Feasibility of Reused Palm oil Blends as a Dielectric Medium for Electric Discharge Machine

M. Dastagiri, P. Srinivasa Rao, P. Madar Valli

Abstract: ***Electric Discharge Machining (EDM) is the most widely used process of unconventional machining for making work pieces with intricate shapes and reconditioning of Dies. EDM can cut any work piece having good electrical conductivity. The EDM machining is obtained through a series of electric sparks, the shaped tool and work piece will not have any physical contact. The sparks are facilitated by dielectric oil through a pulsed generation circuit. The commonly used commercial EDM oils are Kerosene, Paraffin, Transformer oil and these are derived from petroleum oil, whose reserves are extinct briskly. During the process of EDM, operation Pyrolysis happen and a thin layer of carbon suit is found on the work piece outer surface. In this present work, an attempt is made to identify Eco-friendly green Dielectric media using used Palmolive oil and investigations are made with the shaped copper tool as a tool electrode and EN31 steel as a work electrode. A Design of Experiments (DOE) is adopted and experiments are conducted with Applied current (I) pulse on time (Ton) and Pulse off time (TOFF) as input variables and electrode wear rate (EWR), Material removal rate (MRR), Tool wear rate (TWR) and Surface Roughness (SR). The Machining is done on EDM with Commercial EDM oil and with used Palmolive oil and blends of palm oil and EDM oil is performed and findings are given.***

Keywords: ***EDM, Material Removal Rate (MRR), Tool Wear Rate (TWR), Surface Roughness (SR).***

I. INTRODUCTION

Current manufacturing of critical designs with complicated materials with high surface finishing is becoming difficult, EDM is one of the manufacturing processes to solve the above requirements. In the EDM process, dielectric fluid is the important parameter which controls and stabilizes the generated electric pulses to eradicate the work material. Normally used dielectric fluids are generated by fossil fuels and these reserves are extinct very briskly, the use of reused palm oil blends is one of the solutions to this problem. Hence the present research work is concentrating on the use of reused palm oil and blends of reused palm oil with commercial EDM as alternate for dielectric fluid.

Since the 1990s, the vegetable oils are normally used in place of dielectrics in Distribution transformers, as its chemical, electrical and physical properties fulfill the required standard [1]. Al-Eshaikh et al. studied Corn's oil electrical property and its feasibility as a dielectric fluid. The corn's oil dielectric strength is greater than the mineral oil and It is examined that the moisture content is not affected the breakdown strength of Corn oil, due to more than 70% unsaturated fatty acids present in it [2]. A Raymon et al studied the effect of adding antioxidants with vegetable oils like Corn oil, Sunflower oil, Soya bean oils and Rice Bran oil correspondingly. This superior viscosity of oils is reduced by mixing of antioxidants with different quantities. Rice bran oil's viscosity is reduced to only a small amount after the addition of the antioxidants. The viscosity of Soya bean oil is decreased significantly except 5g of butylated Hydroxyl and 5g of acidic acids [3]. Kailas M. Talkit et.al. examined the viscosity of Coconut, Sesame, Sunflower, and Soyabean oil by using Redwood Viscometer. Soyabean oil is added with various proportions of sunflower, coconut oil, and sesame oil and measured its viscosity also. Up to 30°C of operating temperature viscosity of vegetable oils is very high. The viscosity of vegetable oils drastically reduced after 80°C. By adding 90% Soya bean with 10% coconut oil showed a superior viscosity than all other combinations of oil mixing [4]. Hosier et al. deliberated oil viscosity by using physical Reolab MCL at room temperature with and without catalysts. The viscosity of Sunflower oil is considerably raised for all sampling duration, and after ageing olive oil's viscosity, it is not changed significantly. By adding catalyst, Rapeseed oil and Corn oil's viscosity, is slightly increased, copper wire was used as a catalyst [5]. H.M.Wilhelm et.al. did an accelerated thermal ageing test under Oxygen flow rate in a thermo-stabilized bath. Refined vegetable oils viscosities are deliberated with and without adding antioxidants. Viscosity of sunflower is greater than Soya oil and Rice oil variant at 100°C. Whereas Rice bran oil viscosity was observed very low at the same temperature. Refined Rice bran oil, Soya oils took 2hrs to reach the critical viscosity before adding antioxidants, where as Rice oil took 10 hrs of ageing [6]. Dastagiri. M et al. studied the four info process parameters picked as a part of this strategy is Inter-Electrode Gap (IEG), IP, Ton, and Discharge voltage (v). These parameters will be analyzed at three distinct dimensions. By considering MRR, SR, and TWR as yield and estimated for each trail run. Concentrating on demonstrating MRR is increasing, SR as lower and parallel to lesser TWR of the terminal. Hence, the Heuristic strategy along these lines has been received to conjecture the outcomes referenced [7].

