# IMPACT OF THE SHAPE OF THE BOTTLE ON THE EFFECTIVENESS OF COOLING AND WARMING OF WATER


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GRADE 5

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# GENESIS OF THE PROJECT

The quest for eternal supply of cold water.

Which could be the ideal bottle shape to hold cool water for longer duration?

Also, does the same shape meet both the requirements?

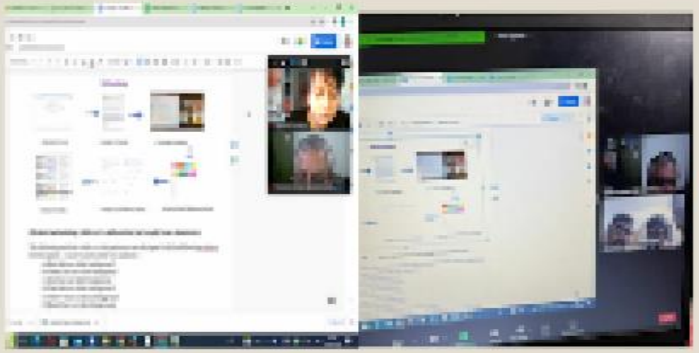
The bottle which cools faster

or

The bottle which retains cool water for a longer period.

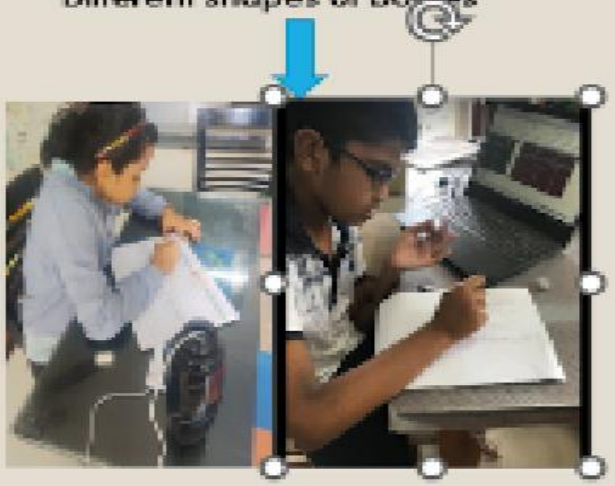
# METHODOLOGY

Survey on shapes of bottles commonly preferred



Orientation

Different shapes of bottles



Measurements and Calculation of SA

Experimental Research

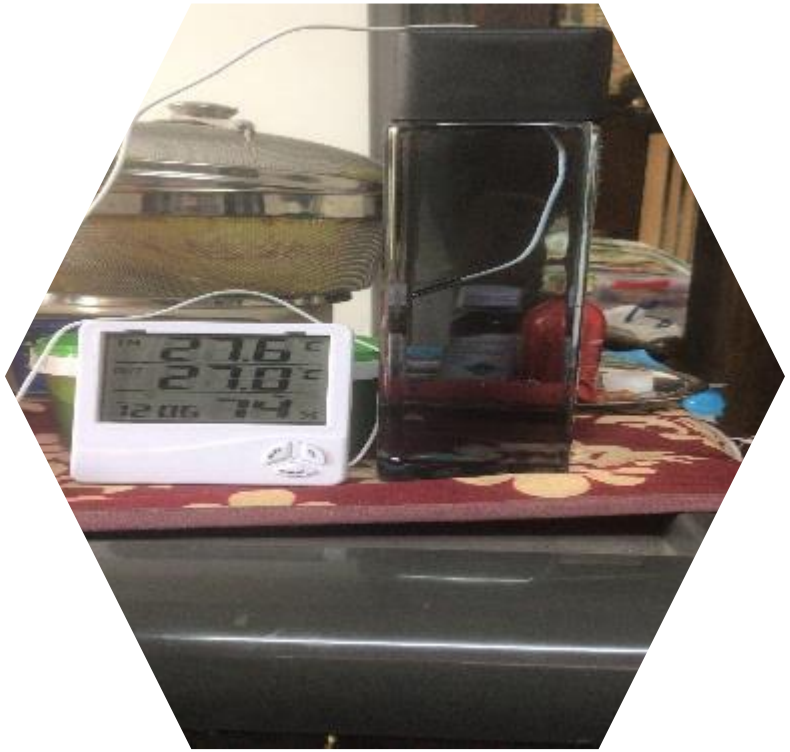
Data Analysis for Cooling and Warming

# METHODOLOGY

- Literature survey to study the present practice
- Customer feedback for the project.
- Select plastic bottles of different shapes (round, square, decagonal, octagonal and rectangular)
- Estimate the surface area of the bottles
- Experimentally study the rate of cooling in the refrigerator
- The rate at which water gets warmer outside the refrigerator with the help of a mobile timer and digital temperature measuring instrument

