{-1}) in sugarcane developmental companies

According to Figure 3, by using offline hydraulic oil filtration technique during 2014-2016, the average fixed costs (AFC) and average variable costs (Rials per hectare) in seven studied companies based on the hydraulic oil replacement technique has been declined from 216903, 422946.5, 736774.5, 762278.62, 307923.1, 538000.6 and 727454.17 (Rials per hectare) during 2011-2013 to 130272, 246678.1, 433977.2, 488947.72, 188042.64, 331748.82 and 452123.17 (Rials per hectare). Offline hydraulic oil filtration technique during 2014-2016 and Figure 3 represents a comparison of the situation of average fixed costs (AFC) and average variable costs (Rials per hectare) in two offline replacement and filtration techniques. Dabal Khazaee Company, with a total average fixed costs and total variable costs of (762279) (Rials per hectare) in the hydraulic oil replacement during 2011-2013 and 488948 (Rials per hectare) in the hydraulic oil filtration during 2014-2016, achieved the highest total average fixed costs and total variable costs among the companies, respectively (Figure 3). In addition, Imam Khomeini company, having a total average fixed costs and total variable costs of 216903 (Rials per hectare) in the hydraulic oil replacement during 2011-2013 and 130272

(Rials per hectare) in the hydraulic oil filtration during 2014-2016 achieved the lowest total average fixed costs and total variable costs among the seven companies.

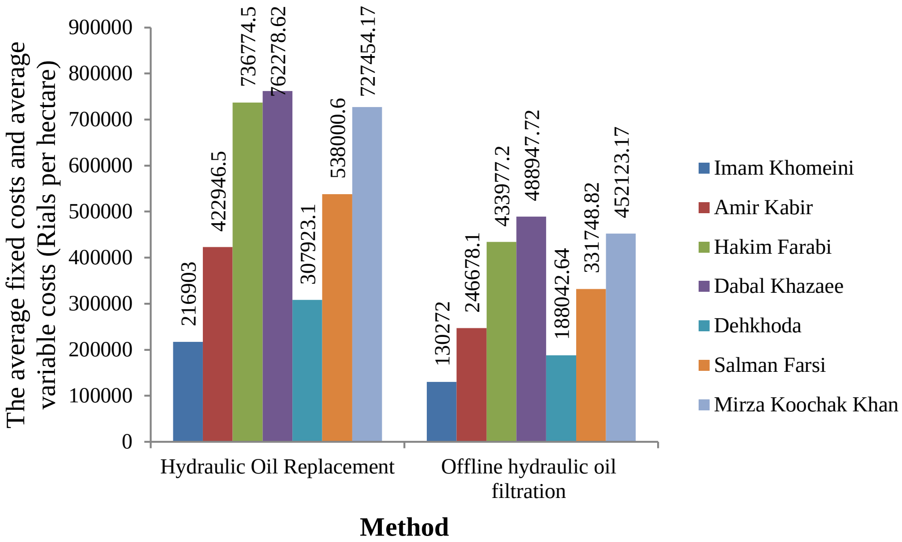

Fig.3. Comparison of the average fixed costs (AFC) and average variable costs (Rials per hectare) for hydraulic oil based on two offline replacements and filtration techniques used in sugarcane developmental companies

Table 3 displays the total amount of savings built up using the offline hydraulic oil filtration in hydraulic oil units within three years. As mentioned before, cost saving on the consumable items including oil was one of the benefits of offline hydraulic oil filtration. Therefore, the establishment of maintenance and repairing program based on the condition analysis could significantly reduce the cost of purchasing consumables items including hydraulic oil. According to Table 3, the total amount of savings built up using offline hydraulic oil filtration in the sugarcane developmental companies was 411014 liters and 44183894339 Rials.

