Full Paper

Propellants, Explosives, Pyrotechnics

DOI: 10.1002/prep.202100011

Utilization of Waste Lubricant Oil in Fuel Phase of ANFO Explosives: Its Field Applications and Environmental Impact

Firoj Ali,*[a] Murari Prasad Roy,[a] Braj Mohan Pat Pingua,[a] Rajatendu Mukherjee,[b] Lalit Agarwal,[b] and Pradeep Kumar Singh[a]

Abstract: Disposal of used lubricant oil in an ecosystem is a serious environmental threat. In this context, recycling waste lubricant oil into a valuable product has an immense commercial and environmental significance and is a challenging area of research. In this article, we have demonstrated the use of waste lubricant oil as a partial replacement of diesel oil of ammonium nitrate fuel oil (ANFO) explosives. Moreover, the effect on detonation properties and rock fragmentation patterns by the use of lubricant oil based ANFO in blasting operation has also been studied. The field trial experiments were carried out with lubricant oil based ANFO explosive to demonstrate the real applicability of the prepared explosive composition at Nimbeti Limestone open-pit mine of Shree Cement Limited, India. These explosive compositions revealed effective detonation performance. Importantly, air quality was analyzed during blasting operations to indicate that the emitted toxic fumes such as CO, NO_x, and fine dust particles ($PM_{2.5}$ & PM_{10}) were found within the permissible limit at the mining area by the use of lubricant oil based explosives. Further, rock fragmentation analysis indicated that ANFO explosive compositions with 20 %, 30 %, and 40 % (w/w) lubricant oil in diesel oil revealed good rock fragmentation as compared with normal ANFO in the conducted experimental blast.

Keywords: Recycling · Waste Oil · ANFO · Alternative Fuel · Field applications · Rock Fragmentation · Air quality monitoring

1 Introduction

Used Lubricant Oil is considered as hazardous waste associated with environmental pollution [1]. It essentially consists of mono and polyaromatic compounds, hydrocarbons, toxic heavy metals, and additives. Some of these ingredients are well known carcinogens in nature [2–3]. The spilled Lubricant oil into the environment in form of oil mist and micro drops are reported to pose a considerable risk to the environment and it is known to cause extensive damage to the environment by contaminating soil, water, and air [1, 4]. Literature reports further confirm that a layer of oil on a water surface effectively inhibits oxygen from entering and blocks sunlight, which affects the life cycle of an aqueous system [4–5]. The disposal of Lubricant oil is an environmental burden and its eco-friendly disposal is a matter of concern. Therefore, there is a basic need for proper utilization of this, into a useful product. Recycling the used lubricant oil was accomplished by various techniques such as re-refining, reprocessing, and reclamation [6–11].

Blasting is an essential prerequisite for the mineral extraction process, which in turn requires extensive use of commercial explosives. As per the report, the global industrial explosives market was valued at $7.1 billion in 2019 and is expected to reach $10.9 billion by 2027 with growing at a compound annual growth rate (CAGR) of 5.5 % from 2020 to 2027 [12]. Globally, ammonium nitrate fuel oil (ANFO) explosive contributed more than half of the industrial market share owing to its stability, ease of handling, cost-efficiency. The metal mining sector in India requires a significant share of ammonium nitrate fuel oil (ANFO) as an explosive to remove a large amount of overburden materials and metallic ore including top surface soil and debris. Diesel oil, which is a commonly used fuel phase for ANFO, consists of 5.7 % by weight in the mixture but affects the overall cost of the ANFO explosive considerably.

Therefore, exploring an alternative fuel phase has been an emerging area of research and has substantial significance for mining and allied industry. Efforts have been made in the last few decades for the various alternative fuel phase of ANFO such as coal dust, confectioners' sugar, aluminum powder, TNT, sugar cane bagasse, rice straw, corn cob, tires residue, and biodiesel by a various research group [13–18]. Apart from Bio-diesel, the other alternative fuels showed poor detonation properties compare to ANFO [15]. Importantly, effective consumption of hazardous materials like waste lubricant oil in form of a useful explosive product is highly desirable from the commercial and environmental

[a] F. Ali, M. P. Roy, B. M. P. Pingua, P. K. Singh
Rock Excavation Engineering Division
CSIR-Central institute of Mining and Fuel Research
Barwa road, Dhanbad, Jharkhand, India
*e-mail: firojali@cimfr.nic.in
[b] R. Mukherjee, L. Agarwal
Smartchem Technologies Limited, Pune 411 036, India

