SRI LANKAN TRADITIONAL METHODS AND INSTRUMENTS OF GEUDA HEAT TREATMENT

GAUM

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1. Introduction

Sri Lanka is one of the famous countries for geuda gemstone which has the potential to convert into premium blue colour through heat treatment. There are several types of geuda varieties and their subcategories (for example Diesel geuda could be subdivided into young, normal thick, very thick depending on its appearance under transmitted light). Table 01 shows different types of geuda varieties and their optimum temperatures and environmental conditions for blue colour enhancement.

Table 01: Optimum temperatures and environmental conditions for different types of geuda

Type of Geuda	Heating Temperature (°C)	Condition	Colour after the heat treatment
Ottu	1600 – 1650	Reducing	Blue
Dum Geuda	1600 – 1650		
Diesel Geuda	1750 – 1800		
Milky Geuda	1750 – 1800		
Silky Geuda	1800 – 1900		
Deguna Stones	1050 – 1500	Oxidizing	Red
Kowangu Pushparaga	1800 – 1900		Yellow

Sri Lankan gem traders had used various types of furnaces and instruments for the geuda heat treatment from the end of the nineteens with the knowledge of heat treatment. In the past furnaces were very simple in structure and with the research and development process nowadays even programmable electric furnaces are available for geuda heat treatment. The article endeavors to discuss different types of furnaces and equipment for geuda heat treatment. At the early stages, there were set of furnaces. According to the (Munasinghe, 1993),Thai gas furnace, Toda Furnace and Condor furnace used over the other furnaces in Sri Lanka before Lakmini gas furnace was manufactured.

Table 02:Various types of furnaces (Source: (Themelis, 1992))

Type of Furnace	Type of Fuel	Source of Thermal Energy	Maximum Temperature(°C)
Open-Flame	Gas	Gas + Air	1600 – 1700
		Oxygen + LPG	1700 – 1750+
		Oxygen + LPG + Air	1800 – 1850+
		Acetylene + Oxygen	2800 +
	Solid	Coke + Air	1000 – 1200
		Lignite + Air	1400 – 1600
		Charcoal + Air	900 – 100
	Liquid	Diesel + Air	1600 – 1700
		Diesel + Air + Oxygen	1750 – 1800+
Electric Resistance		Molybdenum Disilicide	1700
		Graphite	2250
Other		RF (radio frequency) Induction	1900+

2. Traditional Methods and Instruments

2.1. Blow Pipe

Most conventional equipment for gem heat treatment was the blowpipe and it uses the injector principle. Although this method is one of the oldest methods of Heat Treatment, Sri Lankan traditional heat traders still use this for various types of gemstones. The blowpipeis used to reduce the blue colour and blue related hue, which causes purplish tint in pink sapphires and rubies since blowpipe produces an oxidizing environment around the crucible. Moreover, it may be used to intensifying the Pushparaga sapphires, weak yellow colour to golden-yellow colour.

The instrument is very simple containing,

- A small metal or bamboo pipe about 2-3 feet in length and about 30 mm in diameter.
- A bowl made out of clay which has a diameter of about 30 cm.
- Another small shallow depth bowl with around 10 cm diameter.

The energy source of the blowpipe is usually charcoal. The large bowl and also small bowls are filled halfway with sand (SiO_2) and the rest with charcoal. In some areas Lime ($CaCO_3$) used as the filling material of bowls. Then place the gemstones into the small bowl, set it on the top of the larger bowl. The maximum temperature claimed about 900^0C and the treatment time varies according to the colour of the stone and the type of stone used (Table 03). Nevertheless, if the stone has more intensified blue overtone, the heat treatment process may require over two days without interruptions. There are some modified blowpipes with a mechanism to provide air without any interruption using a mechanical system (Fig 03).

Table 03: Soaking time for different types of geuda under Blowpipe

Variety	Time
Ottu	0.5 hrs
'Deguna' Stone	4-5 or 1-3 hrs
Zircon	15-10 Min
Green Tourmaline	1-3 hrs

Figure 01: Operation of Blow pipe with one person (Location: Demmuwatta, Ratnapura, Sri Lanka)

Figure 02: Operation of Blow Pipe with two people (Location: Demmuwatta, Ratnapura, Sri Lanka)

Figure 03: Mechanical Blow Pipe (Location: Demmuwatta, Ratnapura, Sri Lanka)

2.2. Toda Furnace

Japanese made Toda furnace was used for the ceramic industry and laboratory thermo-chemical experiments in Japan. Sri Lankan Export Development Board imported Toda furnace to Sri Lanka in 1984 for the experiments of heat treatments of geuda.

