



**RAHMAN HYDRAULIC TIN SDN BHD**  
(1201-H)

**TESTS CARRIED OUT USING TIN ALLOY  
PELLETS IN REDUCING FUEL CONSUMPTION  
AND EXHAUST EMISSIONS – A CASE STUDY  
AT RAHMAN HYDRAULIC TIN MINE,  
MALAYSIA**

by

**Ir. Mohamed Yakub Ismail, Wong Kim Fook,  
Ir. Kamarudin Abd Karim & Hariyanto Salleh**

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# HISTORY

The origins of tin alloy fuel catalysts are rumoured to be in World War II - in Russia. Legend has it that a Royal Air Force (RAF) aircraft technician working on fighter planes stationed in Murmansk discovered the solution to the problems associated with the supposedly low grade Russian aviation fuel. Sergeant Henry Broquet's tin alloy fuel catalyst technology reportedly allowed the British aircraft to perform as well as they had done with leaded RAF fuel. Mr. Broquet emigrated to South Africa after the war, taking the secrets of his technology with him. By 1989 a company bearing his name was marketing the first of the modern variants of the tin alloy pellets in South Africa and the United Kingdom.



## BACKGROUND

- Two important issues confronting our society today are in energy saving and in reducing air pollution.
- Considerable efforts are being made to improve energy efficiency and reduce vehicle exhaust emissions. Efforts include introduction of regulations, conversion to cleaner fuels and increased fuel efficiency.
- The use of tin alloy pellets is one such application that can reduce vehicle/equipment fuel consumption and reduce exhaust emissions.



## BACKGROUND

- In collaboration with the Malaysian Chamber of Mines (**MCOM**) and International Tin Research Institute (**ITRI**), Rahman Hydraulic Tin Mine (**RHT**) - a wholly owned subsidiary of Malaysia Smelting Corporation (**MSC**) - carried out trials at its mine site located at the very north of Peninsula Malaysia, using tin alloy pellets placed in the vehicles/ equipment fuel tanks of diesel and petrol engines to demonstrate that there is a reduction in fuel consumption and a reduction in exhaust emissions.



## OBJECTIVE OF THIS PAPER

- To demonstrate that there is a reduction in fuel consumption and a reduction of exhaust emissions when tin alloy pellets are placed inside the fuel tanks of:-
  - i. 7 vehicles with diesel engines and 2 vehicles with petrol engines.
  - ii. One electrical generator and one large diesel engine for water pump.



# TIN ALLOY PELLETS WERE PURCHASED FROM/THROUGH:-



**Broquet International Limited :-  
Manufacturer (United Kingdom)**

**Universal Consultants Pte Ltd :-  
Distributor (Singapore)**

**Zenith Solutions Sdn Bhd :-  
Distributor (Subang Jaya, Malaysia)**

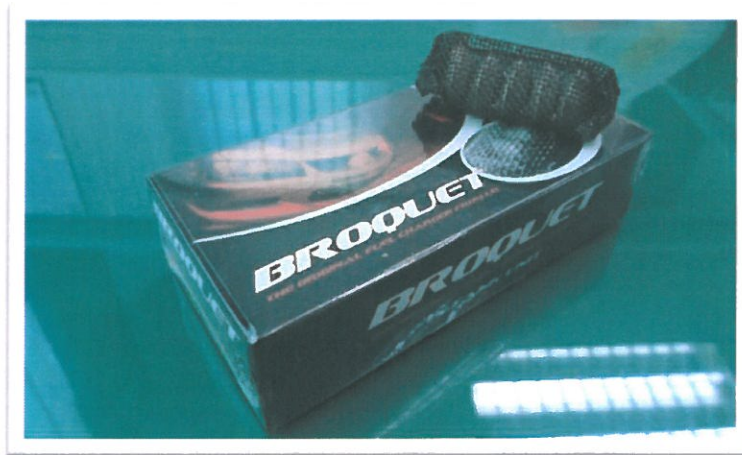
**Rahman Hydraulic Tin Mine :-  
Customer (North Peninsular, Malaysia)**

## STANDARD PACKAGING OF TIN ALLOY PELLETS

i) B/8T - Broquet Packing (8 Pellets)



ii) B/5T - Broquet Packing (5 Pellets)



- Each Pellet weighs an average of 15 grams.





