

Preliminary Study on Utilization of Used Lubricant as Fuel Substitute for Metal Foundries

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INTRODUCTION :

- Coke fired cupola furnaces remain the predominant unit for cast iron production. The use of cheaper raw materials, e.g. steel scraps, is possible in such furnaces. Coke is especially used because it exercises the dual function of fuel and carburizing agent.
- Coke becomes more rare and expensive, which makes most metal foundries temporarily cease their production. The solution could be cokeless cupola furnaces, but the substituting fuel must be cheaper.
- Environmental friendly cokeless cupola furnaces have been developed, where LDO or LPG is used. The emission level, especially for PM and SO₂, can be reduced. In Indonesia the use of both fuels is still considered to be uneconomical.

INTRODUCTION :

- Lubrication is required for all moving parts, e.g. ICE pistons, all bearings, meshing gear sets, etc.
- The right amount in the right place at the right time will prevent friction, heating, expansion and wear. Over one third of energy production is consumed in overcoming friction. Proper lubrication can triple component life.
- There will be environmental problems due to lubricants which are disposed untreated.
- Most lubricants are liquids, e.g. mineral oils, synthetic esters, silicon fluids, etc. Some are derived from petroleum and synthetic oil, which consists of compounds of carbon and hydrogen, so they can be burned.

Considering those problems a research should be conducted in order to investigate the possibility of exploiting used lubricants as a fuel substitute in cupola furnaces of Indonesian metal foundries.

METHODOLOGY :

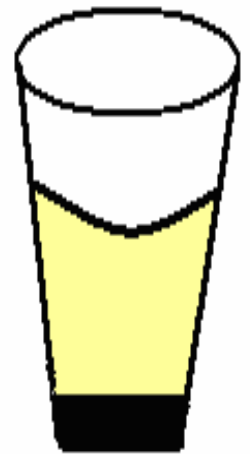
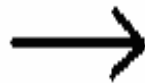
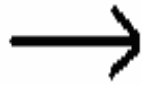
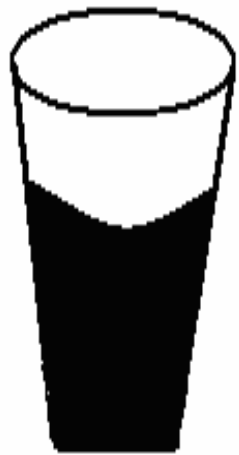
All experiments, excluding the treatment of used lubricants, were carried out with

- four variations of fuel pressure, i.e. 0.5 bar, 1 bar, 1.5 bar and 2 bar,
- two variations of fuel valve position, i.e. half opened and fully opened,
- constant air supply, because the blower setting was unchanged. All is primary air, there is no secondary air.

METHODOLOGY :

TREATMENT OF USED LUBRICANTS

- Heating until 180 C to evaporate water content, then cooling until 30 C,
- pouring H₂SO₄ (with a ratio of 1:7) and stirring for about 90 min to obtain red liquid, then let dark colored residues settle for 24 hrs,
- separating the clear upper fraction from the settling dark fraction, adding *Triethylamine* (TEA) into the clear fraction with the ratios of 1: 25, 1: 30, 1: 35 and 1: 40, stirring for about 90 min to obtain green liquid and finally settling for 24 hrs,
- recovering the clear upper portion which can be used as fuel.