Table 3- Savings in sugarcane developmental companies using offline hydraulic oil filtration during the studied years

Company		2014	2015	2016	Total
Imam Khomeini	Oil (liter)	7000	8800	9700	25500
	Cost saving (rial)	806570607	991745429	1083838328	2882154363
Amir Kabir	Oil (liter)	12000	14200	22800	49000
	Cost saving (rial)	1469961972	1677475065	2699952429	5847389466
Hakim Farabi	Oil (liter)	21000	21000	40000	82000
	Cost saving (rial)	2261508914	2509577337	4763310493	9534396744
Dabal Khazaee	Oil (liter)	23300	28000	22100	73400
	Cost saving (rial)	1803570533	1977212822	3027447007	6808230362
Dehkhoda	Oil (liter)	10560	10560	10560	31680
	Cost saving (rial)	1174264947	1110212619	1137502073	3421979639
Salman Farsi	Oil (liter)	15000	22000	36500	73500
	Cost saving (rial)	1603907811	2188273898	3814493661	7606675370
Mirza Koochak Khan	Oil (liter)	28321	10971	36642	75934
	Cost saving (rial)	1259237207	1504405731	5319425457	8083068395

Figure 4 compares the total amount of Rial savings in seven Imam Khomeini, Amir Kabir, Hakim Farabi, Dabal Khazaee, Dehkhoda, Salman Farsi and Mirza Koochak Khan Companies. As can be seen from data in Figure 4, the total amount of savings built up in Hakim Farabi Company was 9534396744 Rials and the total amount of oil consumption was 82000 liters, indicating higher amount of savings in oil consumption compared to other companies.

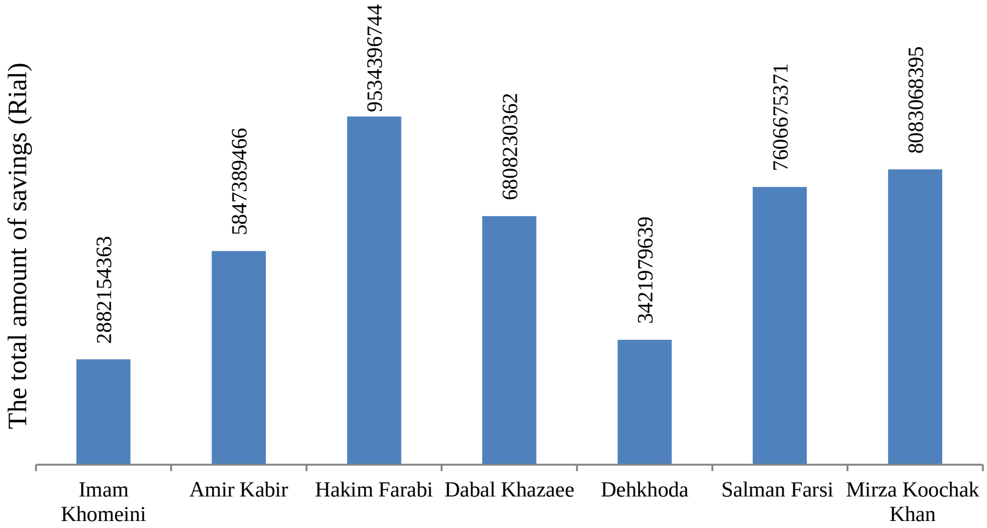

Fig.4. Comparison of the total amount of Rial savings in seven sugarcane developmental companies during 2014-2016

According to Figure 5, the cost-benefit ratio for using offline hydraulic oil filtration in six companies of Imam Khomeini, Amir Kabir, Hakim Farabi, Dabal Khazaee, Salman Farsi and Mirza Koochak Khan companies has been increased from 4.66, 8.5, 13.16, 10.49, 9.33 and 7.33 during 2014 to 6.27, 15.62, 27.71, 17.61, 22.19 and 30.94 in 2016, respectively and Dehkhoda Company experienced a decline of cost benefit ratio from 6.83 in 2014 to 6.62 in 2016. This could be attributed to the lower operational capacity of the company relative to oil consumption and Figure 5 shows a comparison of cost benefit analysis using offline hydraulic oil filtration in sugarcane developmental companies during 2014-2016. As evident in this figure**,** the highest and lowest benefit-cost ratios were observed in Hakim Farabi and Imam Khomeini Companies (2014), Hakim Farabi and Imam Khomeini (2015) and Mirza Koochak Khan and Imam Khomeini (2016), respectively. Finally, the lowest benefit-cost ratio during the crop years 2014-2016 was related to the Imam Khomeini sugarcane developmental company with a profit/cost ratio of 4.66, 5.74 and 6.27.