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II. EXPERIMENTATION

A. Equipment Used

Electronica made sinker type EDM is chosen to do the present work is presented in Fig 1.

Fig. 1. Electronica made sinker EDM machine.

The electrode used for this experimentation is pure copper with 10 mm diameter and work component is EN 31 of 70*70*10 mm size is chosen, as shown in Fig. 2 and the work part mechanical properties are stated in Table 1.

Fig. 2. EN 31 work component used with Palm oil 70-30 blend.

Table. 1 Mechanical properties of EN31- work material

Properties	Value
Density	7.8 Kg/m^3
Elongation	0.3
Hardness	63 HRC
Modulus of elasticity	215 GPa
Reduction of Area	0.45
Tensile Strength	750 MPa
Yield Stress	450 MPa

B. Selection of Machine Parameters

In normal industrial application the process parameters for EDM are applied current (I), Pulse on time (T_{on}) and pulse off time (T_{off}) were selected for this experimentation as input parameters, for finding out the Electrode Wear Rate (EWR), Material Removal Rate (MRR), Surface Roughness (SR) and Tool Wear Rate (TWR) as output parameters, with three factors, Four levels are picked through orthogonal array (OA) of L16 [7, 9, 11] experimentation from Minitab 16. Electronic weighing machine with 0.001 mg. minimum weighing calibrated tool is used to measure loss of Material Removal and Tool Wear are used to calculate MRR, TWR. Surface roughness is measured by Talysurf roughness tester in microns. The dielectric fluid used as reused Palm oil and this oil is collected from local fried chicken makers. The blends prepared by palm oil, is mixed with commercial EDM of ranging as P90-10, P80-20, P70-30, P60-40, P50-50, P40-60, P30-70, P20-80, P10-90 in liters. The duration for each experimental trial run is 10 min.

C. Experimentation and Discussion

As shown in Fig. 2 the work part, and copper tool are weighed before every trail run and is fixed to the EDM. The difference in the weight for every trial run is calibrated and the values are noted down. Fig. 3 shows the MRR values of every trail run of all reused palm oil blends. The MRR graph shows blends of P30-70, 20-80 and 10-90 values, lay on the EDM oil values and at trial run 12, 16, 16 the MRR values are greater than the EDM oil. The remaining blends P90-10, P80-20, P70-30, P60-40, P50-50, P40-60's MRR values are less than the EDM oil trail runs.

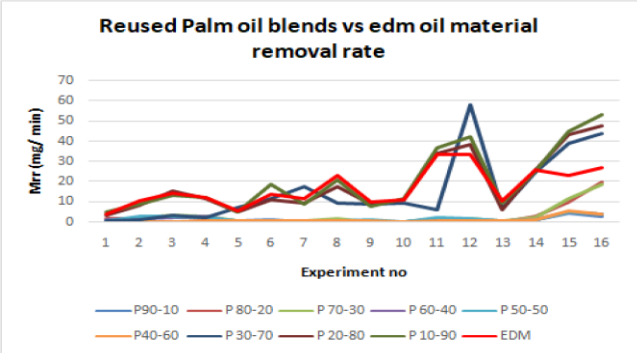

Fig. 3. Graph for MRR reused palm oil blends Vs EDM oil

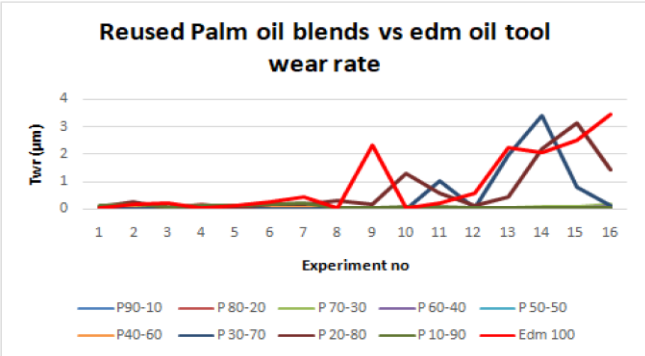

Fig. 4. Graph for TWR reused palm oil blends Vs EDM oil

TWR graph as shown in Fig. 4. all the reused palm oil blends values are lesser than the EDM oil values i.e. the tool wear rate is lesser in all the blends of reused palm oil values, therefore the advantages obtained are tool redressing time and cost come down, setup time and machining time reduces and yields per good productivity. However at 14th and 15th trail run P30-70, P20-80 performed more TWR than EDM oil is obtained.