Supporting information for this article is available on the WWW under https://doi.org/10.1002/prep.202100011

point of view. Only a few examples were reported where used lubricant oil was recycled in manufacturing commercial explosives [19,20]. These works described the safety operation conditions of lubricant oil in explosives at low temperatures. However, the effect of lubricant oil in the fuel phase on detonation properties of ANFO, blast performance, and its environmental impact analysis was rare in contemporary literature. To the best of our knowledge, in India effective use of lubricant oil in ANFO is rare in the Explosive industry. Considering the scope of such an alternative fuel phase, we herein demonstrate the use of waste lubricant oil as a partial replacement of diesel (D/O) of ANFO explosives. These compositions showed effective blasting performance. Importantly, an air quality monitoring study revealed that the emitted toxic fumes such as CO, NO_x, and fine dust particles ($PM_{2.5}$, PM_{10}) were in allowed limit in the close vicinity of the mining site by the use of lubricant oil based explosive compositions.

2 Experimental Section

2.1 Materials & Methods

Ammonium Nitrate (AN) prill (Optimex) was obtained from Smartchem Technology Pvt. Limited, Pune. The bulk density of the used AN prill was (0.75–0.85) $g\,cm^{-3}$. The average particle size of the prilled AN was 2.36 mm. Waste Lubricant oil was also obtained from various mines for the studies. All commercial chemicals were procured from a local supplier used as received without further purification unless stated otherwise. The velocity of detonation (VOD) was measured using the dautriche method (IS Code 6609) unconfined condition and MicroTrapVoD/Data Recorder, an instrument by MREL was used for VOD measurement in hole/unconfined condition. Fragmentation analysis was done by image analysis method using Wipfrag software. The flashpoint of the diesel and mixture of fuel phase was measured by using Abels Flash point apparatus. The viscosity of the mixed fuel phases was measured with the help of Brookfield Viscometer (DV-II).

2.1.1 Continuous Velocity of Detonation Method

The velocty of detonation (VOD) measurement of explosive was carried out by insertion of a VOD probe cable having a resistance of 10.8 $ohm\,m^{-1}$. The explosive in the form of cartridges of different sizes is charged in the blast holes. VOD probe is laid along the whole length of the blast hole. After that, it was connected with a coaxial cable up to a remote point. It was finally connected with MicroTrapVoD/Data Recorder at a safe distance from the blasting site. The VOD probe is fused in the bottom of the blast hole. After detonation, explosive burns, this results into the burning of the VOD probe. The rate of burning of the probe is recorded in the monitors in the form of voltage drop. This voltage is finally converted into length using the known resistance of the wire. The length versus time plot is analysed, which slope gives detonation velocity of the explosive (VOD).

2.1.2 Method for Fragmentation Assessment

Digital image processing technique using Wipfrag software was used for the Rock fragmentation analysis. Numbers of the image were captured of the muck pile, scaling the image, and further analysis using the software. The output of the analyses is in the form of a number of exposed fragmented blocks, maximum, minimum, and mean size of the fragmented blocks, sieve analysis as per the requirement *i.e.* at different percentile sizes viz. D_{10}, D_{25}, D_{50}, D_{75} & D_{90}. This software is based on the principal of the Kuz-Ram Model.

2.1.3 Method of Air Quality Monitoring

The air quality monitoring for particulate matters and gaseous pollutants were done at the mines site. $PM_{2.5}$ and PM_{10} were monitored through wet chemistry using a High volume sampler instrument with an average flow rate of 1.1 $m^3\,min^{-1}$ for 24 hours [21]. To determine the SO_2 concentration in ambient air sample was collected by drawing air at a flow rate of 1.0 $L\,min^{-1}$ through an absorbing solution of 0.04 M potassium tetra chloromercurate (K_2HgCl_4). The prepared complex was further allowed to react with 0.6% sulphamic acid, pararosaniline, and formaldehyde (0.2%) to develop an intense colour complex. The absorption of the developed complex was determined using a UV-Vis spectrophotometer. For NO_2, samples were collected by similar air flow rate through a mixture of 0.4% Sodium hydroxide (NaOH) and 0.1% Sodium arsenite ($NaAsO^{2-}$). The concentration of NO_2^- ion produced was measured calorimetrically using a UV-Vis spectrophotometer.