# METHODOLOGY

- Analyse the data for observing cooling and warming trend with change in shape of the bottles
- Demonstrate the concept and the findings to the customers




# CALCULATION OF SURFACE AREA

**Octagonal Surface Area**

One side was measured using a sheet of Adhesive Paper which was measured using a scale and cut accordingly. Then it was multiplied into 8.

Total Surface Area= Surface area of one strip x 8

= 22cm x 3.3cm x 8

=72.6cm x 8

= 580 sq.cm

# CALCULATION OF SURFACE AREA

**Round Surface Area**

The surface area of the bottle was found by Wrapping it with a sheet of paper and measuring its length and breadth

Length of the sheet =19.2cm

Breadth of the sheet= 24 cm

Surface area =19.2x24

= 460.8 sq.cm

# EXPERIMENTATION (SetI)

## COOLING

| Time(minutes) | Round (Temperature) | Square (Temperature) | Octagon (Temperature) |
|---|---|---|---|
| 0 | 24.43 | 24.3 | 23.9 |
| 60 | 20.13 | 19.67 | 18.77 |
| 120 | 18.1 | 16.27 | 15.57 |
| 180 | 14.77 | 13.9 | 13.63 |
| 240 | 13.13 | 12.7 | 11.7 |
| 300 | 11.6 | 11.53 | 10.9 |
| 360 | 10.97 | 10.93 | 9.87 |
| 420 | 10.53 | 9.93 | |
| 450 | 10.17 | | |

| Average Rate of cooling(minutes/deg.C) | Round | Square | Octagon |
|---|---|---|---|
| | 31.54 | 29.23 | 25.66 |
| Volume of Bottle- ml | 750 | 750 | 750 |
| Lateral Surface Area(cm square) | 427.04 | 522.5 | 580 |

**Outcome:**

1. Octagonal shaped bottle proves to be the best option for cooling water.
2. Round shaped bottles yields lowest cooling rates.

## WARMING

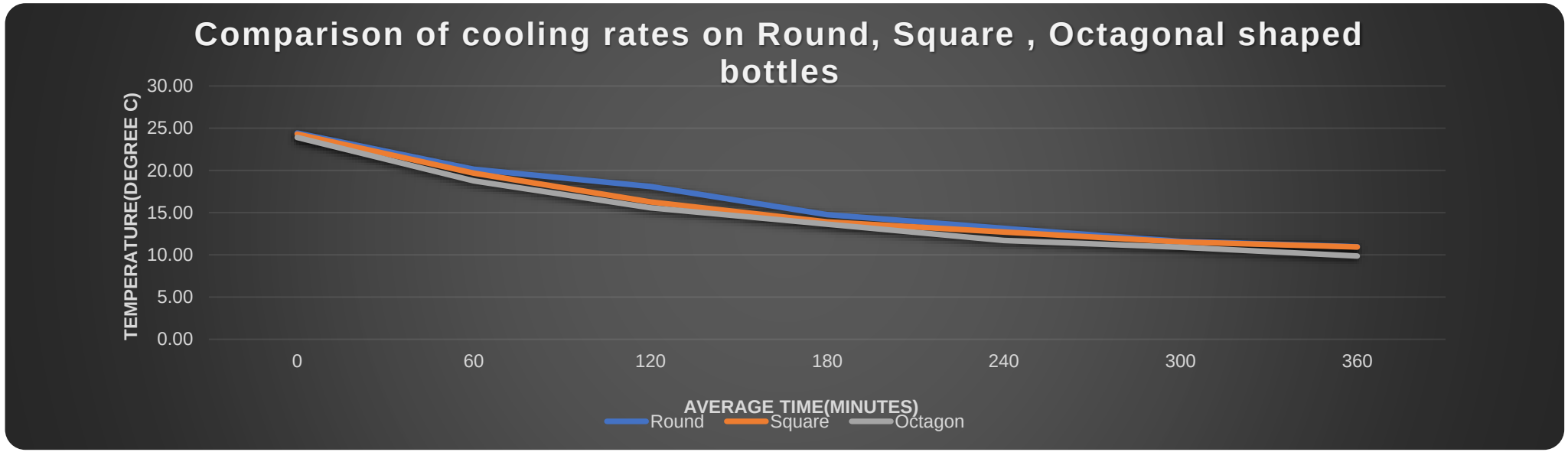
| Time (minutes) | Round (Temperature) | Square (Temperature) | Octagon (Temperature) |
|---|---|---|---|
| 0 | 10.07 | 10 | 9.93 |
| 150 | 16.93 | 17.5 | 17.43 |
| 240 | 20.17 | 20.1 | 20.9 |
| 270 | 21.43 | 21.7 | 22.03 |
| 330 | 22.33 | 22.5 | 22.93 |
| 390 | 22.43 | 23.37 | 23.8 |