I

II

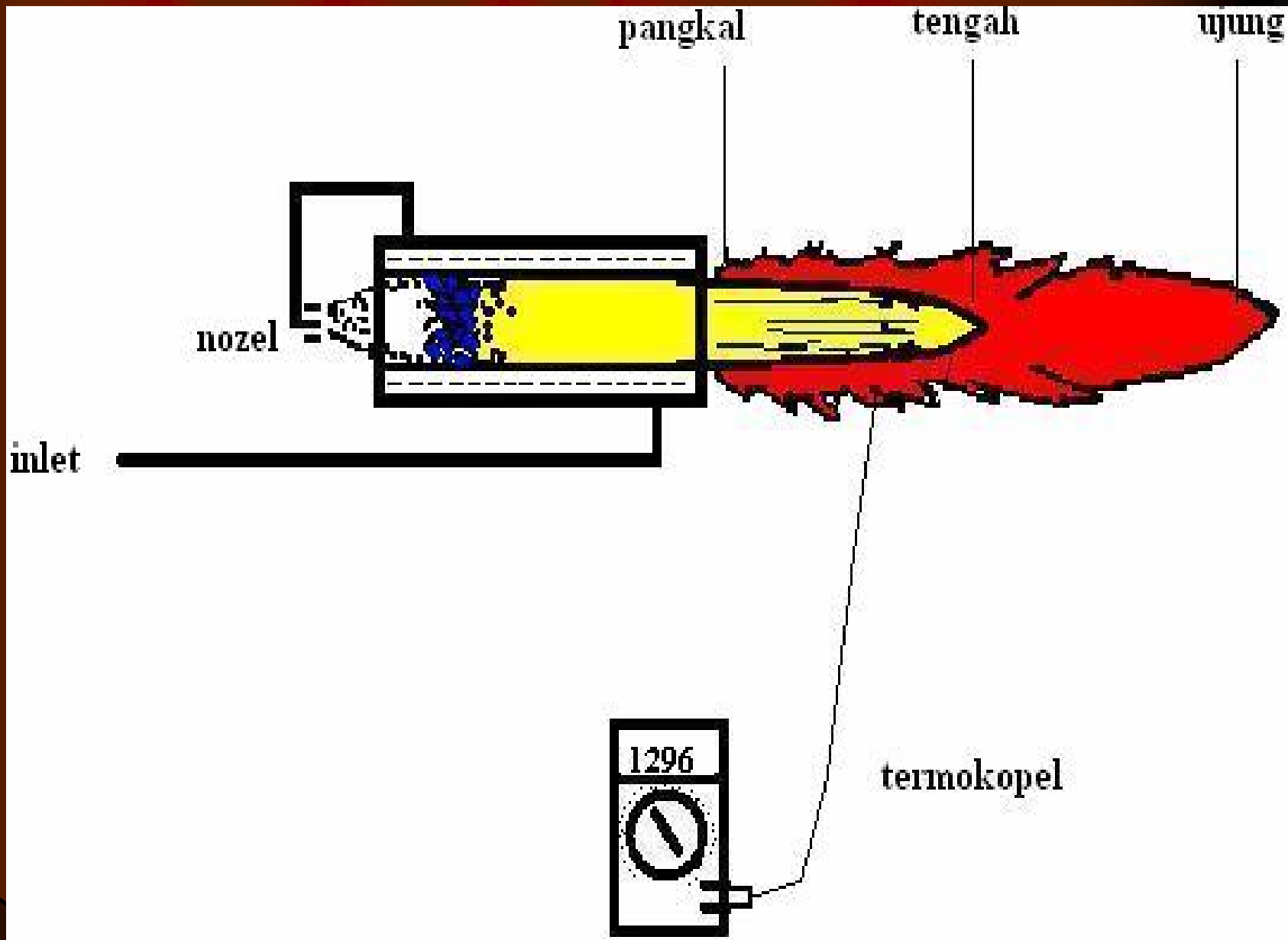
III

IV

METHODOLOGY :

MEASUREMENTS OF TEMPERATURES

- The burner is a vaporizing type with a double walled torch. The inner and outer diameters of the annulus are 50 mm and 60 mm
- The fuel is fed by a pump. Vaporization occurs in the concentric space between the tubes before it flows through a nozzle into a combustion chamber
- Thermocouples are placed in three points, i.e. base, midpoint and tip of stable flames
- Thermocouples are connected to a multimeter as a temperature reader.



METHODOLOGY :

MEASUREMENTS OF FUEL CONSUMPTIONS

They are observed for the same fuel pressure and valve opening variations. The measurement is carried out by investigating the rate of fuel surface drop inside a cylindrical fuel tank (20 liter capacity). Multiplying the decrease rate with the cross sectional area of the tank and the oil density will yield the sought fuel consumption.

METHODOLOGY :

MEASUREMENTS OF MELTING TIMES

- A 27 cm diameter cylindrical crucible (made from CI and covered with refractory brick) is used to melt 2 kg of aluminum. The melting time is the period to increase the material temperature from ambient up to its melting temperature,
- Measurement begins when flames from the burner is directed and contacted to the metal inside the crucible and terminates when the metal commences to melt, as seen through an opening in the crucible mouth

METHODOLOGY :

MEASUREMENTS OF FLAME LENGTHS

The measurement was conducted simply with the help of a ruler which is longitudinally positioned in the same direction as the flame jet. The recorded length is the utmost distance that can be achieved by the flame. Pictures were taken for different cases in order to make analysis easy.