2.2 Field Investigations

Our preliminary laboratory results encourage us to conduct field trials in actual mining conditions to assess the practical use of the prepared explosive compositions at Nimbeti Limestone mine of Shree Cement Limited, Rajasthan, India. The site falls in Geological Survey of India toposheet No. 45 J/2, J/7, and 45 J/8. The geographical location of the project is 26°15′37″ to 26°16′34″ N and 74°10′59″ to 74°11′26″ E. The local and regional geology in this mining area is a rock of Ajabgarh group of Delhi Supergroup consist of rock Limestone, Calc and Micha Schist, Calc Gneisses, and Pegmatite. The strike direction of Limestone beds in the area is N25°E S25°W. The beds are dipping in the SE direction. Dip amount varies from 280 to as high as 860.

The reversal of dip is seen in the western part of the area, where a local synform is formed. The plant and mine view of Nimbeti Limestone are shown in Figure 1 (A&B).

2.3 Preparation of Explosive Compositions

The diesel oil (D/O) and Lubricant oil (L/O) were mixed in a variable percentage ratio such as 80:20 (i.e 20% Lubricant oil in D/O), 70:30 (i.e 30% Lubricant oil in D/O), 60:40 (i.e 40% Lubricant oil in D/O), 50:50 (i.e 50% Lubricant oil in D/O) and 40:60 (i.e 60% Lubricant oil in D/O).

These mixed fuel phases were used to prepare ammonium nitrate fuel phase explosives for all the studies. For each composition, 94% (wt%) ammonium nitrate was used, and 6% (wt%) of mixed fuel phase (i.e various proportions of Lubricant oil in D/O) was used to make the various explosives compositions and used for all studies unless stated otherwise.

3 Results and Discussion

Lubricant oil (L/O) was obtained from mine machines as a waste. It was blackish in color and viscous in nature. The density was calculated and found to be in the range of 0.84 $g\,cm^{-3}$ to 0.92 $g\,cm^{-3}$. Owing to the suspended solids present in the oil and its viscous nature, it was filtered prior to calculate the physical properties of the mixed fuel phases such as density, porosity, and oil absorption & retention were depicted in Figure 2.

Calculated densities of pure diesel oil and lubricant oil were 0.80 $g\,cm^{-3}$ and 0.86 $g\,cm^{-3}$ respectively. Waste lubricant oil (L/O) and diesel oil (D/O) were mixed in a variable proportion such as 80:20; 70:30; 60:40; 50:50 and 40:60 (diesel oil: Lubricant oil; wt%) to formulate the fuel phase compositions. Density of different fuel mixtures vary from 0.83 $g\,cm^{-3}$ to 0.85 $g\,cm^{-3}$ (Figure 2A).

Further, using the prepared fuel mixtures, the oil absorption and retention ratio was calculated on ammonium nitrate prills. The mixtures of fuel i.e 80:20; 70:30; 60:40; 50:50 and 40:60 (D/O: Lubricant oil, wt%) showed a good oil absorption ratio and found in the range of 8.14% to 7.94% at ambient temperature. The viscosity of the mixed fuel compositions was also measured using Brookfield Viscometer. Viscosity was increased from 200 cps to 350 cps for 20% lubricant oil to 60% lubricant oil in diesel oil, which is due to the addition of more viscous lubricant oil.

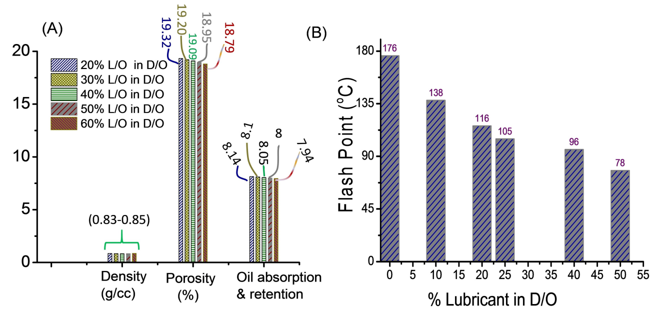

Figure 2. (A) Densities, porosity, and oil absorption & retention properties of the mixed fuel phase; (B) Flash point of a various proportion of lubricant oil (L/O)-diesel oil (D/O) mixtures.