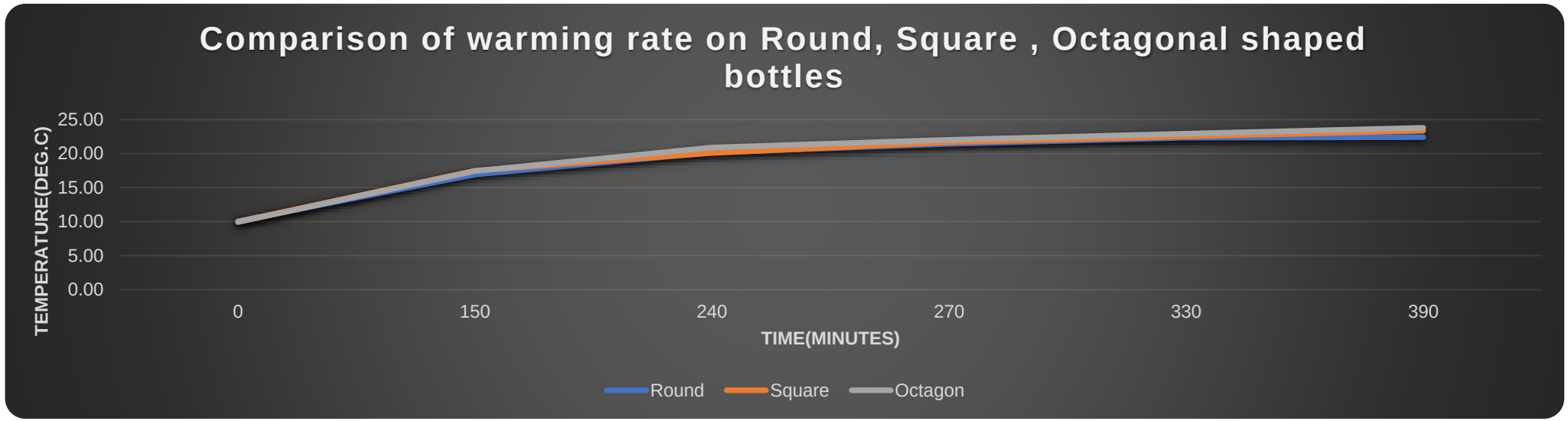
| Average Rate of warming minutes/deg.C) | Round | Square | Octagon |
|---|---|---|---|
| | 31.55 | 29.17 | 28.12 |
| Volume of Bottle-ml | 750 | 750 | 750 |
| Lateral Surface Area(cm square) | 427.04 | 522.5 | 580 |

**Outcome:**

1. Square and octagonal shaped bottles keep water cooler for shorter time than round shaped bottles
2. Round shaped bottles retains cold water for longest time as compared to other shapes.

# GRAPHICAL REPRESENTATION (Set-I)



# EXPERIMENTATION (SetII)

## COOLING

| Temp | Round Time(minutes) | Square Time(minutes) | Rectangle Time(minutes) |
|---|---|---|---|
| 26 | 0 | 0 | 0 |
| 24 | 10 | 16 | 23 |
| 22 | 33 | 31 | 43 |
| 20 | 65 | 55 | 56 |
| 18 | 104 | 79 | 83 |
| 16 | 153 | 127 | 182 |
| 14 | 251 | 153 | 288 |
| 12 | 439 | 260 | 468 |

| Average Rate of cooling(minutes/deg.C) | Round 31.36 | Square 18.57 | Rectangle 33.43 |
|---|---|---|---|
| Volume of Bottle-ml | 1000 | 1000 | 1000 |
| Lateral Surface Area(cm square) | 494 | 635 | 448 |

**Outcome:**

1. Other shaped bottles with lower surface area take comparatively much longer time for cooling
2. Square shaped bottle appear to be the best option for cooling water.
3. Further trials are required to confirm the above findings.