## LIST OF VEHICLES AND EQUIPMENT TESTED AT RHT MINE

No	Test Vehicles/Equipment	Type and Capacity of Engines	Age of Vehicles/Equipment (Years)	
			2013	2014
1	Pick-up Truck (4-Wheel Drive)	Diesel Engine - 2.5 liters	5	6
2	Pick-up Truck (4-Wheel Drive)	Diesel Engine - 2.5 liters	5	6
3	Pick-up Truck (4-Wheel Drive)	Diesel Engine - 2.5 liters	5	6
4	Pick-up Truck (4-Wheel Drive)	Diesel Engine - 2.5 liters	2	3
5	Pick-up Truck (4-Wheel Drive)	Diesel Engine - 2.5 liters	5	6
6	Cargo Truck c/w Hydraulic Crane	Diesel Engine - 7.5 liters	24	25
7	Tipper Truck (18-Tonnes)	Diesel Engine - 7.5 liters	1	2
8	Electrical Generator (500 KVA)	Diesel Engine - 15 liters	6	7
9	Large Diesel Engine (500 HP) for Water Pump	Diesel Engine - 19 liters	5	6
10	Jeep (4-Wheel Drive)	Petrol Engine – 1.3 liters	16	17
11	Car-Sedan Volvo	Petrol Engine – 2.5 liters	17	18

## VEHICLES AND EQUIPMENT TESTED AT RHT MINE



**Pick-up Truck (4-Wheel Drive)**



**Pick-up Truck (4-Wheel Drive)**



**Pick-up Truck (4-Wheel Drive)**



**Pick-up Truck (4-Wheel Drive)**



**Pick-up Truck (4-Wheel Drive)**



**Cargo Truck c/w Hydraulic Crane**

## VEHICLES AND EQUIPMENT TESTED AT RHT MINE



**Tipper Truck (18-Tonnes)**



**Jeep (4-Wheel Drive)**



**Car-Sedan Volvo**



**Electrical Generator (500 KVA)**



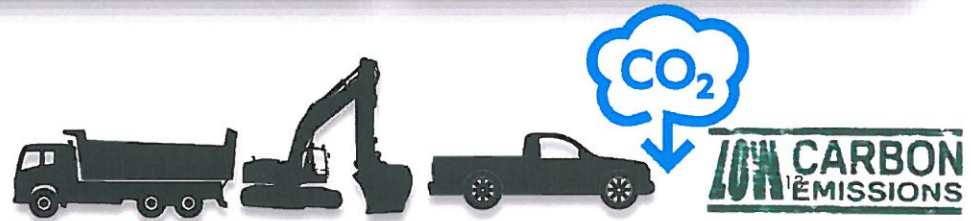
**Large Diesel Engine (500 HP) for Water Pump**

## BASELINE DATA ON VEHICLES AND EQUIPMENT TESTED

- Baseline Data (without pellets) on fuel consumption and emissions was recorded before starting the trial tests using tin alloy pellets.



