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LEARNING GAS-LIQUID REACTIONS USING FLEXAGONS

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ABSTRACT

Flexagon is one of the paper folding techniques used to create different shapes having different faces. This has been extended to simplify the teaching-learning process in Chemical Engineering. A set of two flexagons have been developed which can summarize the entire topic of Gas-Liquid reactions taught in the Chemical Engineering curriculum. It serves a dual purpose with the students getting satisfaction from creating a flexagon and making it extremely simple to memorize the concepts. This may not be restricted to Chemical Engineering but can also be used for other disciplines.

KEYWORDS: Flexagon, Origami, Trihexaflexagon, Chemical Reaction Engineering, Gas-liquid reactions.

INTRODUCTION

Flexagon is a geometric model usually made by paper folding technique. The name is associated with the fact that it can be flexed or folded in certain ways to reveal faces besides the ones which appear on the front. Flexagons are named based on the sides and the faces. For example, tritetraflexagon means that it has three faces and four sides. Similarly a trihexaflexagon has three faces and six sides (hexagon). Flexagons also forms a part of Origami which deals with creating different shapes using paper. Trihexaflexagon was discovered by Arthur Stone – a twenty three year old student while folding left over paper strips in different ways. Flexagons were introduced to the general public by Gardner (1956) in the first Mathematical Games column written by him for a magazine. Different types of flexagons have been extensively used by artists, school teachers and mathematicians to explain or highlight concepts which are connected. Chapman (1961) used square flexagons to simplify mathematical concepts while Pappas (2001) used various flexagons to make mathematics interesting. Cundy and Rollett (1989) used this concept for mathematical modeling. Gupta (2007) used trihexaflexagon to explain Water cycle, Evolution, Butterfly's lifecycle and Food chain in a play way manner in one of his famous series of books – Arvind Gupta Toys. There are several concepts in Chemical Engineering which are interconnected and are often difficult for the students to remember or memorize. Tools like flexagon can not only make this relatively simple but interesting as well. Gas-liquid reactions (Levenspiel, 1999) is one of the fundamental topics of Reaction Engineering taught to the undergraduate students of Chemical Engineering. This topic includes the kinetics of these reactions and the design of reactors. There are fundamental equations related to both these topics which are mandatory for the students to remember. The conventional pedagogy prompts them to literally cram these equations. However, using flexagons it was observed that they are able to remember them much easily. Moreover, both these subtopics can be summarized in two flexagons which practically is as good as saying – "two chapters in two flexagons".

CREATING AN OUTLINE FOR THE FLEXAGON

The skeleton for the trihexaflexagon can be sketched on an A4 size paper. The requirement is that the length to width ratio should be two. Hence a 20 cm × 10 cm strip cut from an A4 size paper should suffice. Divide the width into four equal parts (2.5 cm each) and the length into eight equal parts using faint lines. Draw two diagonals connecting one corner to the opposite corner. Draw six parallel lines to each of the diagonals. This is shown in Figures 1 and 2. These lines originate from the intersection of the horizontal and the vertical lines drawn earlier. On either side of the diagonals there are three parallel lines. Alternatively this can be sketched either in MS Word or Paint.