RESULTS AND DISCUSSIONS

Waste oil treatment

No	Characteristics	Treatment types				
		Used lubricant	1:25	1:30	1:35	1:40
1	Specific gravity 60/60°F	0.9056	0.8866	0.8926	0.8886	0.8762
2	Kinematic Viscosity 40 °C, cSt	85.05	63.23	71.95	58.78	55.19
3	Kinematic Viscosity 100 °C, cSt	10.58	9.374	9.904	8.649	8.604
4	Residual Carbon, % wt	1.780	1.055	1.691	1.359	0.339
5	Water Content, % vol	0.2	0.7	1.0	1.1	0.4
6	Residue, % wt	0.368	0.266	0.294	0.278	0.331
7	Higher Heating Value (kcal/kg)	10684.9	10756.5	10734.0	10749.0	10795.0

RESULTS AND DISCUSSIONS

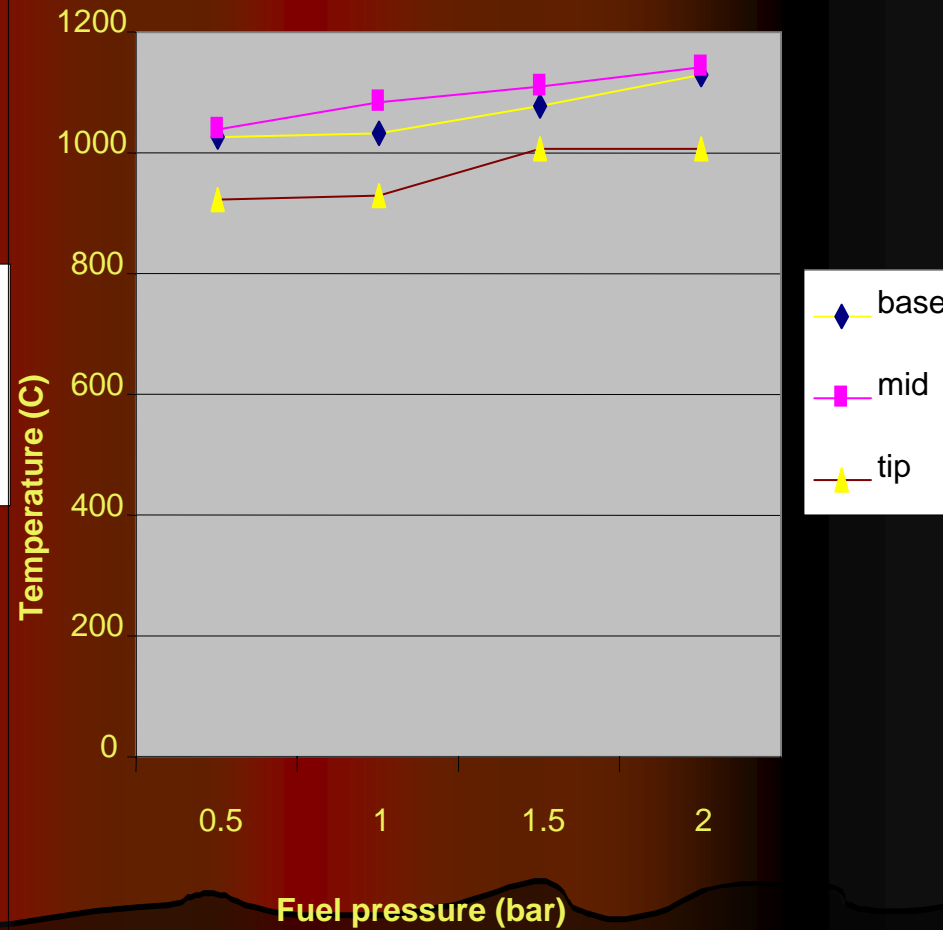
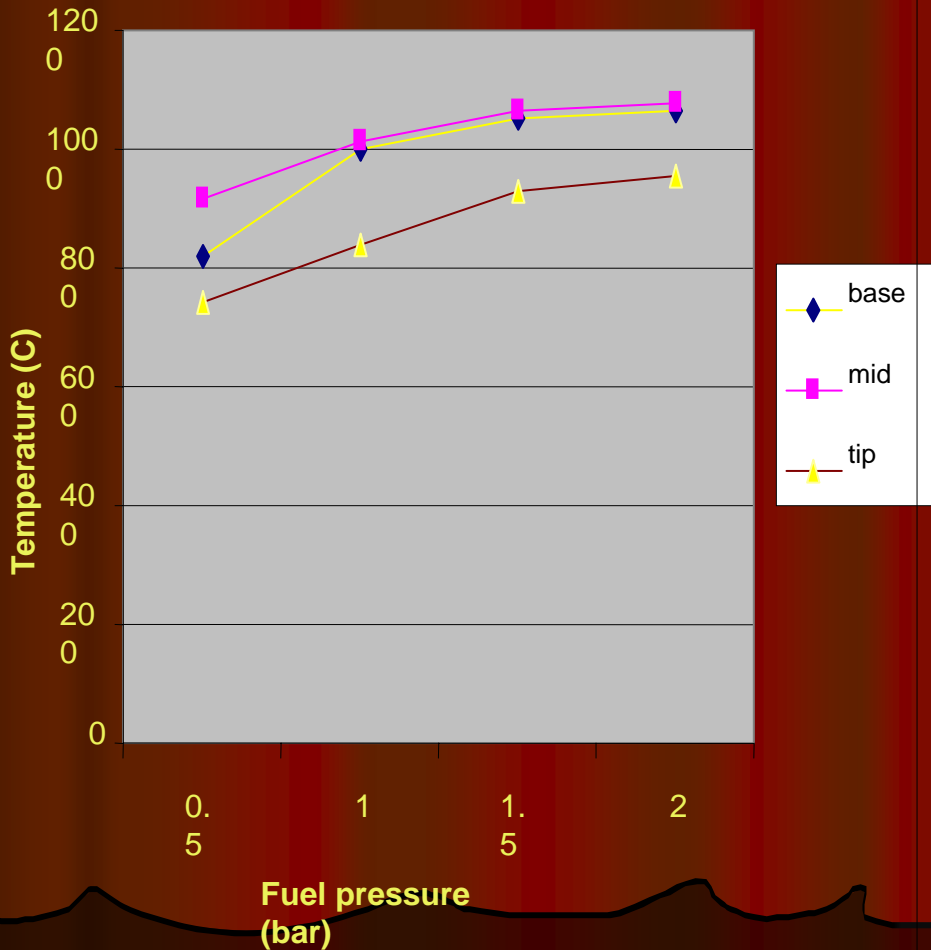
The treatment can significantly reduce specific gravity and kinematic viscosity, which makes the fuel easier to be sprayed and atomized.