From EWR graph Fig. 5 the blend 40-60 values are at 12th trail run, P40-60 reacted at a greater rate than EDM oil. EWR is the material removal of work piece to tool material removal, so EWR values will slightly higher than the EDM oil values these increased values will be at few trails runs only not the entire experimentation of individual blends.

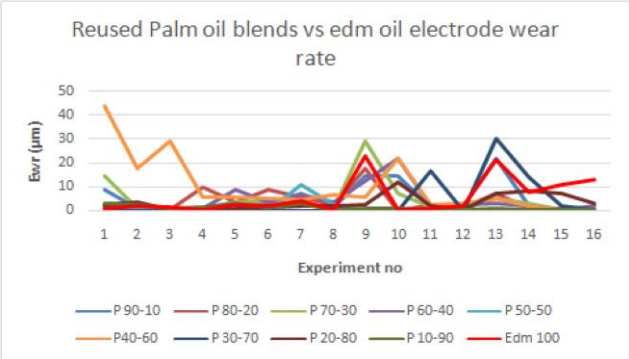

Fig. 5. Graph for EWR reused palm oil blends Vs EDM oil

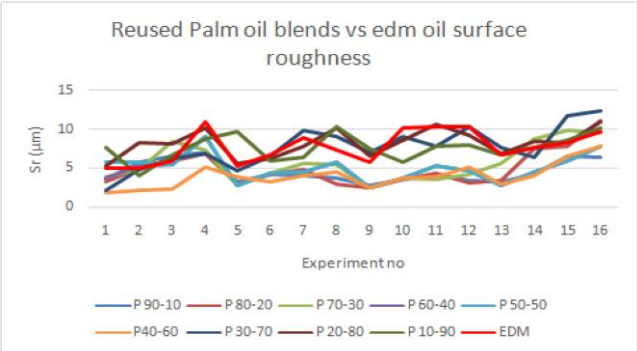

Fig. 6. Graph for SR reused palm oil blends Vs EDM oil

From Fig. 6. The SR value is for blend P70-30, trail runs at 3, 15, 16 for blend P30-70, trail runs at 7, 8, 9, 15, 16 for blend P20-80, trail runs at 2, 3, 8, 9, 11, 16 for blend P10-90, trail runs at 1, 5, 8 the SR values are greater than the EDM oil trial run values. All the blends, SR values were found lesser than the EDM oil. All the reused palm oil blends generated the greater surface roughness (finishing) than the EDM oil.

III. RESULTS AND DISCUSSIONS

EDM oil samples of SEM images are shown in Fig. 7, 8, 10 with different magnification ranges. Fig. 12 shows that the more amounts of craters, debris and recast layers were observed on the surface after spark erosion completion. With trail run 1 at I is 9A, T_{on} and T_{off} is 100 µs.

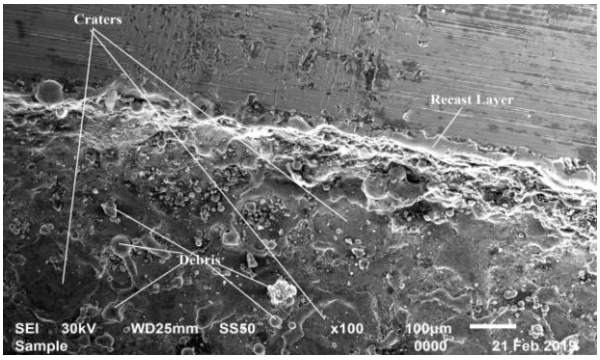

Fig. 7. SEM image X100 magnification of EDM oil

Fig. 8 and 9 shows that lumps amount of metal deposits, spherical globules, recast layer, porous region, deep craters were observed after machining the erode materials deposition is occurred on the work surface due to improper washing of dielectric fluid. Carbon soot presence is also observed, this is due to the mineral oil which is generated from hydro carbon based paraffin crude oils loosen its carbon atoms during erosion process at high liquefy temperature and this carbon particles will enter in to the liquefied work material which change, the work component properties and the liquefied work material therefore pollute the dielectric fluid. The International Agency for Research on Cancer (IARC) stated that, petroleum based cutting fluids which possess heterocyclic and polyaromatic rings are carcinogenic, and contact with it may result in deadly diseases like cancer [7]. Serious health issues like cancer, respiratory problems and genetic diseases are the outcomes of toxic and less biodegradable cutting fluids when they come to physical contact [8].