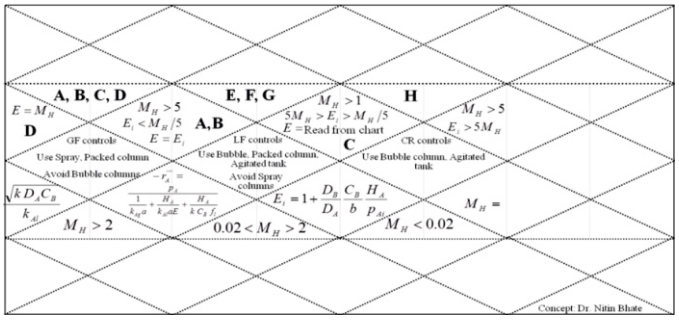

Figure 1: Flexagon for Kinetics of Gas-liquid Reactions

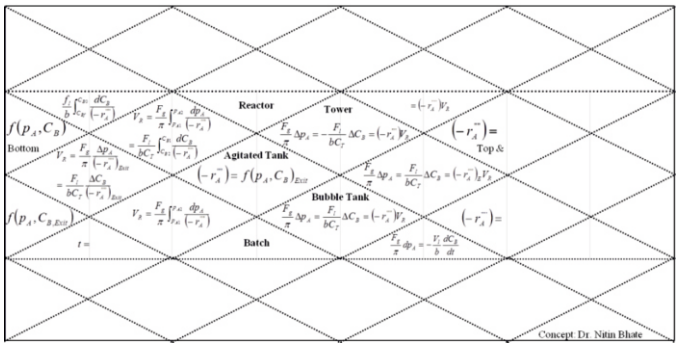

Figure 2: Flexagon for Design of Gas-liquid Reactions

CREATING A TEMPLATE

The templates for the two flexagons developed for kinetics and design of reactors respectively for gas-liquid reactions are shown in Figures 1 and 2. The kinetics of these reactions are divided into eight different regimes (A to H) based on the condition given by M_H (Hatta modulus) and the relationship between M_H and E_i (Enhancement factor). Based on these the regime is identified and the rate determined. Additionally it also helps to identify the controlling resistance (gas film, liquid film or chemical reaction) and selection of contactor. Once the regime and rate are determined and the contactor selected the volume in the case of tower (plug flow) and agitated tank (mixed flow) or time in the case of batch reactor can be determined using the relevant equations. The region between two horizontal dotted lines and six vertical sections from the left is to be used for the content to be included as shown in Figures 1 and 2. Moreover, it is also seen that there are seven diamonds, four half diamonds on the left and the right (sixth vertical line) and three half diamonds near the dotted horizontal lines. The information should be so written that it should be in continuation in the half diamonds.

PROCEDURE FOR FOLDING THE PAPER TO MAKE A FLEXAGON

Figures 1and 2 show two horizontal dotted lines (above and below the text). Fold the paper inside along these lines and turn it on the side of the folds. This essentially means that the side with the folds should be in the front and the written matter at the back (which is not visible). Along the length the paper has been divided into eight equal parts. Fold along the vertical lines on the same side (blank side). Also fold along the diagonals on the same side – five diagonals from top left to bottom right and bottom left to top right respectively. Cut slightly more than one vertical section – eighth section (last section in Figures 1 and 2) and about 1/4th of section seven. Insert the seventh section into the pocket of first section to make a prism. The written matter should be seen from the outside. Crease the top and the bottom edges of the prism inwards. When the folds are at this stage, rotate several times to reinforce the creases. The flexagons are ready to play with and memorize the concepts of gas-liquid reactions (Figure 3).

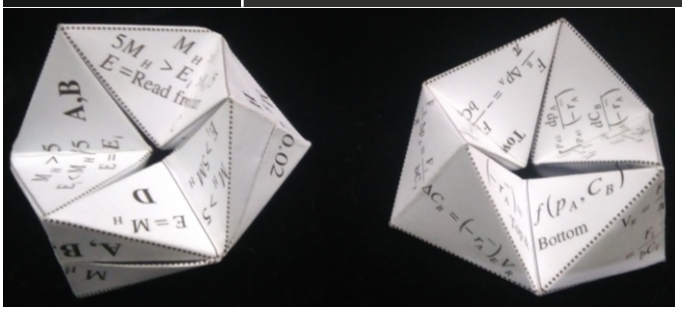

Figure 3: Flexagons for Gas-Liquid Reactions

CONCLUSIONS

It is quite exciting to play with the tool created by one-self. It not only gives and eternal satisfaction but also helps memorize the concepts related to gas-liquid reactions. Additionally this tool can also become a ready reckoner for the students during the exam time. This tool was tried out with the students in the sixth semester (Third Year) of Chemical Engineering at the Maharaja Sayajirao University of Baroda while teaching the subject Chemical Reaction Engineering – II which includes the topics kinetics of gas-liquid reactions and design of contactors. The feedback from the students revealed an overwhelming response. Moreover, the performance of the students in the semester examination was much better than the previous batch. Thus, the innovative use of flexagons in Chemical Engineering can certainly aid the teaching-learning process. The fact that it takes about 5-10 minutes to construct a flexagon it can form an integral part of classroom teaching.

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