Flashpoint is a crucial parameter for any chemicals in order to ensure its safe operation. Prior to use the prepared fuel phase compositions with ammonium nitrate for explosive applications, the flashpoint was measured using abel flash point detector. For pure lubricant oil, it was found 178 °C. With the increase of D/O% in the fuel mixture, the flashpoint was significantly reduced from 178 °C to 78 °C, which is close to the flashpoint of D/O (Figure 2B). Thus, partial replacement of D/O with lubricant oil provide similar kind of physical properties viz density, oil absorption & retention properties, and flash point in comparison with D/O, which is normally used fuel oil in ammonium nitrate Fuel Oil explosive (ANFO).

After analysis of physical properties of mixed fuel phases, ammonium nitrate fuel oil explosives were made with the mixed fuel phase (Figure 3). Initially, a sensitivity test of the prepared ANFO explosives with lubricant oil was per-

Figure 1. (A) Overview of Nimbeti Limestone mines, Rajasthan, India; source: Google earth view; (B) Mines view.

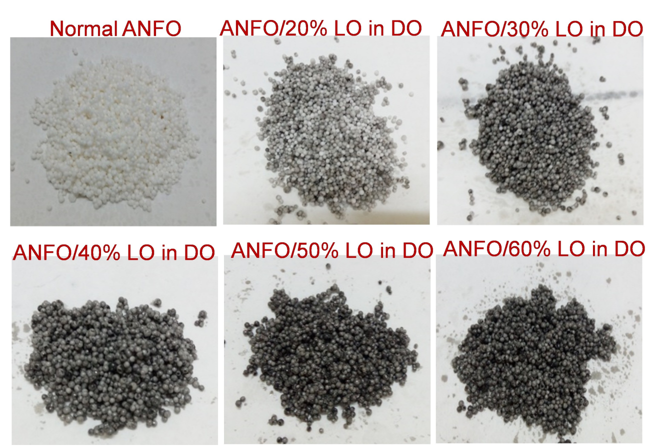

Figure 3. Photographs of the physical appearance of prepared ANFO explosives with lubricant Oil.

formed to evaluate its explosive property. The ANFO compositions prepared with variable percentage ratio of Diesel and lubricant oil mixture were initiated with No. 6 and 8 electronic detonators. No detonations were observed. Results confirmed the non-cap-sensitive nature of the prepared explosives.

Explosives quality and blast design parameters both play an important role in the rock fragmentation and efficiency of the overall blasting performance. Thus, to check the performance of the prepared ANFO explosives, blasting parameters such as spacing, burden, charge factor, etc. were kept unaltered. The details parameters and blast design were depicted in Table 1 and Figure 4.

3.1 VOD Analysis

The velocity of detonation (VOD) is considered as one of the most essential parameters and measurable indicators of explosives efficiency in real-time. Uniform VOD is required throughout the explosive column in the blast hole to produce sufficient bore hole pressure on the wall of the bore hole for even breakage of the rocks. ANFO is known as a relatively low VOD explosive having more gaseous energy and highly useful for soft rocks [22–24]. VOD in the unconfined condition of the various proportion of lubricant oil in D/O based ANFO explosive compositions were measured by the Dautriche method (IS 6609). The velocity of detonation in unconfined conditions was found in the range of (2854–2186) m swt.%[1]. Whereas the in hole VOD was recorded using MicroTrapVoD/Data Recorder instrument, and results were shown in Figure 5. The prepared explosives were charged in a 165 mm diameter hole with an average hole depth of 13 meter. (8–10) mm stone chips were used as stemming materials to confined the blast hole (Figure 4). Detailed blast design parameter and delay pattern were provided in Table 1, Figure 4 (and Figure S1 in the Supporting information).

In hole VOD were observed in the range of 4400–3830 m s^{-1}. For 20% lubricant oil in D/O based ANFO explosives, in hole VOD was observed 4537 m s^{-1}, which was close to normal ANFO VOD. Whereas, for 50% lubricant oil in D/O based ANFO, the observed in hole VOD was 4137 m s^{-1}. In hole VOD of normal ANFO was recorded using a similar method and found 4579 m s^{-1} (Figure 5(ii)).

With the increase of lubricant oil proportion from 20%–50% in D/O, VOD also decreases gradually in confined and unconfined conditions. The VOD measurement of prepared explosives clearly indicated that these compositions have significant detonation performance as compared with normal ANFO explosives and could be useful as an appropriate alternative for rock excavation works.

Table 1. Blast design parameters.