# MEASUREMENT OF FUEL CONSUMPTION



# FUEL SAVINGS AFTER ADDING TIN ALLOY PELLETS (TESTS DONE OVER 6 MONTHS IN 2013)

No	Test Vehicles/Equipment (A)	Age of (A) (years)	Average Fuel Consumption - BEFORE Adding Tin Alloy Pellets	Average Fuel Consumption - AFTER Adding Tin Alloy Pellets	Fuel Saving %
1	Pick-up Truck (4-Wheel Drive)	5	183 ml/km	172 ml/km	6.0
2	Pick-up Truck (4-Wheel Drive)	5	230 ml/km	217 ml/km	5.7
3	Pick-up Truck (4-Wheel Drive)	5	124 ml/km	116 ml/km	6.5
4	Pick-up Truck (4-Wheel Drive)	2	94 ml/km	90 ml/km	4.3
5	Pick-up Truck (4-Wheel Drive)	5	94 ml/km	90 ml/km	4.3
6	Cargo Truck c/w Hydraulic Crane	24	327 ml/km	303 ml/km	7.3
7	Tipper Truck (18-Tonnes)	1	253 ml/km	240 ml/km	5.1
8	Electrical Generator (500 KVA)	6	0.37 litre/kWh	0.35 litre/kWh	5.4
9	Large Diesel Engine (500 HP) for Water Pump	5	41.48 litre/hour	39.76 litre/hour	4.1
10	Jeep (4-Wheel Drive )	16	118 ml/km	109 ml/km	7.6
11	Car-Sedan Volvo	17	107 ml/km	100 ml/km	6.5

Diesel savings ranging from 4.1% to 7.3%

Petrol savings ranging from 6.5% to 7.6%

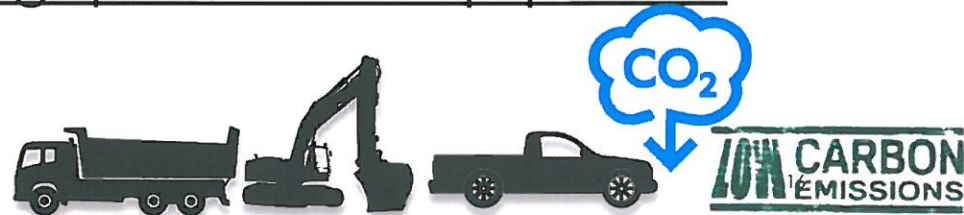
# FUEL SAVINGS AFTER ADDING TIN ALLOY PELLETS (TESTS DONE OVER 6 MONTHS IN 2014)

No	Test Vehicles/Equipment (A)	Age of (A) (years)	Average Fuel Consumption - BEFORE Adding Tin Alloy Pellets	Average Fuel Consumption - AFTER Adding Tin Alloy Pellets	Fuel Saving %
1	Pick-up Truck (4-Wheel Drive)	6	184 ml/km	172 ml/km	6.5
2	Pick-up Truck (4-Wheel Drive)	6	219 ml/km	204 ml/km	6.8
3	Pick-up Truck (4-Wheel Drive)	6	135 ml/km	128 ml/km	5.2
4	Pick-up Truck (4-Wheel Drive)	3	94 ml/km	88 ml/km	6.4
5	Pick-up Truck (4-Wheel Drive)	6	92 ml/km	87 ml/km	5.4
6	Cargo Truck c/w Hydraulic Crane	25	346 ml/km	320 ml/km	7.5
7	Tipper Truck (18-Tonnes)	2	260 ml/km	242 ml/km	6.9
8	Electrical Generator (500 KVA)	7	0.55 litre/kWh	0.51 litre/kWh	7.3
9	Large Diesel Engine (500 HP) for Water Pump	6	45.42 litre/hour	41.89 litre/hour	7.8
10	Jeep (4-Wheel Drive )	17	128 ml/km	122 ml/km	4.7
11	Car-Sedan Volvo	18	104 ml/km	96 ml/km	7.7

Diesel savings ranging from 5.2% to 7.8%

Petrol savings ranging from 4.7% to 7.7%

- Exhaust emissions tests were done on the following pollutants:-
  - (1) Carbon Monoxide (CO)
  - (2) Sulphur Dioxide (SO<sub>2</sub>)
  - (3) Oxides of Nitrogen (NO<sub>x</sub>)
- Emission measurements were done 6 months after adding the pellets.
- The emissions measurements were done with the assistance of :- M/s Acumen Scientific Sdn Bhd – Penang, Malaysia, using specialized equipment.