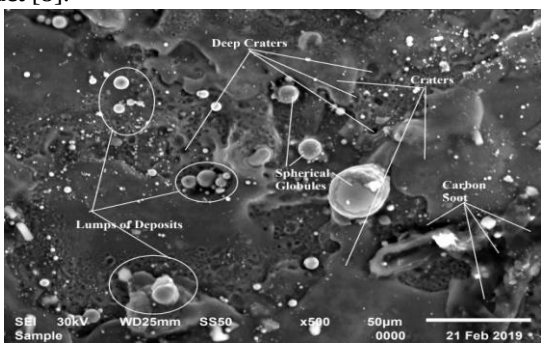

Fig. 8. EDM oil SEM images at X500 magnification.

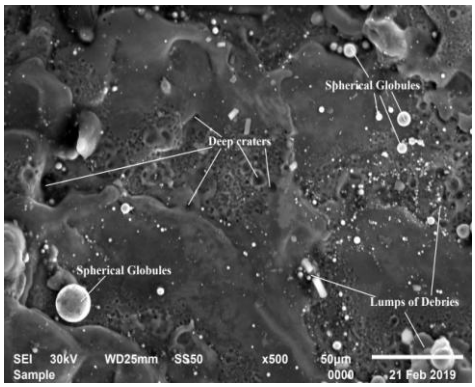

Figure.9. EDM oil SEM image at X500 magnification.

Fig. 10, 11 and 12 shows the SEM images of P90-10 oil blend work sample. At trail run 1 where I is 9A, T_{on} and T_{off} is 100 µs. These images show the metal deposition, crater formation, recast layers, spherical globules, porous region and micro cracks on work surface [12-14]. From Fig.6. the SR values of the P90-10 are better than the EDM work material, the SEM images of P90-10 are showing the better surface topography than the EDM work images.

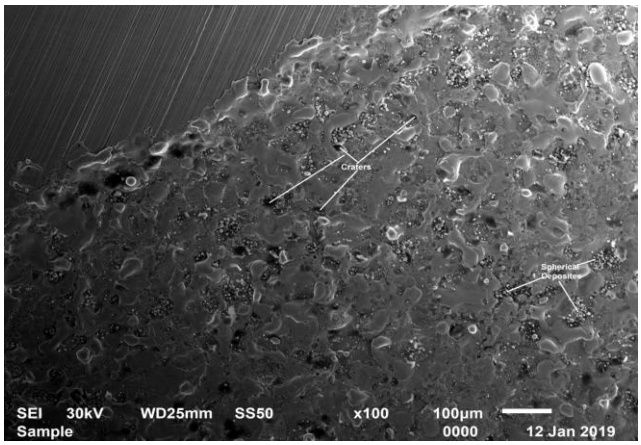

Fig. 10. P90-10 reused palm oil blend SEM image at X100 magnification.

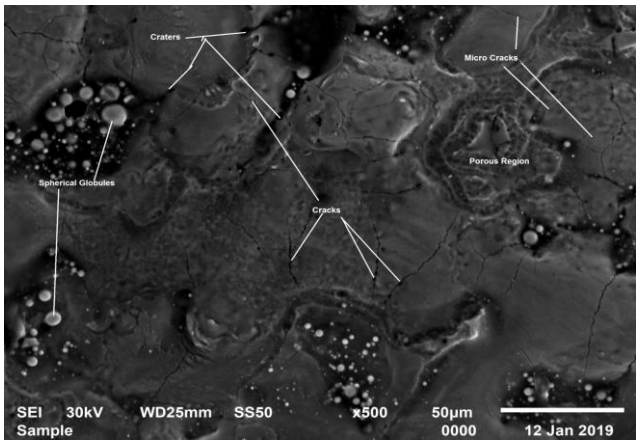

Fig. 11. P90-10 reused palm oil blend SEM image at X500 magnification.