## WARMING

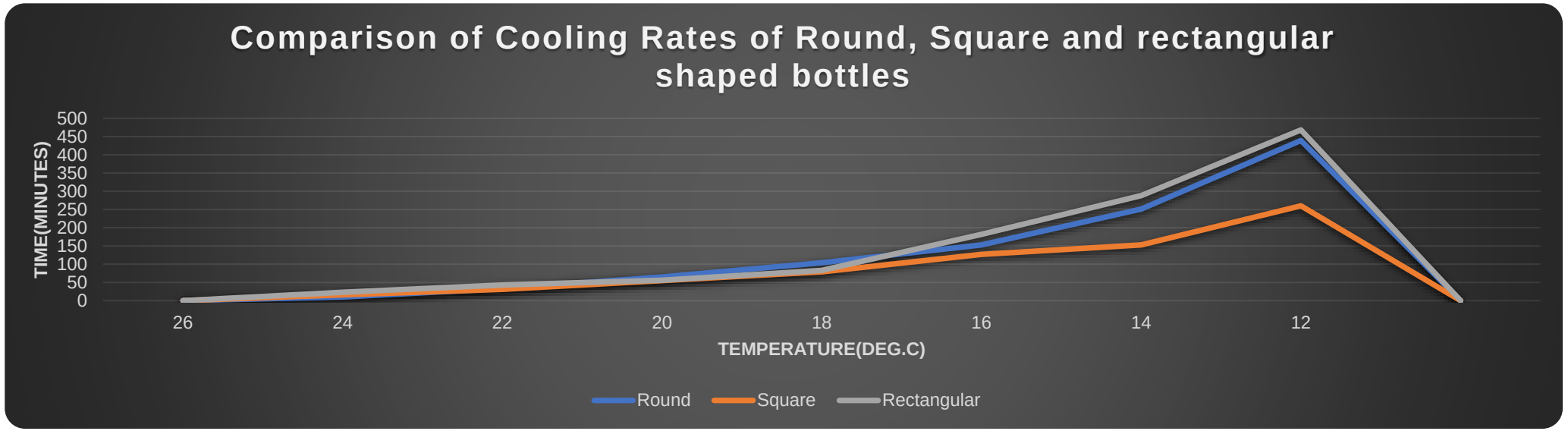
| Temp (minutes) | Round (Temperature) | Square (Temperature) | Rectangular (Temperature) |
|---|---|---|---|
| 12 | 0 | 0 | 0 |
| 14 | 11 | 6 | 11 |
| 16 | 22 | 17 | 25 |
| 18 | 36 | 28 | 43 |
| 20 | 55 | 43 | 65 |
| 22 | 82 | 65 | 97 |
| 24 | 108 | 86 | 170 |
| 26 | 151 | 155 | 228 |
| 28 | 257 | 210 | 321 |