# MEASUREMENT OF EXHAUST EMISSIONS



# REDUCTION OF CARBON MONOXIDE (CO) EMISSION AFTER ADDING TIN ALLOY PELLETS (TESTS DONE OVER 6 MONTHS IN 2013)

Test vehicles/ Equipment (A)	Age of (A) (years)	CO (ppm)		Emission Reduction %
		BEFORE Adding Tin Alloy Pellets	6 Months AFTER Adding Tin Alloy Pellets	
Pick-up Truck (4-Wheel Drive)	5	3,800	1,310	66
Pick-up Truck (4-Wheel Drive)	5	900	540	40
Pick-up Truck (4-Wheel Drive)	5	750	500	33
Pick-up Truck (4-Wheel Drive)	2	1,280	150	88
Pick-up Truck (4-Wheel Drive)	5	2,700	650	76
Cargo Truck c/w Hydraulic Crane	24	720	400	44
Tipper Truck (18-Tonnes )	1	550	200	64
Electrical Generator (500 KVA)	6	800	420	48
Large Diesel Engine (500 HP) for Water Pump	5	790	450	43
Jeep (4-Wheel Drive)	16	30,160	19,780	34
Car- Sedan Volvo	17	23,410	3,040	87

Reduction of  
Carbon  
Monoxide  
emission  
ranging from  
33% to 88%  
**(Diesel)**

Reduction of  
Carbon  
Monoxide  
emission  
ranging from  
34% to 87%  
**(Petrol)**

# REDUCTION OF CARBON MONOXIDE (CO) EMISSION AFTER ADDING TIN ALLOY PELLETS (TESTS DONE OVER 6 MONTHS IN 2014)

Test vehicles/ Equipment (A)	Age of (A) (years)	CO (ppm)		Emission Reduction %
		BEFORE Adding Tin Alloy Pellets	6 Months AFTER Adding Tin Alloy Pellets	
Pick-up Truck (4-Wheel Drive)	6	1,127	582	48
Pick-up Truck (4-Wheel Drive)	6	1,398	678	52
Pick-up Truck (4-Wheel Drive)	6	1,300	656	50
Pick-up Truck (4-Wheel Drive)	3	1,202	1,058	12
Pick-up Truck (4-Wheel Drive)	6	1,863	851	54
Cargo Truck c/w Hydraulic Crane	25	636	495	22
Tipper Truck (18-Tonnes )	2	3,990	1,813	55
Electrical Generator (500 KVA)	7	515	424	18
Large Diesel Engine (500 HP) for Water Pump	6	84	58	31
Jeep (4-Wheel Drive)	17	58,300	50,000	14
Car- Sedan Volvo	18	4,438	3,714	16

Reduction of  
Carbon  
Monoxide  
emission  
ranging from  
12% to 55%  
**(Diesel)**

Reduction of  
Carbon  
Monoxide  
emission  
ranging from  
14 % to 16%  
**(Petrol)**

# REDUCTION OF SULPHUR DIOXIDE (SO<sub>2</sub>) EMISSION AFTER ADDING TIN ALLOY PELLETS (TESTS DONE OVER 6 MONTHS IN 2013)

Test vehicles/ Equipment (A)	Age of (A) (years)	SO <sub>2</sub> (ppm)		Emission Reduction %
		BEFORE Adding Tin Alloy Pellets	6 Months AFTER Adding Tin Alloy Pellets	
Pick-up Truck (4-Wheel Drive)	5	16	4	75
Pick-up Truck (4-Wheel Drive)	5	10	4	60
Pick-up Truck (4-Wheel Drive)	5	10	4	60
Pick-up Truck (4-Wheel Drive)	2	10	3	70
Pick-up Truck (4-Wheel Drive)	5	9	1	89
Cargo Truck c/w Hydraulic Crane	24	12	4	67
Tipper Truck (18- Tonnes )	1	10	3	70
Electrical Generator (500 KVA)	6	13	3	77
Large Diesel Engine (500 HP) for Water Pump	5	20	8	60
Jeep (4-Wheel Drive)	16	128	54	58
Car- Sedan Volvo	17	200	37	82