If HHV is a negative function of specific gravity, it means that the treatment can increase its calorific value.

RESULTS AND DISCUSSIONS

Flame temperatures

Left : Half opened, Right : Fully opened



RESULTS AND DISCUSSIONS

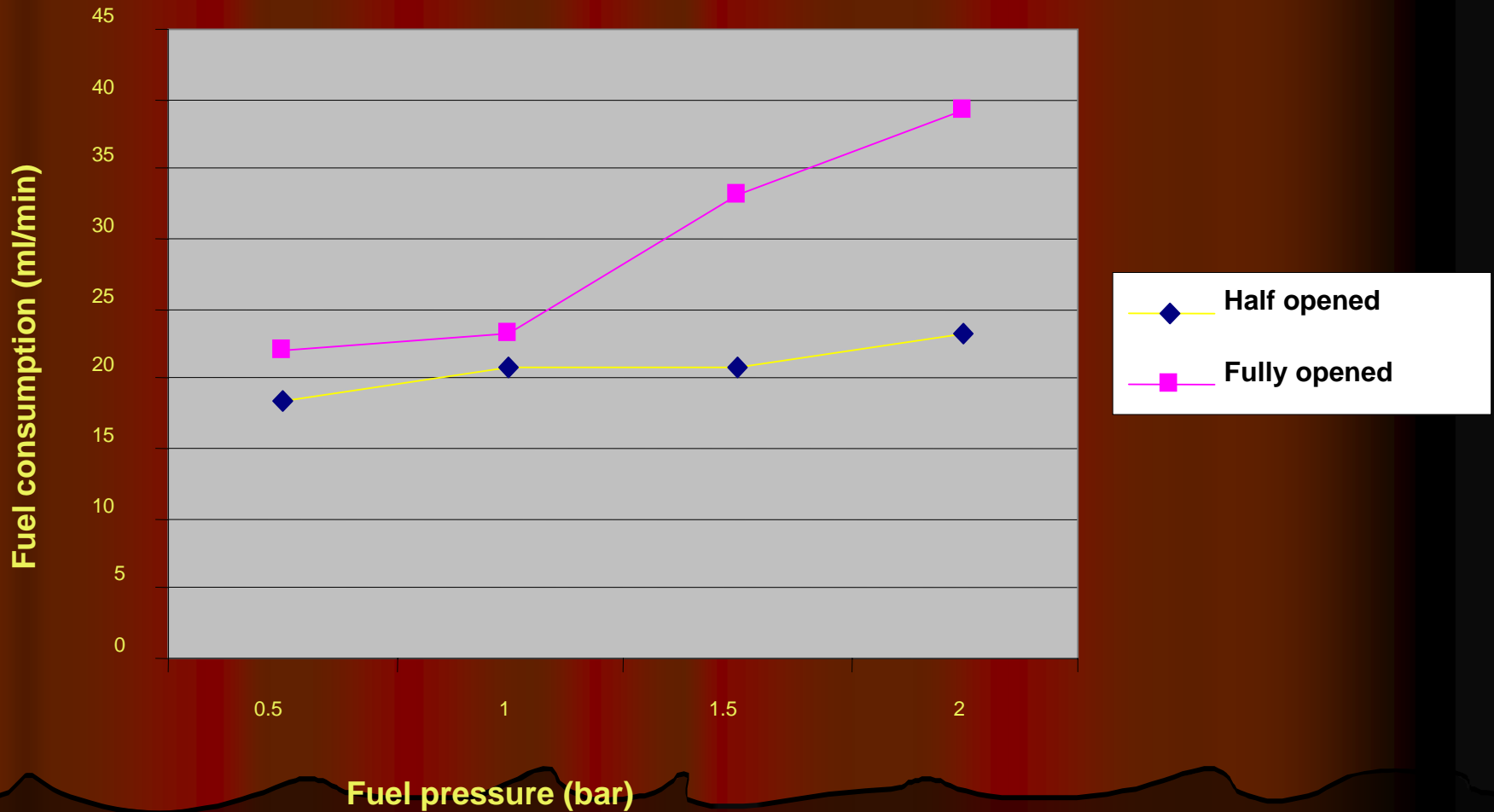
Temperatures go higher if higher fuel pressures are applied, due to more fuel supplied to the burner and more heat release. However the temperature increase is less significant at higher pressures because more fuel is not accompanied with more supplied air, therefore the mixtures become richer. The influence of fuel valve opening is significant as well, where fully opened valve will generate higher temperatures.

RESULTS AND DISCUSSIONS :

The highest temperatures are always attainable in flame midpoints where combustion intensity achieves the highest rate, while the lower temperatures occur in flame bases and tips. Near the flame base, evaporation and mixing of fuel with air still take place, so the combustion has not really begun. Meanwhile in the flame tip the amount of combustibles has been reduced significantly, so the reaction rate will be lower. However, at higher pressures the temperature difference between midpoints and bases is negligible. It seems that the stoichiometric condition has not been achieved, because more fuel supply still tends to increase the temperature.