SL No.	Hole diameter (mm)	Average blast hole depth (m)	Burden (m)	Spacing (m)	Stemming height (m)	Bottom deck with wooden spacer (m)	No. of holes	No. of rows	Charge factor (kg/m^3)	Charge per hole (kg)	Total explosive (Kg)	ANFO Explosives (Fuel phase compositions)
1	165	13	4.5	6	4	1	71	4	0.37	131-132	9300	20% lubricant oil in D/O
2	165	12.5	4.5	6	4	1	48	4	0.369	123-126	5950	30% lubricant oil in D/O
3	165	12.8	4.5	6	4	1	52	4	0.36	125-127	6552	40% lubricant oil in D/O
4	165	12.9	4.5	6	4	1	66	4	0.39	120-122	7990	50% lubricant oil in D/O
5	165	13.3	4.5	6	4	1	91	4	0.36	131-132	11970	60% lubricant oil in D/O

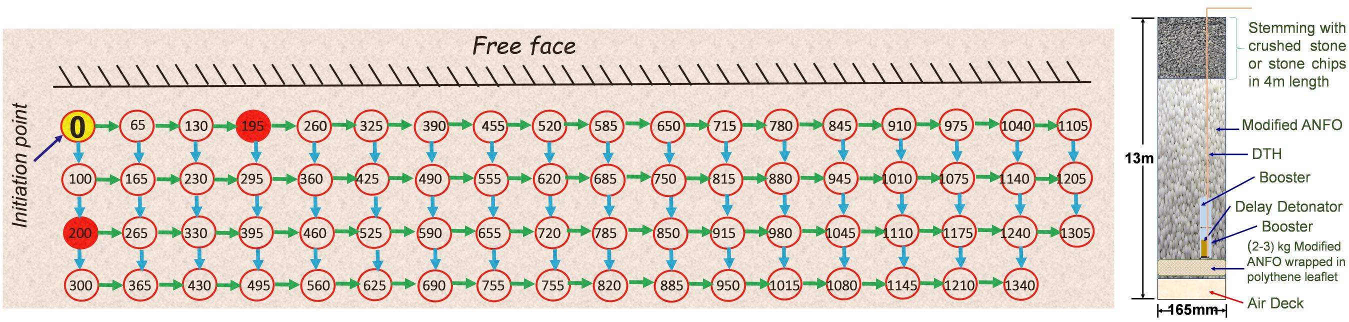

Figure 4. Blast design and timing pattern of the trial blast.

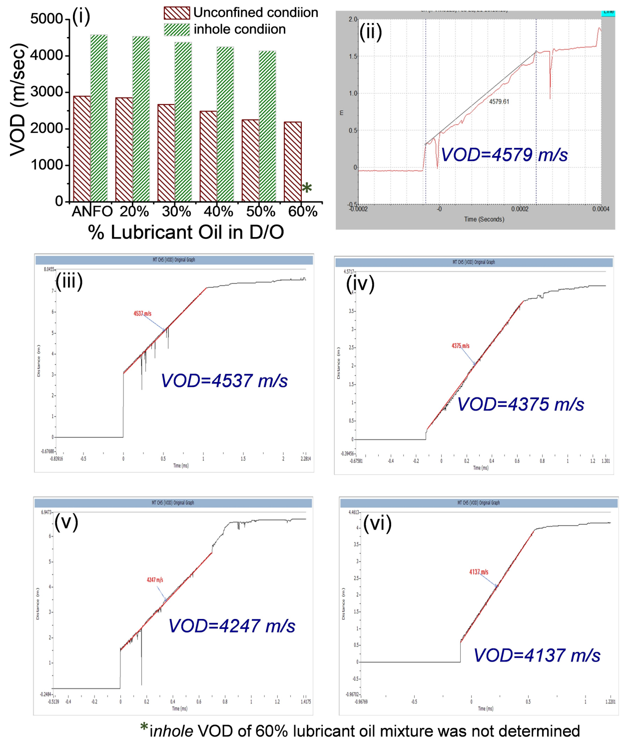

Figure 5. (i) Velocity of detonations (VOD) of prepared ANFO with various proportions of lubricant oil in D/O; In hole VOD measurement graph of (ii) Normal ANFO; (iii) 20% Lubricant oil in D/O explosive compositions; (iv) 30% Lubricant oil in D/O explosive compositions; (v) 40% Lubricant oil in D/O explosive compositions; (vi) 50% Lubricant oil in D/O explosive compositions.

3.2 Detonation Pressure

Detonation pressure in a hole is also an important parameter to describe the performance of an explosive.

