U-SIT And Think News Letter - 51

Updates and Commentary

Unified **S**tructured **I**nventive **T**hinking is a problem-solving methodology for creating unconventional perspectives of a problem, and discovering innovative solution concepts, when conventional methodology has waned.

Dear Readers:

. This week's email reveals that there still are readers of the U-SIT and think NewsLetter even after a 14-week hiatus. Thanks.

. I expect to take another break from writing newsletters for a brief period. If you don't get another one in two weeks, assume that I've temporarily aborted this project to finish another project. I shall return.

. Back issues of Spanish translations of the mini-lectures are now bundled.

3. Mini USIT Lecture – 51 USIT – a Method for Solving Engineering-Design Type Problems

Plausible Root Causes lead to new Concepts

In the last mini-lecture I began a discussion of using the plausible root causes heuristic to find new thought paths and to discover new concepts. The plausible root-causes hierarchal diagram for a dripping teabag was developed to two levels and a solution concept was found. A single branch of the diagram was examined terminating on surface tension and porosity.

```
                      weight
                          \
porosity                   to drip – location
     \                    /
to form drip – contact area
     /
surface tension
```

Development of a plausible root-causes hierarchal diagram is based on **questions** we ask ourselves as we rationalize our way to deeper understanding of a phenomenon. Two solution concepts were offered. Both required modifications of surface tension. Two questions came to my mind: The first was, "How do you modify surface tension?" And to answer this a second question arose: "What is surface tension?"

I'll start with the first question. If we propose to increase or decrease surface tension that controls drip formation we need to understand the forces controlling the process. Their name suggests tensile forces in the interface where <u>surface</u> (interface) and <u>tension</u> exist. A forming drip has three interfaces: liquid to vapor, liquid to solid, and solid to vapor. The third interface skirts the boundary of the forming drip while it is still attached to the solid (teabag). (See sketch below of the intersection of three phases: V, L, and S.

Question: What do we know from training and experience? We know that a drop of liquid resting on a solid surface may or may not attach to the surface. Attaching is referred to as wetting. If no wetting occurs the drop forms itself into an unattached ball sitting on the surface. If complete wetting occurs, the liquid spreads across the solid into a thin film. Intermediate degrees of wetting produce a partial ball on a pseudo pedestal.

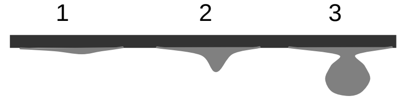
We also know that there are surface-active agents (called surfactants) that are used to control wetting. This leads to the rational that we can modify the surface tension using the attribute *surface activity* of something we can either add to the tea or to the surface of the teabag. (Expert opinion needed here.) We have now reached a next lower level in the plausible-root causes diagram.

Concept: Use a surfactant to modify the surface tension of tea.

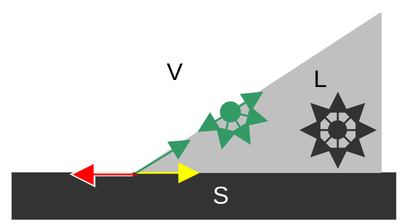
Back to the 2nd **Question**: What is surface tension?

weight
\
porosity   to drip – location
\   /
surface activity   to form drip – contact area
\   /
to alter – surface tension
/
surface tension

It is evident that forces within a liquid hold it together (cohesion) while forces between the liquid and the solid on which it rests spread it out (adhesion).



When a drip starts it first spreads on the surface (1 adhesion) then as it grows, under the influence of gravity (2), it pulls itself into a ball (3 cohesion). Gravity, working against adhesion, causes liquid to collect at the center of a uniformly wetted patch as liquid continues to flow (1, 2). Cohesion of the liquid, working against adhesion, draws the liquid into a necked-down shape (3) that eventually breaks away as a drip when its weight exceeds its adhesion. Hence, surface tension plays several roles since there are several interfaces to consider. In fact, there are three surface tensions at work as mentioned above.



Surface tension of the liquid-vapor (L-V) interface is of particular interest. Note that an interior liquid molecule (black in the sketch) experiences cohesive forces in all directions (black arrows), whereas a surface molecule (green with green arrows) experiences no outward forces resulting in a net inward force. These unbalanced forces at the interface are the source of surface tension. Similar forces exist on surface molecules at the other two interfaces (V-S and L-S). An immediate deduction from this simple analysis is that the only molecules that will assist altering surface tension are interface molecules. So why put a surfactant into tea? It would require less surfactant to coat the solid.