The furnace uses oxygen and LPG as the fuel which can be controlled by a set of regulators to produce different temperatures and environmental conditions inside the furnace. Combination of oxygen and LPGand their different ratios adequate to produce about 1800^0C temperature inside the furnace within two hours and a thermocouple is used to measure the temperature.

Toda furnace was very popular in Sri Lanka before the Lakmini furnace was manufactured and used to heat treat every type of geuda since it has a capability to change the atmospheric condition (Oxidizing and Reducing) by changing the oxygen to LPG ratio.

2.3. Condor Furnace

The most common type of furnace use in Thailand and also implemented in Sri Lanka late nineties and still, some of the gem traders use this type of furnace since its simple configuration and convenience of handling. Diesel mixed with air or oxygen use as the fuel and a set of propellers that connected to a motor control the fuel and air volumes injection to the furnace.

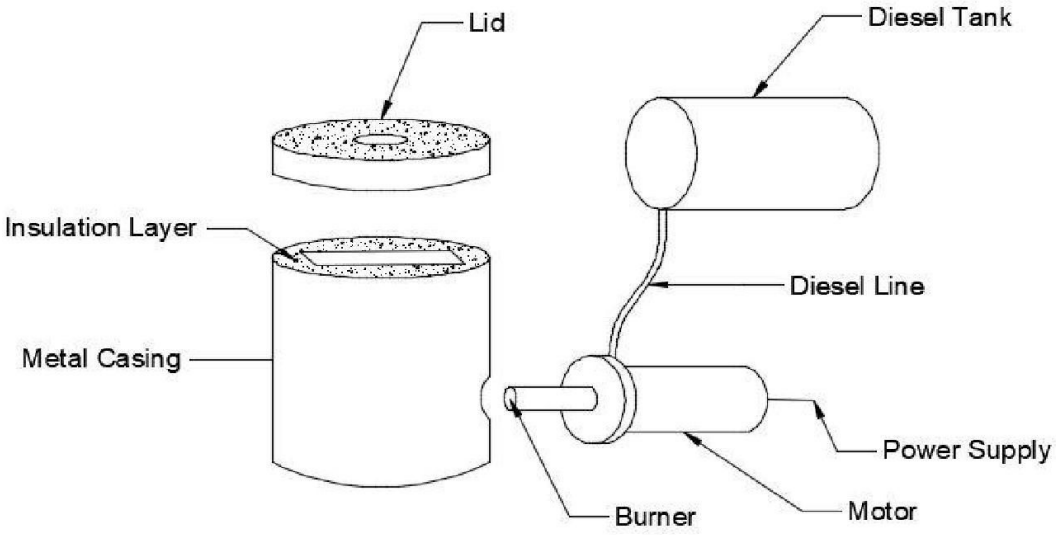

Figure 04: Structure of Condor Furnace

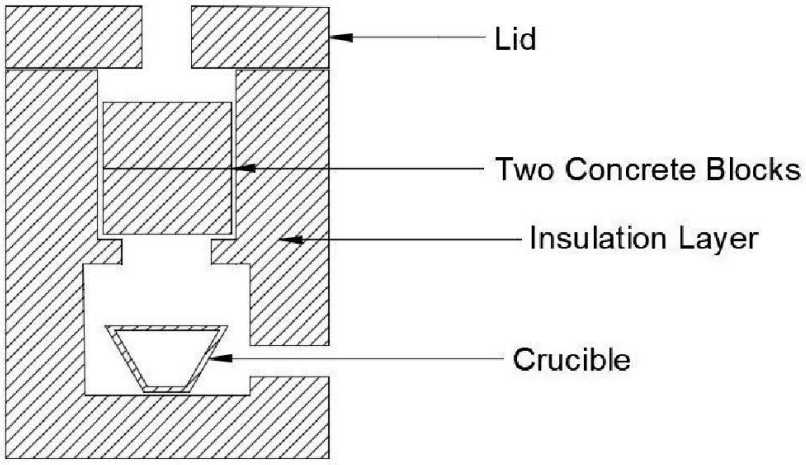

Figure 05: Cross Section of the Condor furnace

Measuring of the temperature inside the furnace is very difficult since it has not got any mechanism to do that and well-experienced people identify the temperature inside the furnace by the colour of the flame. The fan inside the motor provides sufficient turbulence inside the burner to mix oxygen with diesel and oxygen to diesel ratio can change by using the lever near the motor (Fig 06, Right). The maximum temperature that can reach through the furnace is about 1700 ^{0}C

Since the crucible used in the condor furnace is comparatively small coupboard to the furnace, the manufacturer has made two concrete blocks to keep reducing conditions inside the furnace (Fig 07).