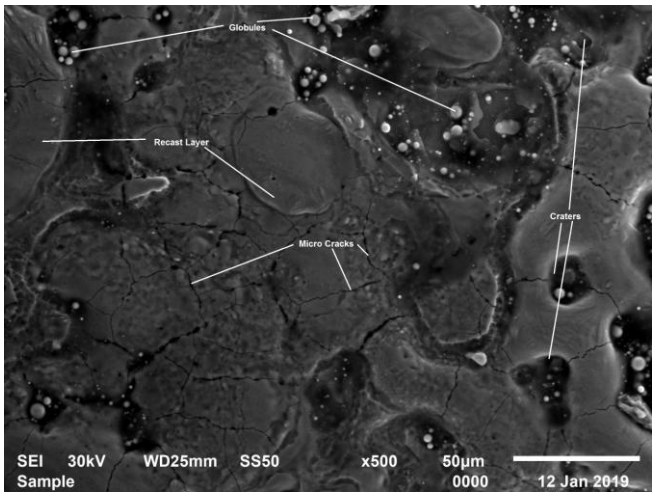

Fig. 12. P90-10 reused palm oil blend SEM image at X500 magnification.

SEM images of Fig. 13 - 15 shows the blend of P50-50 surface topography. From Fig.13-15 craters, porous region; recast layer, metal globules, and molten metal deposition were observed from the SEM images and the experimental trail run is conducted at I is 9A, T_{on} is 100µs and T_{off} is 100 µs.

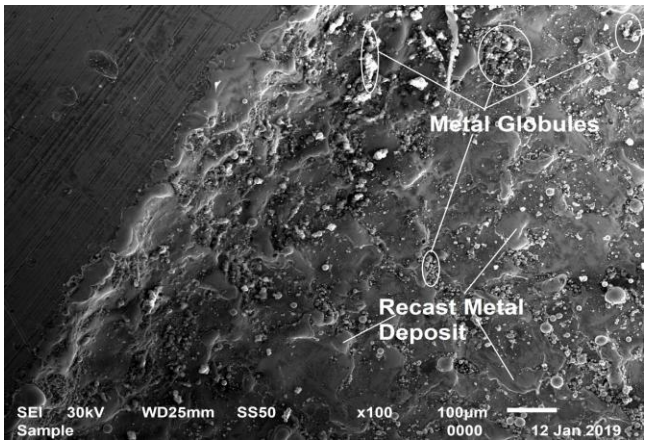

Fig. 13. P50-50 reused palm oil blend SEM image at X100 magnification.

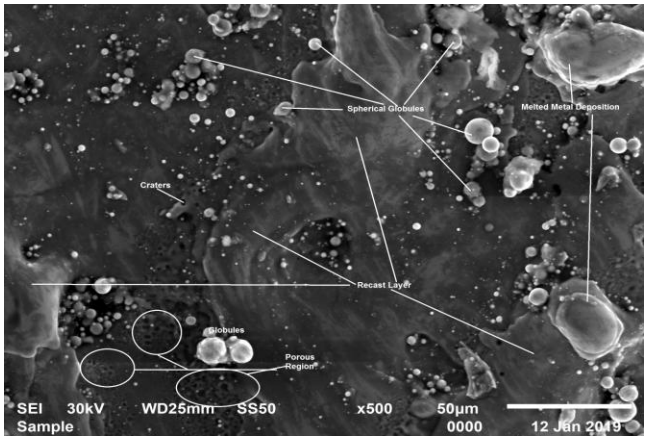

Fig. 14. P50-50 reused palm oil blend SEM image at X500 magnification.

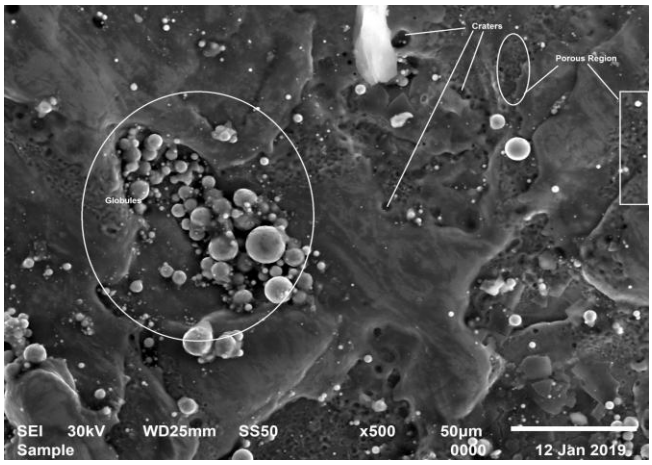

Fig. 15. P50-50 reused palm oil blend SEM image at X500 magnification.

SEM images of Fig. 16, 17 and 18 shows the blends of P30-70 surface topography represents the spherical globules, deposits, debris, recast layer and porous region. Where at 5th trail run was conducted at I is 12A, T_{on} is 100 µs and T_{off} is 200 µs.