Concept: Coat the teabag with a surfactant to modify its surface tension.

An interesting observation about this thought process is the way we intentionally ignored specification of objects in the plausible root-causes diagrams. This ploy frees our thinking to focus on attributes and what they do. Once they are understood we can look for objects in which to activate the needed attributes.

Another interesting observation is the shape of a developing drip – in particular its necked-down region. Here the only interface is liquid-to-vapor. Over the area of attachment to the solid the interface is liquid-to-solid. The greater the liquid-to-solid surface tension the more the tendency is for the liquid to spread. The greater the liquid-to-vapor surface tension the greater is the tendency to form a neck. Actually, we had already recognized these effects in the last mini-lecture. But now we have improved our understanding and a new question comes to mind.

Question: Why would liquid want to adhere to solid?

We learned a possible answer to this in high school chemistry: like molecules like each other, unlike molecules don't like each other. This heuristic applied particularly to polar and non-polar molecules. Water is a polar molecule. Its two hydrogen atoms are not symmetrically bonded on opposite sides of its oxygen atom. This puts the center of negative charge away from the center of positive charge that is in the nucleus. The separation produces a moment-of-charge making H_2O a polar molecule. Now we have a handle for managing surface tension. For example, water molecules at the surface of a drop are strongly pulled into the drop by surface tension. A "water-like" coating on the material at an L-S interface could increase adhesion and try to spread the water onto the interface, whereas an interface of water-"un-like material" could encourage the water to form into balls.

Molecules that like water are called hydrophilic and those don't like water are called hydrophobic. Surfactants are molecules having both kinds of activity; they have a hydrophilic end (polar) and a hydrophobic end (non-polar). This suggests to me a way of increasing the surface tension of water (contained in tea) on teabag material if the material is made of non-polar molecules.

Concept: Coat non-polar teabag material with a surfactant that attaches its hydrophobic end (non-polar) to the bag material leaving its hydrophilic end (polar) exposed to water molecules in tea. This should increase the adhesion of tea to teabag. [To be discussed with an expert.]