Figure 06:Front view (Left) and Back view (Right) of the Condor Burner (Location: Hidallana, Ratnapura)

Figure 07: Plan View of two concrete blocks (Location: Hidallana, Ratnapura)

2.4 Lakmini Furnace

Since Toda France and Condor furnace have some difficulties for importing to Sri Lanka and also they were not designed especially for gemstones heat treatments, Sri Lankan government together with universities, research institutes and private sector manufactured a gas furnace called 'Lakmini' which has a capability to heat treat geuda gemstones under high oxidizing and high reducing conditions. Lakmini furnace manufactured by the Lanka Refractories Limited and it very similar to the Japanese Toda furnace but water cooling dual burner are positioned in horizontally while in Toda furnace contain one vertically oriented water cooling burner.Oxegen and LPG are the fuel for the Lakmini and with the proper combination of both gases can providethe temperatureabove 1800^{0}C within 2-3 hours.

2.3.1. Construction of the Lakmini Furnace

The Lakmini furnace has the main six segments namely,

- The cylindrical part that consists of the furnace chamber
- Box-shaped base
- Two Lids
- Crucibles
- Thermal couple for temperature measurement
- Cooling system

The base consistsa bout 3 cm thickness waler cooling layer and hollow metal part.The air trapped inside hollow metal part act as an insulation layer hence preventsoverheat of the basement. Water cooling system provides sufficient cooling power to the two burners. The burners consist oftwoneedle valve for LPG and Oxegen with the embedded cooling system.

Figure 08: Lakmini furnace (©Uva Wellassa University)

2.3.2. Advantages and Limitation of the Lakmini Furnace

Although Lakmini furnace has the highest popularity among gem traders in Sri Lanka for the convenience of geuda heat treatment, there are advantages as well as some drawbacks in the furnace. When considering the advantages, they can be listed out as follows:

- Durability is high since it constructed with durable metals and materials.
- Price is comparatively low in Sri Lanka compared with other imported gas furnaces.
- Could achieve oxidizing and reducing conditions with proper control of LPG and Oxegen.
- The maximum temperature is above 1800^0C
- Heat loss is minimized due to 3-4 cm width insulation layer and that reduces fuel consumption in the long run.

The first and most affected drawback in the furnace is uneven temperature distribution in verticle profile inside the furnace (Fig 09) and temperature measurement errors. Since burners located close to the bottom of the chamber the temperature at the uppermost parts have less temperature than we expect. If two or more crucibles are placed inside the furnace the non-uniform distribution of temperature effect more significantly and hence colour improvement may not occur in a correct way. Thermo-couple is located in the upper part of the furnace and it is mounted on the furnace wall. Because of its location, the temperature indicates in the display has a deviation from actual temperature inside the furnace.

The next issue occurs if trying to measure the flow rates in each flow meters since they are not calibrated for the oxygen and LPG but for the normal air. According to (Rupasinghe *et al.*, 1993) if the oxygen flow meter shows 40 l/min, the actual value is about 36.5 l/min and for LPG, if the meter reading is 6 l/min, the real value is around 4.25 l/min.

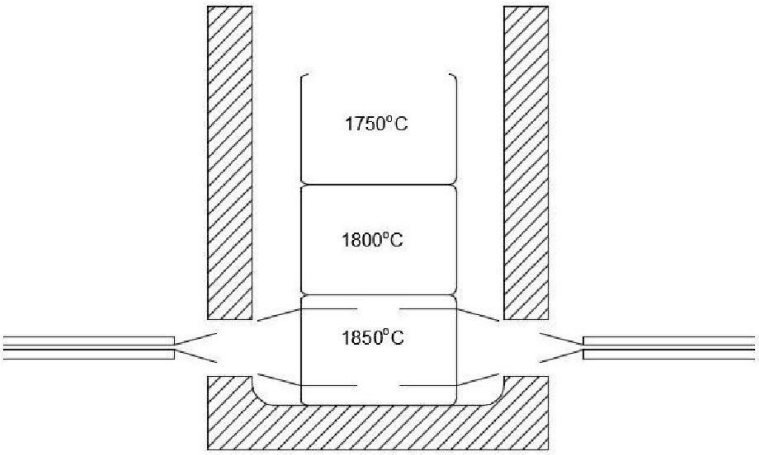

Figure 09: Illustration of temperature distribution in Lakmini Furnace

3. Acknowledgement

I would like to express my gratitude to Uva wellassa University, instrumnt owners in Ratnapura for givin me permition to take photos of the instrumets. Special Thanks goes to Miss.Chulodha Wickramarathna for taking photos in Ratnapura.

4. References

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