According to Figure 6, the break-even point (ha) for using offline hydraulic oil filtration in seven companies of Imam Khomeini, Amir Kabir, Hakim Farabi, Dabal Khazaee, Dehkhoda, Salman Farsi and Mirza Koochak Khan companies has been decreased from 2151.15, 1046.84, 647.08, 781.45, 1529.77, 894.92 and 1249.08 during 2014 to 1742.02, 857.98, 485.21, 439.48, 1246.44, 713.83 and 447 in 2016, respectively. Figure 6 shows a comparison of break-even point (ha) analysis using offline hydraulic oil filtration in sugarcane developmental companies during 2014-2016. The highest and lowest break-even point (ha) were observed in Imam Khomein and Hakim Farabi Companies (2014), Imam Khomein and Mirza Koochak Khan (2015), and Imam Khomein and Mirza Koochak Khan

(2016), respectively. Finally, the highest break-even point (ha) during the crop years 2014-2016 was related to the Imam Khomeini sugarcane developmental company with a break-even point (ha) of 2151.15, 2154.13 and 1742.02.

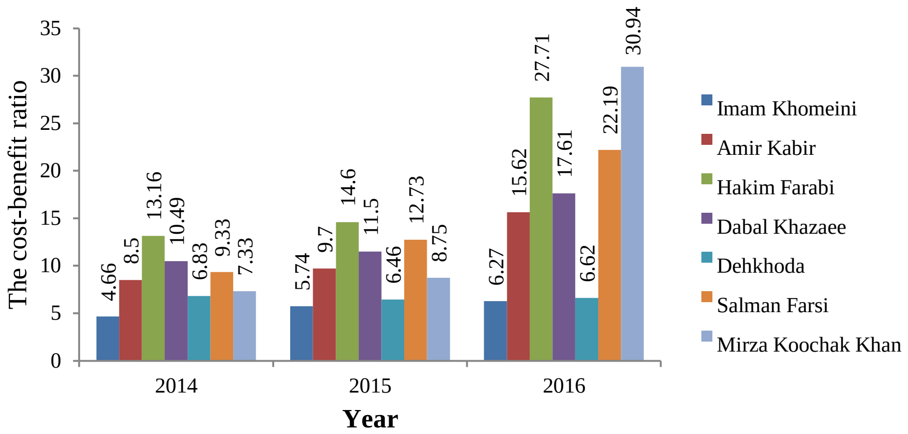

Fig.5. The comparison of cost-benefit ratio based on the using offline hydraulic oil filtration in sugarcane developmental companies

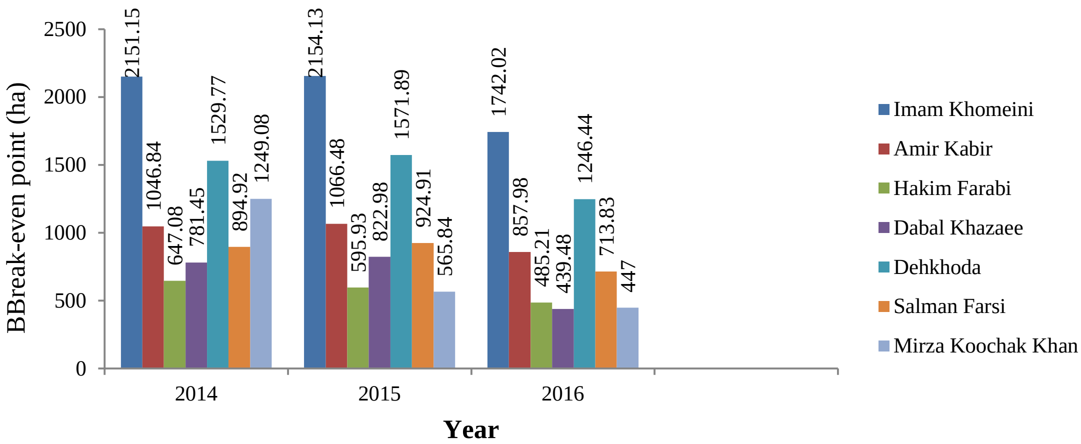

Fig.6. The comparison of break-even point (ha) based on the using offline hydraulic oil filtration in sugarcane developmental companies