RESULTS AND DISCUSSIONS

Fuel consumption



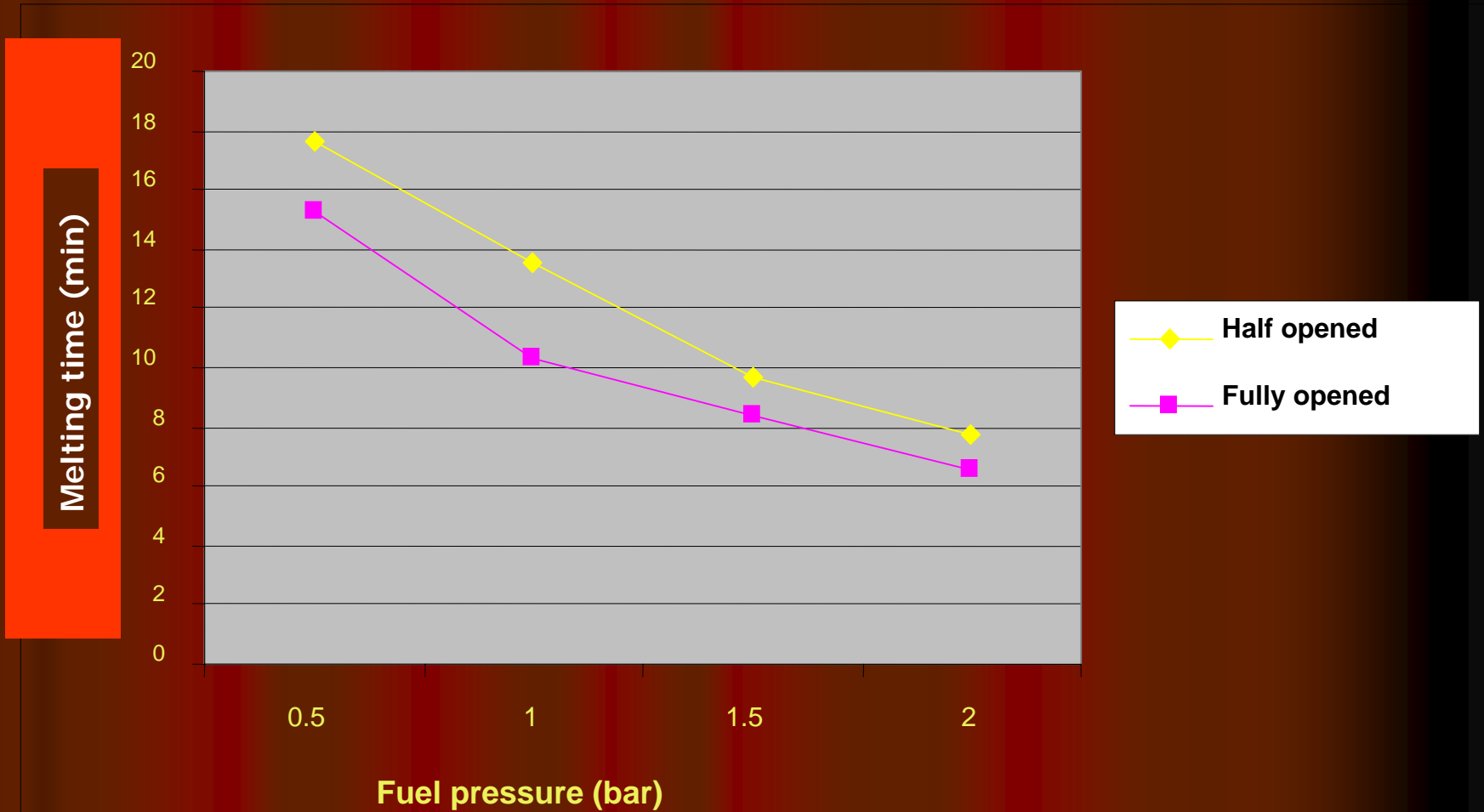
RESULTS AND DISCUSSIONS

Higher fuel pressures and wider valve openings will allow more fuel quantity to the burner due to less flow resistance. If the valve is half opened, the fuel pressure seems to play negligible role in fuel flow, but at fully opened mode, the fuel amount is highly dictated by the fuel pressure.

For lower pressures the influence of valve opening is small (around 18% increase), while for higher pressures the effect is very strong (around 63% escalation).

RESULTS AND DISCUSSIONS

Melting time



RESULTS AND DISCUSSIONS

Higher pressures and wider valve opening will result in shorter melting times due to more fuel flow and more intensive combustion heat. However the decrease is less substantial at higher pressures and wider openings. It is probably caused by non linearity of supplied fuel with generated heat required for melting. In spite of remarkable increase of fuel flow at higher fuel pressures, the decrease of melting time is not as much as expected. The reason is that combustion air is not supplied in the proper amount according to fuel supply but always kept unchanged, therefore the released heat is limited by the incoming air quantity.