The bore hole detonation pressure associated with the reaction zone of a detonating explosive is directly proportional to the square of its velocity of detonation (VOD) [25,26]. The detonation pressure (P_d) was calculated using the approximation formula given below [25].

$$P_d = \frac{1}{4}\rho_e (VOD)^2 10^{-6}$$

Where, P_d = Detonation pressure (GPa), ρ_e = Density of explosive (g cm^{-3}), VOD = Velocity of detonation (m s^{-1}).

Calculated detonation pressures of the prepared explosive compositions were found in the range of (3.42–4.01) GPa, as shown in Table 2. Detonation pressure of normal ANFO was also measured using the above cited formula as a control experiment and found 4.14 GPa. These results clearly revealed significant detonation characteristics of the prepared explosive compositions with partial replace of D/O with used lubricant oil as compared with normal ANFO [27].

Table 2. Calculated detonation pressure and densities of prepared ANFO explosives.

ANFO Explosive with various fuel phases	Density of explosives (ρ_e) (g cm^{-3})	Calculated detonation pressure (P_d) (GPa)
ANFO	0.79	4.14
20% Lubricant oil in D/O	0.78	3.78
30% Lubricant oil in D/O	0.79	3.78
20% Lubricant oil in D/O	0.79	3.56
20% Lubricant oil in D/O	0.80	3.42

3.3 Fragmentation Analysis

Rock fragmentation is an important index for the blasting operations, which control the cost of transportation, hauling, and crushing process [28–31]. It is also known to reduce the time-cycle of operation by avoiding the secondary blasts and mucking difficulties of the blasted rocks [29]. When the detonation velocity of explosives is greater than the P wave velocity of rock mass then the resultant fragment size is optimised [30]. The shock waves, which are produced in a rock generate excess tensile stress. The value of this tensile stress is more than the tensile strength of the rock mass, which helps in the rock breakage mechanism. Rock fragmentation is affected by the efficiency of explosives, various blasting parameters, and types of rock strata [30,31]. Moreover, the mean size of the blasted rock and uniformity index is also an important parameter of the blasting operation. All the trial blasts were performed under identical blasting parameters such as spacing, burden, charge factor, etc, to evaluate the efficiency of prepared explosive compositions on the rock fragmentation.

The blasted rock fragments were analysed to evaluate the efficiency of the prepared explosives compositions in compare with the normal ANFO, as control (Figure 6). Fragmentation assessment was carried out by the image processing of the mock pile from the various trial blasts of the prepared explosives using Wipfrag software. The analysed images, netting, contour, and histogram curves of the blasted rock are depicted in Figure 6 and Figures S2–S6 in the Supporting information.

The results indicated that the average mean size of the rock fragmented blocks of conducted experimental blasts was in the range of 3.5 mm to 22.5 mm diameter. The most common size of the block varied in between 1.5 mm to 500 mm after excluding the fine size of the fragmented rock in the analysis. The maximum size of the boulder was found with a diameter of 1054 mm to 2239 mm.

Rock fragment sizes increase gradually with an increase of lubricant oil proportion in the explosive compositions (Figure 7A). These results indicated that explosive compositions with 20%, 30%, and 40% lubricant oil in D/O showed similar kinds of rock fragmentations in comparison with normal ANFO in the trial blast. However, trial blast conducted with explosives compositions with 50% and 60% lu-

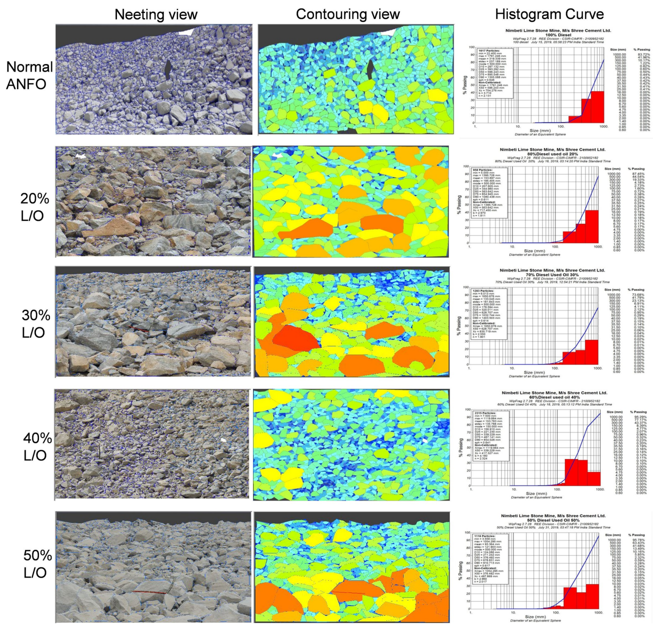

Figure 6. Images and analysed data of muck pile after blasting with Normal ANFO and ANFO prepared with 20 %, 30 %, 40 %, and 50 % Lubricant oil in D/O compositions.