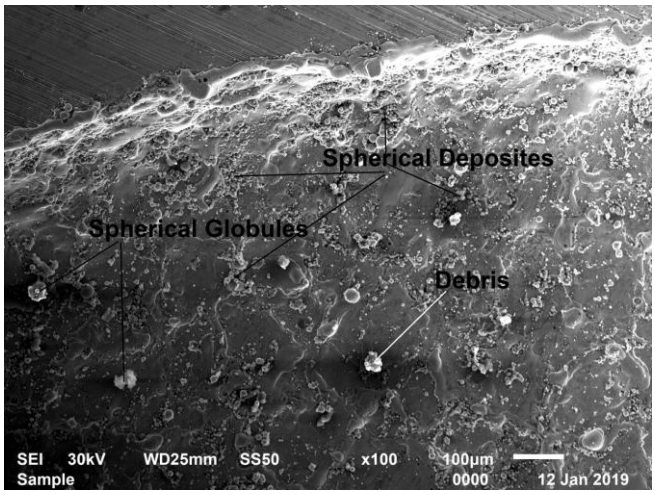

Fig. 16. P30-70 reused palm oil blend SEM image at X100 magnification.

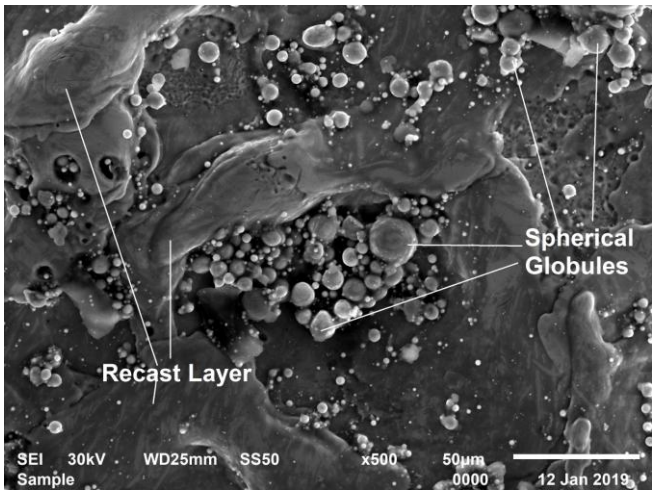

Fig. 17. P30-70 reused palm oil blend SEM image at X500 magnification.

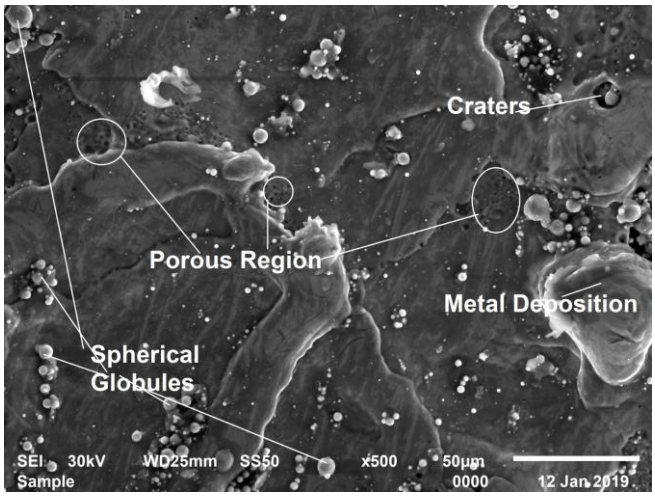

Fig.18. P30-70 reused palm oil blend SEM image at X500 magnification.

IV. CONCLUSION

In the present work reused (recycled) palm oil and its blends were successfully tested for suitability as dielectric oil by EDM process with copper is tool electrode and EN31 as work electrode. The experimental investigations found are as follows:

- Tool wear rate trends, Electrode Wear trends are similar, hence reused palm oil can be implemented for production work.
- The carbon suit generated with used reused palm oil is negligible. Hence work piece is not affected. This is evident from SEM images of work piece topology presented.
- The reused palm oil surface roughness of work piece is similar to that of surface roughness obtained by commercial EDM oil.
- The Palmolive oil is bio-degradable and very fewer fumes are observed during operation when compared to the operation of EDM with commercial grade oil, so it is human friendly as it is harmless.
- The cost of reused Palmolive oil is very much cheaper than commercial EDM oil.

Hence from these, it is concluded that used Palmolive oil can be alternative to commercial EDM oil.

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