Reduction of Sulphur Dioxide emission ranging from 60% to 89%  
**(Diesel)**

Reduction of Sulphur Dioxide emission ranging from 58% to 82%  
**(Petrol)**

# REDUCTION OF SULPHUR DIOXIDE (SO<sub>2</sub>) EMISSION AFTER ADDING TIN ALLOY PELLETS (TESTS DONE OVER 6 MONTHS IN 2014)

Test vehicles/ Equipment (A)	Age of (A) (years)	SO <sub>2</sub> (ppm)		Emission Reduction %
		BEFORE Adding Tin Alloy Pellets	6 Months AFTER Adding Tin Alloy Pellets	
Pick-up Truck (4-Wheel Drive)	6	29	14	51
Pick-up Truck (4-Wheel Drive)	6	25	10	60
Pick-up Truck (4-Wheel Drive)	6	34	27	21
Pick-up Truck (4-Wheel Drive)	3	69	9	87
Pick-up Truck (4-Wheel Drive)	6	81	11	86
Cargo Truck c/w Hydraulic Crane	25	4	1	75
Tipper Truck (18- Tonnes )	2	190	104	45
Electrical Generator (500 KVA)	7	152	82	46
Large Diesel Engine (500 HP) for Water Pump	6	306	252	18
Jeep (4-Wheel Drive)	17	2,300	1,189	48
Car- Sedan Volvo	18	33	13	61

Reduction of Sulphur Dioxide emission ranging from 18% to 87% **(Diesel)**

Reduction of Sulphur Dioxide emission ranging from 48% to 61% **(Petrol)**

# REDUCTION OF OXIDES OF NITROGEN (NO<sub>x</sub>) EMISSION AFTER ADDING TIN ALLOY PELLETS (TESTS DONE OVER 6 MONTHS IN 2013)



Test vehicles/ Equipment (A)	Age of (A) (years)	NO <sub>x</sub> (ppm)		Emission Reduction %
		BEFORE Adding Tin Alloy Pellets	6 Months AFTER Adding Tin Alloy Pellets	
Pick-up Truck (4-Wheel Drive)	5	210	90	57
Pick-up Truck (4-Wheel Drive)	5	220	120	45
Pick-up Truck (4-Wheel Drive)	5	190	90	53
Pick-up Truck (4-Wheel Drive)	2	300	120	60
Pick-up Truck (4-Wheel Drive)	5	110	20	82
Cargo Truck c/w Hydraulic Crane	24	80	20	75
Tipper Truck (18- Tonnes )	1	170	40	76
Electrical Generator (500 KVA)	6	210	100	52
Large Diesel Engine (500 HP) for Water Pump	5	250	140	44
Jeep (4-Wheel Drive)	16	310	60	81
Car- Sedan Volvo	17	390	100	74

Reduction of Oxides of Nitrogen emission ranging from 44% to 82% **(Diesel)**

Reduction of Oxides of Nitrogen emission ranging from 74% to 81% **(Petrol)**

# REDUCTION OF OXIDES OF NITROGEN (NO<sub>x</sub>) EMISSION AFTER ADDING TIN ALLOY PELLETS (TESTS DONE OVER 6 MONTHS IN 2014)



Test vehicles/ Equipment (A)	Age of (A) (years)	NO <sub>x</sub> (ppm)		Emission Reduction %
		BEFORE Adding Tin Alloy Pellets	6 Months AFTER Adding Tin Alloy Pellets	
Pick-up Truck (4-Wheel Drive)	6	336	205	39
Pick-up Truck (4-Wheel Drive)	6	281	152	46
Pick-up Truck (4-Wheel Drive)	6	461	339	26
Pick-up Truck (4-Wheel Drive)	3	48	9	81
Pick-up Truck (4-Wheel Drive)	6	309	133	57
Cargo Truck c/w Hydraulic Crane	25	56	19	66
Tipper Truck (18- Tonnes )	2	2,108	1,270	40
Electrical Generator (500 KVA)	7	1,979	927	53
Large Diesel Engine (500 HP) for Water Pump	6	3,450	2,934	15
Jeep (4-Wheel Drive)	17	27	20	26
Car- Sedan Volvo	18	167	103	38