Consistent with this study results, Masoudi (2001) stated that the maintenance group of locomotive condition of Iran railways had reported 123 cases of oil change in the first ten months of 2000 which were due to diagnosing unfavorable condition like water contamination, excessive increase or decrease of viscosity and unusual increase of rusting elements. Hence, the damages to 67 cylinders, 58 pistons, 281 rings and 40 sets of bearings have been prevented which can result in saving more than 309,000 dollars. Also, by increasing the oil function from 65000 km to 96000 km and preventing the unnecessary oil change, this unit has been able to save 734,000,000 rials in oil consumption. Furthermore, Masoudi (2001) stated that during the implementation of a BaseLine aiming to determine rusting effect of erosive particles for a steam turbine of Arak petrochemical complex with a volume of 18000 liters, the unusual amount (17 ppm) of Silica element was identified. The amount of Tin and Aluminum was risen simultaneously which implies an uncommon erosion of the device. The following graph returns back to a normal situation after eliminating the contamination, and the device continues to function normally. Thus, identifying and controlling the amplifier erosion elements of an expensive petrochemical and power plant equipment, by means of the maintenance condition of the machines lead to enormous economic savings. It should be mentioned that the financial loss due to the unplanned stoppage of the mentioned turbine was 200 million rials per hour and its major maintenance is estimated hundreds of thousands of dollars.

Conclusions and suggestions

Since the contamination caused by hydraulic fluids spilling exerts its deleterious effects in the long term, this factor is often ignored or consecutive breakdowns and system failures caused by it are attributed to other factors. The studies have shown that at least 75 percent of all hydraulic systems fail due to contaminated or aging hydraulic fluid and neglecting the issue. Therefore, in order to prevent the likelihood of problems occurring, the following strategies should be applied: replacing all of the hydraulic fluids from the discharge system with the new oil and use of offline hydraulic oil filtration system for removal of contaminated oil particles. The application of the offline filtration method has the following advantages over the replacement method: 1) Avoiding any future damage to the machine that directly affects the expense reduction. 2) Recycling and reusing a large amount of oil, which has a tremendous economic importance. As a result, the offline oil filtration system plays a fundamental role in the smooth and continuous operation of hydraulic systems. The results of this study on the improvement of maintenance and repair operations in sugarcane harvest machines based on the offline hydraulic oil filtration method have been summarized as follows:

1- In terms of reduced oil consumption, Mirza Koochak Khan Company was in a sufficiently favorable condition compared to other studied companies (Imam Khomeini, Amir Kabir, Hakim Farabi, Dabal Khazaee, Dehkhoda and Salman Farsi).

2- Dabal Khazaee Company, with a total average fixed costs and total variable costs of (762279) (Rials per hectare) in the hydraulic oil replacement during 2011-2013 and having 488948 (Rials per hectare) in the hydraulic oil filtration during 2014-2016, showed the highest total average fixed costs and total variable costs among the seven sugarcane developmental companies.

3- Imam Khomeini company, with a total average fixed costs and total variable costs of 216903 (Rials per hectare) in the hydraulic oil replacement during 2011-2013 and having 130272 (Rials per hectare) in the hydraulic oil filtration during 2014-2016, achieved the lowest total average fixed costs and total variable costs among the seven sugarcane developmental companies.

4- The total amount of savings built up using offline hydraulic oil filtration in the sugarcane developmental companies was 411014 liters and 44183894339 Rials.

5- The total amount of savings built up in Hakim Farabi Company was 9534396744 Rials. Meanwhile, the total amount of saving in oil consumption was 82000 liters, indicating higher amount of savings compared with other companies.

6- The lowest benefit-cost ratio during the crop years of 2014-2016 was related to the Imam Khomeini sugarcane developmental company with a profit/cost ratio of 4.66, 5.74 and 6.27.