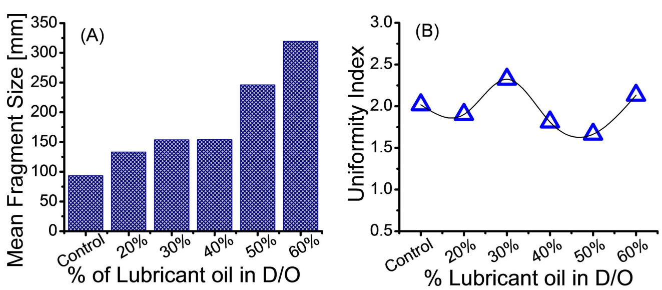

Figure 7. (A) Mean particle size; (B) Uniformity index of fragmented rock with a various proportion of lubricant oil in ANFO compositions.

bricant oil shows larger sizes of mean fragment size compare to normal ANFO blasting results.

The uniformity index (n) of the trial blasts of each explosive composition was analysed and depicted in Figure 7B and it was in the range of 1.66 to 2.13. Results clearly indicated excellent blasting output with a uniformity index of 2.3 & 2.1 for the 30 % & 60 % lubricant oil in D/O compositions respectively, whereas, for normal ANFO trial blasts, it was about 2.0. Uniformity index (n) in these blasts was in between 2 to 3, it means the maximum same fragment size boulders were evenly distributed in the muck pile. Nevertheless, in some blasts, it was 1 to 2 indicating poor fragmentation in terms of fine fragments or big size boulders.

3.4 Impact on the Air Quality

A massive quantity of dust particles along with some toxic fumes such as CO, NO_x, CO_2, SO_2, etc. are usually generated on detonation of explosives during mining operations and causes environmental pollutions in and around the open cast mines area. Nowadays, particulate matter (PM) is consider as a major air pollutant which is also generated from blasting operation. Thus, we have investigate the impact of the prepared lubricant oil based ANFO explosive detonation on air pollution in and around the Nimbeti limestone mines. Blasting operations with normal ANFO explosive was treated as control. Air quality monitoring was done at the mine office and the nearest village from mines and results were shown in Figure 8.

The analysed data indicate that SO_2 concentration varies from 6.98 $\mu g\,m^{-3}$ to 8.11 $\mu g\,m^{-3}$ at mine office, whereas it was in the range of (6.46–7.35) $\mu g/m^3$ at the nearest village. SO_2 concentration was found within the acceptable limit as per the environmental protection agency (EPA) [32,33]. The SO_2 concentration for control blasting was 7.95 $\mu g\,m^{-3}$ & 7.05 $\mu g\,m^{-3}$ at mines office and nearest village respectively.

Similarly, NO_2 gas varies 14.9 $\mu g\,m^{-3}$ to 19.5 $\mu g\,m^{-3}$ at mines office and 11.9 $\mu g\,m^{-3}$ to 13.8 $\mu g\,m^{-3}$ at nearest village. For normal ANFO blasting operation, it was 18.2 $\mu g\,m^{-3}$ and 13.2 $\mu g\,m^{-3}$ at mines office and nearest village location respectively (Figure 8 and Table 3).

Further, the result confirms the presence of CO gas $< 1.15\ \mu g\,m^{-3}$ in both locations. These results clearly indicated that fumes generated from the blasting operation with prepared ANFO-lubricant oil explosive compositions have minimal impact on the environments in comparison