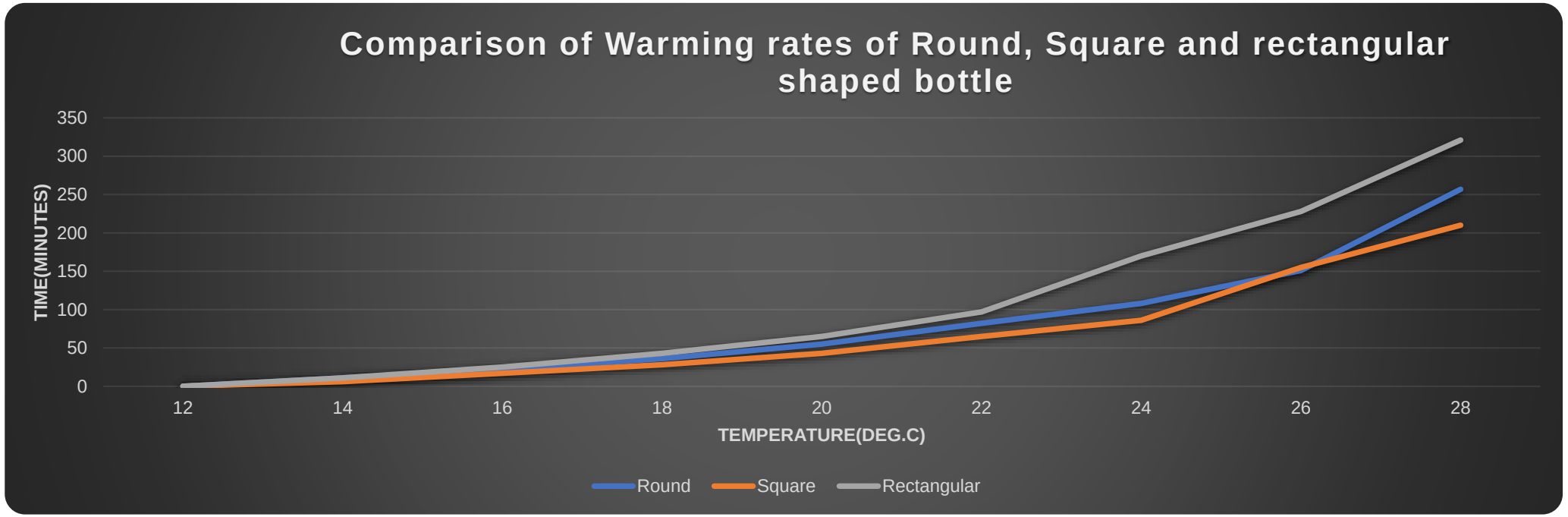
| Average warming Rate(minute/deg.C) | Round 16.06 | Square 13.13 | Rectangle 20.06 |
|---|---|---|---|
| Volume of bottle-ml | 1000 | 1000 | 1000 |
| Lateral Surface area-cm square | 494 | 635 | 448 |

**Outcome:**

Rectangular and round shaped bottles keep water cool for a longer time as the surface area is lower than square shaped bottle

# GRAPHICAL REPRESENTATION (Set-II)



# ANALYSIS OF THE RESULTS AND CONCLUSION

Based on 14 activities conducted so far with different shapes of bottles the following conclusions have been drawn:

1. Round shaped bottle filled with water results in the slowest cooling rate.

2.Octagonal shaped bottles filled with water result in the fastest cooling rate.

3.Cooled water stored in round shaped bottles maintain water cooler for a much longer time than Octagonal shaped bottles.

4.Cooled water stored in octagonal shaped bottles maintain water cooler for a much shorter time than round shaped bottles.

5.Lateral Surface area is a vital factor for heat exchange with surroundings. Larger the surface area for the same volume, faster is the heat exchange.

(Experiments were conducted for two sets. One set was conducted at Chennai and another set was conducted at Bangalore. No. of trials conducted at Chennai is inadequate presently to draw conclusions and hence further trials are being planned.)

# SIGNIFICANCE AND IMPACT

Our findings are in alignment with practical day to day applications as mentioned below:

- Octagonal Bottle has a greater surface area and hence cools faster than round shaped bottles
- But the cylindrical bottle having the least Surface area maintains water cool for a much longer time.
- Hence the conventional practice of using the shape of the bottle for cooling water and for keeping it cool outside is not recommended.

We must use bottles with larger surface area for cooling water and bottles with minimum area for maintaining it cool outside.

# CUSTOMER FEEDBACK

Some Samples of Customer Feedback

- The work done is an excellent demonstration of the fact that heat transfer is proportional to surface area given the same experimental conditions.

- The experiment, proved a thought of the relationship between surface area and cooling which we usually never consider in our day to day aspect. Good invention to adapt in daily needs.

- This project is helpful in our day-to-day life for everyone. Please update once the result has been published. All the best !

# LITERATURE SURVEY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2. https://en.m.wikipedia.org/wiki/Surface-area-to-volume_ratio

3. https://csef.usc.edu/History/2011/Projects/S1824.pdf

4.https://www.quora.com/What-is-surface-area-to-volume-ratio-and-what-role-does-it-play-in-different-applications-like-heat-transfer/answer/Aditya-Pathak-1?ch=15&oid=9215477&share=48558134&srid=uoX3J&target_type=answer

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7. https://thermtest.com/stay-colder-for-longer-in-a-container-made-of-plastic-or-metal

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