Reduction of  
Oxides of  
Nitrogen  
emission  
ranging from  
15% to 81%  
**(Diesel)**

Reduction of  
Oxides of  
Nitrogen  
emission  
ranging from  
26% to 38%  
**(Petrol)**

## QUANTITY OF PELLETS USED



- One pellet was added to 4 liters of fuel tank capacity. Each new pellet weighs an average of 15 grams.
- Above guideline was given by Zenith Solutions, the local Distributor of Broquet Tin Alloy Pellets.
- A total of 1000 pellets were used for this project at RHT Mine.

## Costs Incurred by RHT for This Project

- The total estimated cost incurred during 2013 and 2014 for the trial runs is around RM 200,000 (about RM 80,000 for buying the pellets and RM 120,000 for carrying out the tests).





# REDUCTION OF WEIGHT OF TIN ALLOY PELLETS (TESTS DONE OVER 6 MONTHS IN 2014)

Test vehicles/ Equipment (A)	Age of (A) (years)	BEFORE Adding Tin Alloy Pellets (grams)	6 Months AFTER Adding Tin Alloy Pellets (grams)	Percentage of Weight Reduction (%)
Pick-up Truck (4-Wheel Drive)	6	309.5	309.2	0.10
Pick-up Truck (4-Wheel Drive)	6	329.2	328.9	0.09
Pick-up Truck (4-Wheel Drive)	6	306.5	306.3	0.07
Pick-up Truck (4-Wheel Drive)	3	318.6	317.4	0.38
Pick-up Truck (4-Wheel Drive)	6	319.0	318.9	0.03
Cargo Truck c/w Hydraulic Crane	25	622.2	621.8	0.06
Tipper Truck (18- Tonnes )	2	603.3	603.0	0.05
Electrical Generator (500 KVA)	7	1353.8	1352.7	0.08
Large Diesel Engine (500 HP) for Water Pump	6	2830.0	2829.0	0.04
Jeep (4-Wheel Drive)	17	142.7	142.6	0.07
Car- Sedan Volvo	18	322.0	321.0	0.31

Reduction of  
weight of Tin  
Alloy Pellets  
ranging from  
0.03% to 0.38%  
**(Diesel)**

Reduction of  
weight of Tin  
Alloy Pellets  
ranging from  
0.07% to 0.31%  
**(Petrol)**

## FINDINGS OF TEST WORKS AT RHT MINE

- 1) Tin alloy pellets, placed in the fuel tanks of vehicles/equipment (using diesel) do reduce fuel consumption ranging from 4% to 8%.
- 2) Tin alloy pellets, placed in the fuel tanks of vehicles (using petrol) also reduce fuel consumption ranging from 5% to 8%.
- 3) Tin alloy pellets used in (1) and (2) above also reduce exhaust emissions, as follows:-
  - Carbon Monoxide (CO) – emission reduction ranging from 12% to 88%
  - Sulphur Dioxide (SO<sub>2</sub>) – emission reduction ranging from 18% to 89%
  - Oxides of Nitrogen (NO<sub>x</sub>) – emission reduction ranging from 15% to 82%

- 4) Negligible weight reduction & change of chemical composition of the Tin Alloy Pellets, before & after the trial tests.
- 5) Further work (by international bodies/institutions & Governments) is needed to confirm current findings from trials at RHT, and to take this project further, as the potential benefits could be enormous.



RHT's Open Pit Mine,  
Klian Intan, Perak, Malaysia

**RHT**  
RAHMAN HYDRAULIC TIN SDN BHD  
(1201-H)





**THANK YOU**