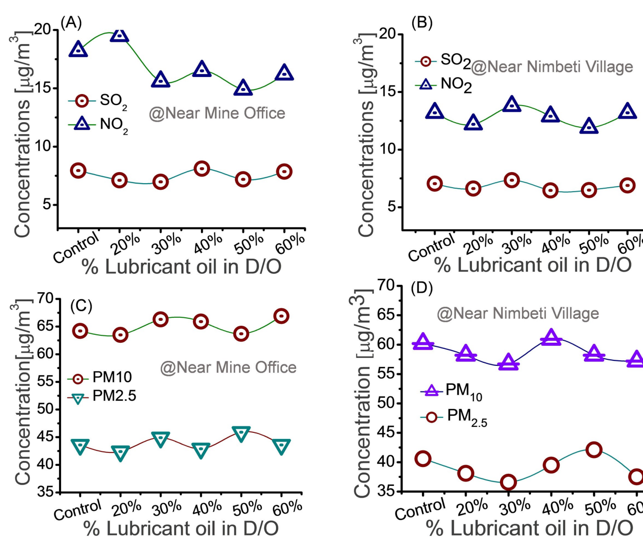

Figure 8. Toxic fumes (SO_2 & NO_x) analysis: (A) near mines office; (B) near Nimbeti village; Dust particle analysis: (C) near mines office; (D) near Nimbeti village; after blasting operation using prepared ANFO explosive compositions. Normal ANFO explosive was treated as a control.

Table 3. Measured properties of lubricant oil based ANFO explosives.

Properties	20% LO in D/O	30% LO in D/O	40% LO in D/O	50% LO in D/O	ANFO
Density (g/cc)	0.78	0.79	0.79	0.8	0.79
Porosity (%)	19.32	19.2	19.09	8.1	19.28
VOD (m/s)	4537	4375	4247	4137	4579
Detonation pressure (GPa)	4.01	3.78	3.56	3.42	4.14
Mean particle size (mm)	133.045	153.783	153.897	246.153	93.364
Uniformity Index	1.901	2.324	1.811	1.664	2.017
SO2 gas (µg/m3)	7.12	6.98	8.11	7.19	7.95
NOX gas (µg/m3)	18.2	15.6	16.5	14.9	18.2
PM 2.5 (µg /m3)	42.4	44.9	42.9	45.9	42.6
PM10 (µg /m3)	63.5	66.3	65.9	63.7	64.2

with normal ANFO blasting. Thus, these compositions could be suitable alternatives to the normal ANFO explosives.

We have also monitored dust particles specially PM_{10} & $PM_{2.5}$ generated by the blasting operation with normal ANFO (control) and prepared ANFO with lubricant oil compositions (Figure 8). PM_{10} was in the range of (63.7 to 66.9) $\mu g\,m^{-3}$ and (56.7 to 60.9) $\mu g\,m^{-3}$ at mine office and nearest village respectively for blasting with the prepared ANFO with lubricant oil compositions. Whereas, it was 64.2 & 60.2 $\mu g\,m^{-3}$ for the control blasting operations. Similarly, $PM_{2.5}$ was found in the range of (42.4 to 45.9) $\mu g\,m^{-3}$ and (36.6 to 42.1) $\mu g\,m^{-3}$ at mine office and nearest village respectively for the prepared ANFO with lubricant oil compositions and was found in an acceptable limit. Dust particle analysis results also revealed that ANFO-lubricant oil explosive compositions have a negligible effect on environments in comparison with the normal ANFO blasting technique.

4 Conclusion

In summary, we have demonstrated a unique way of recycling harmful waste lubricant oil into a valuable commercial explosive product. Waste lubricant oil was successfully utilized as a partial replacement of diesel oil and was use to formulate the various fuel phase mixture for cost-effective ANFO explosive compositions. Laboratory experiments, as well as field trial blast, clearly indicated that 20%, 30%, and 40% Lubricant oil based ANFO explosive compositions have significant detonation characteristics. Moreover, mean rock fragments particle size increases with the increasing the Lubricant oil proportion in diesel oil mixture. However, 50% and 60% Lubricant oil based ANFO explosives show comparatively poor detonation properties. Importantly, the prepared explosive compositions show minimal emission of toxic fumes on the environment at close proximity of the detonation zone. This article provides an example of an effective field demonstration of lubricant oil based ANFO explosive with significant detonation properties and with minimal environmental hazardous impact in and around the mining site.

Acknowledgements

F.A. acknowledges CSIR-CIMFR (MLP-78/2019–20) for the research grant. The authors express their thankfulness to the officials of Nembeti Limestone Mine of M/s Shree Cement Ltd. for providing necessary facilities during field investigations. Finally, we are grateful to the referees, whose constructive comments have greatly improved the quality of this article.

Data Availability Statement

Data available in the article. Further data that supports the findings of this study are available in the supplementary material of this article.

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Manuscript received: January 13, 2021
Revised manuscript received: May 18, 2021
Version of record online: June 17, 2021