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                                                      weight
                                                          \
                                          porosity          to drip – location
                                              \              /
                           surface activity     to form drip – contact area
                                   \              /
surface tension                      to alter  –  surface tension
      \                            /
    to increase – surface tension
      /
hydrophilic
```

Two other points of contact are available for examination: 2nd) teabag-to-string and 3rd) string- to-tag. Potentially active attributes for string at the 2nd point include …

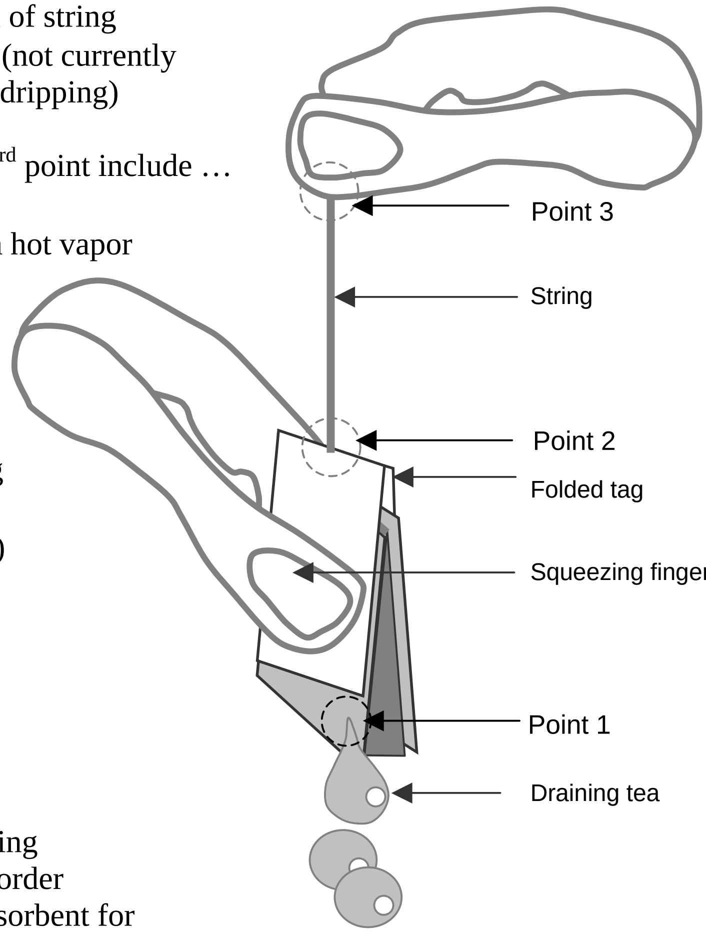
- strength — sufficient to support teabag and undrained liquid
- thermal conductivity — to limit thermal conduction through string to tag
- flexibility — for ease of packaging (not currently active with respect to dripping)

Potentially active attributes of teabag at the 2nd point include …

- strength — sufficient to react pull of string
- flexibility — for ease of packaging (not currently active with respect to dripping)

Potentially active attributes of string at the 3rd point include …

- (same as at point 2nd plus …)
- length — to isolate fingers from hot vapor



Potentially active attributes of tag at the 3rd point include …

- strength — to support string + bag + tea
- size — sufficient for grasping
- friction — to prevent slipping
- flexibility — packaging (not active)

Since string is flexible, attributes at either point can be made available at the 1st point by bringing string or tag to the 1st point. Idea: activate shape and absorbability attributes of tag.

Concept: Grasp string with one hand and bring the tag under the bag with the other hand in order to momentarily delay dripping. Make tag absorbent for this application – activate its absorbability attribute. Modify its shape attribute, give the tag volume with a dimpled shape to hold a few drips.

Another idea: activate shape and mobility of tag.

Concept: Fold tag into a tent-shape and pass string through the crease with a knot tied at its end. Hold the knot in one hand and slide the tag down over the teabag so the teabag can be squeezed to speed draining without mess or discomfort to fingers. (See figure) For this application decrease tag's thermal conductivity attribute, increase its thickness (shape attribute), or decrease its density attribute.

These last two ideas came to mind while listing attributes available at the 2nd and 3rd contact points. No time was taken to construct an appropriate plausible root-causes diagram for either of these two points. I see this as indicative of the wealth of inspiration available in using attributes as metaphors.

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6. Feedback

More nice words:

"Thank you for coming back on line with these most interesting and informative newsletters."

John Dunbar

7. Papers and essays

The following materials can be read by clicking on their titles. Links are also available on the USIT website (www.u-sit.net/Publications)

1. "Injecting Creative Thinking Into Product Flow"
2. "Problem Statement"
3. "Metaphorical Observations"

8. Other Interests

1. Have a look at the USIT textbook, "Unified Structured Inventive Thinking – How to Invent", details may be found at the Ntelleck website: www.u-sit.net (*Note*; not at www.ic.net)
2. USIT Resources Visit www.u-sit.net and click on Registration.

Publications	Language	Translators	Available at …
1. Textbook: **Unified Structured Inventive Thinking – How to Invent**	English	Ed Sickafus (author)	www.u-sit.net
2. eBook: **Unified Structured Inventive Thinking – an Overview**	English	Ed Sickafus (author)	www.u-sit.net
	Japanese	Keishi Kawamo, Shigeomi Koshimizu and Toru Nakagawa	www.osaka-gu.ac.jp/php/nakagawa/TRIZ/
	Korean	Yong-Taek Park	www.ktriza.com/www/usit/register_form.htm
"**Pensamiento Inventivo Estructurado Unificado – Una Apreciación Global**"	Spanish	Juan Carlos Nishiyama y Carlos Eduardo Requena	www.u-sit.net
3. eBook "**Heuristics for Solving Technical Problems – Theory, Derivation, Application**" -- **HSTP**	English	Ed Sickafus (author)	www.u-sit.net
"**Heurísticas para Resolver Problemas técnicos – Teoría Deducción Aplicación**"	Spanish	Juan Carlos Nishiyama y Carlos Eduardo Requena	www.u-sit.net
4. **U-SIT and Think Newsletter**	English	Ed Sickafus (Editor)	www.u-sit.net
	Japanese	Toru Nakagawa and Hideaki Kosha	www.osaka-gu.ac.jp/php/nakagawa/TRIZ/
	Korean	Yong-Taek Park	www.ktriza.com.
Mini-lectures from NL_01 through NL_47	Spanish	Juan Carlos Nishiyama y Carlos Eduardo Requena	www.u-sit.net click on Registration

Please send your feedback and suggestions to Ntelleck@u-sit.net and visit www.u-sit.net

To be creative, U-SIT and think.