7- The highest break-even point (ha) during the crop years of 2014-2016 was related to the Imam Khomeini sugarcane developmental company with a break-even point (ha) of 2151.15, 2154.13 and 1742.02.

8- The further analysis has shown that the hydraulic oil filtration operation prevented the early replacement of hydraulic oil and thus reduced the costs.

According to the results of this study and the sources studied, the following suggestions have some important implications for improving performance and increasing the efficiency of operating systems:

1- The successful implementation of this project dependens upon the regular sampling and trained personnel. Therefore, the managers need to pay close attention to offering appropriate trainings and considering the proper application of the principles of oil analysis and offline filtration.

2- Since the purpose of this study was to investigate the general impacts of offline hydraulic oil filtration on the performance of sugarcane harvesting machines, the researcher made a decision to use the past oil consumption statistics and data for analyzing data. Considerably more work is needed to be done to determine the effects of these parameters on the oil consumption by separating existing data and even measuring new data in the form of research projects.

3- These findings suggest several courses of action for similar studies investments on offline oil filtration operation in sugarcane machines (such as the proposal presented in the previous paragraph), and an in-depth examination of the technical, environmental and managerial factors and, finally, the development of a comprehensive local or national standard and criteria for the operators of the technique.

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مقاله علمی- پژوهشی

ارزیابی اقتصادی روش‌های تعویض و تصفیه روغن هیدرولیک دروگرهای نیشکر در کشت و صنعت‌های نیشکری خوزستان

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چکیده

از آنجا که آلودگی روغن هیدرولیک اثرات زیان‌بار خود را در درازمدت نمایان می‌سازد اغلب مورد بی‌توجهی قرار می‌گیرد یا آن‌که علت توقفات پی در پی و خرابی سیستم به عوامل دیگری نسبت داده می‌شود. بنابراین برای جلوگیری از به‌وجود آمدن چنین مشکلاتی دو استراتژی زیر ارائه شده است: با روش تعویض تمامی روغن از سیستم تخلیه و روغن نو جایگزین گردد یا با روش پالایش آفلاین روغن هیدرولیک ذرات از روغن آلوده جدا گردد. در همین راستا، مطالعه حاضر با هدف بررسی وضعیت اقتصادی ماشین‌های برداشت نیشکر با تأکید بر فرآیند فیلتراسیون روغن هیدرولیک در هفت واحد از شرکت‌های توسعه نیشکر و صنایع جانبی استان خوزستان انجام شد. به این منظور، تمام آمار و اطلاعات مربوط به هفت واحد از شرکت‌های توسعه نیشکر و صنایع جانبی در طول سال‌های زراعی ۱۳۹۵-۱۳۹۰ جمع‌آوری و طبقه‌بندی شدند. نتایج نشان می‌دهد صرفه‌جویی انجام شده بر حسب لیتر و همچنین صرفه‌جویی ریالی به‌کارگیری روش پالایش آفلاین روغن هیدرولیک برای کشت و صنعت‌های نیشکر در طی سه سال زراعی ۱۳۹۵-۱۳۹۳ که از این روش استفاده گردیده، به‌ترتیب برای واحد امام خمینی: ۲۵۵۰۰ لیتر و ۲۸۸۲۱۵۴۳۶۳ ریال، امیرکبیر: ۴۹۰۰۰ لیتر و ۵۸۴۷۳۸۹۴۶۶ ریال، حکیم فارابی: ۸۲۰۰۰ لیتر و ۹۵۳۴۳۹۶۷۴۴ ریال، دعبل خزاعی: ۷۳۴۰۰ لیتر و ۶۸۰۸۲۳۰۳۶۲ ریال، دهخدا: ۳۱۶۸۰ لیتر و ۳۴۲۱۹۷۹۶۳۹ ریال، سلمان فارسی: ۷۳۵۰۰ لیتر و ۷۶۰۶۶۷۵۳۷۰ ریال و میرزا کوچک خان: ۷۵۹۳۴ لیتر و ۸۰۸۳۰۶۸۳۹۵ ریال می‌باشد.

واژه‌های کلیدی: ارزیابی اقتصادی، تصفیه، تعویض، دروگر نیشکر، روغن هیدرولیک

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