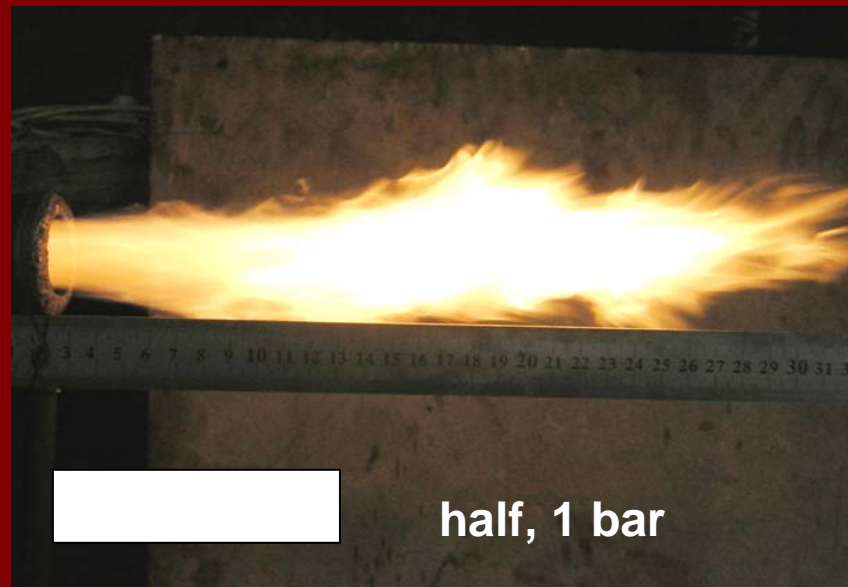
RESULTS AND DISCUSSIONS

Flame length

Fuel pressure (bar)	Half opened		Fully opened	
	Length (cm)	Flame color at burner mouth	Length (cm)	Flame color at burner mouth
0.5	19	Red	27	Yellow
1.0	32	Yellow	29	Blue
1.5	25	Light blue	45	Bright yellow
2.0	24	Blue	50	Bright yellow



half, 0.5 bar



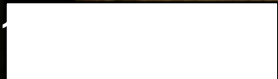
half, 1 bar



half, 1.5 bar



half, 2 bar



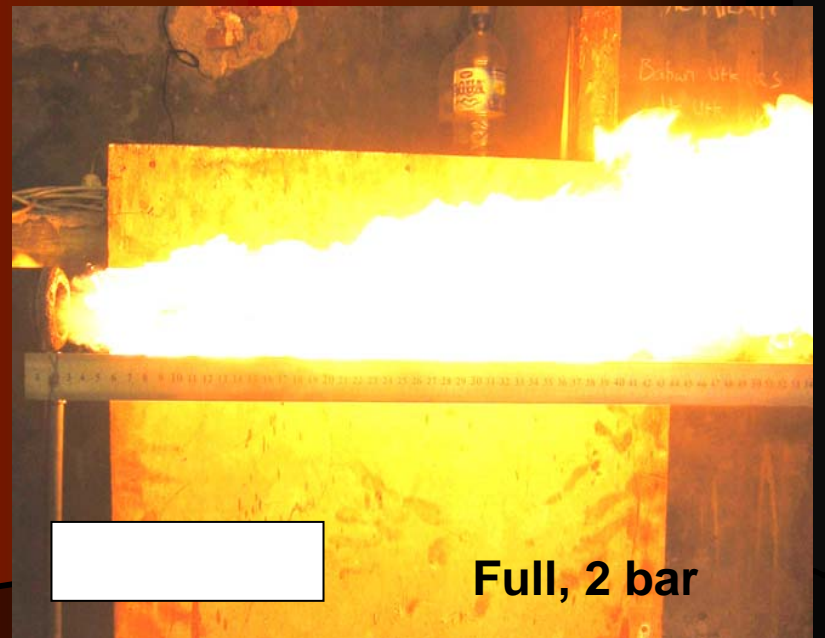
Full, 0.5 bar



Full, 1 bar



Full, 1.5 bar



Full, 2 bar

RESULTS AND DISCUSSIONS

For the same fuel pressures, wider opening will normally lengthen the flame, due to more required time and space to completely oxidize the higher fuel flow rates.

Flame length is important to be investigated for combustion applications because it determines furnace dimension or distance of heated materials.

It seems that the colors represent the temperature or released heat, where red indicates lowest temperatures, while bright yellow corresponds to highest temperatures.

CONCLUSIONS :

- Used lubricant can be utilized as fuel substitute in metal foundries, especially for metals with low melting temperature, such as aluminum.
- Used lubricant must be treated prior to usage to improve its combustion characteristics and remove its heavy metal content.
- The designed burner is appropriate and satisfying
- It is possible to generate high temperatures inside the furnace with some conditions, such as high fuel flow rate (achievable through higher fuel pressure and fully opened valve), appropriate air supply, etc.

ACKNOWLEDGEMENT :

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**THANK YOU
VERY MUCH
FOR YOUR
ATTENTION**