**How many times have you seen ballpoint pens, in a pocket or into a bag, leaking their ink and causing a big stain! The ball of the pen tip lets pass ink even when it is not requested, so producing the harmful effect. Let's try to solve this problem with the instruments offered by TRIZ.**

The first step toward the solution is choosing the right problem to solve: for this aim it is helpful to adopt a system thinking approach, i.e. to use the System Operator (paragraph 1.3.3.5). The starting point is the definition of the reference box of the schema, that sets the detail level and the time of the system and of the problem we want to describe, and from which all the others boxes result. The problem is very simple: we have a pen that dirties some cloth or fabric in general; this could be a good choice for the central box of the nine screens. The relative question will be: how can the elements of the system, which are the pen and the cloth or fabric, make that the ink doesn't stain? The others boxes as completed as represented in figure 1.

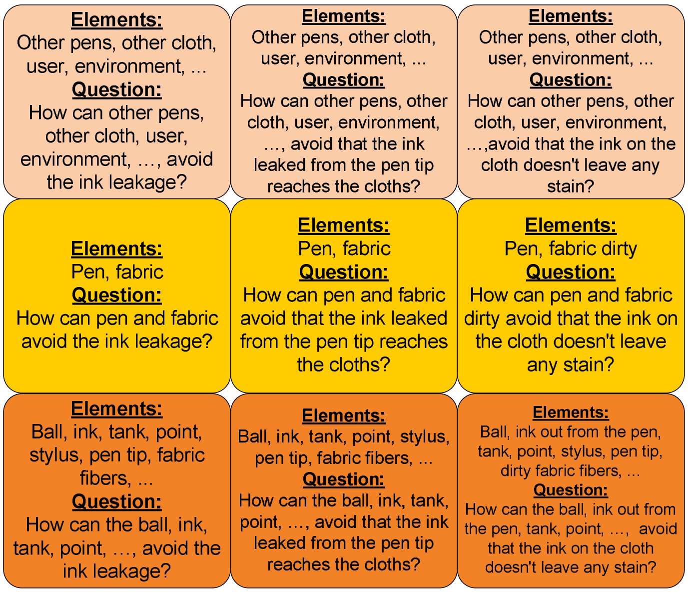


Fig. 1: Searching for roundabout problems: System Operator completed

As you can see, the *past* column, that of the prevention opportunities, represents the time before the ink comes out from its tank so the problem becomes how to stop the ink inside; from the *present* column, standard solutions as a pen cap or a retractable pen tip could be suggested; while on the right column (*future*), i.e. of the mitigation of the problem, the question concerns how to transform a problem into a no-problem, thus even if the ink came out from the pen it doesn't produce any undesired effect.
The next step is choosing the right problem to solve: for example we can consider the subsystem past as the starting problem because we have a lot of possible subjects able to solve it, and it is better to prevent some problems than to try to solve them when they are already happened. So it is useful to build a functional model of this initial situation.



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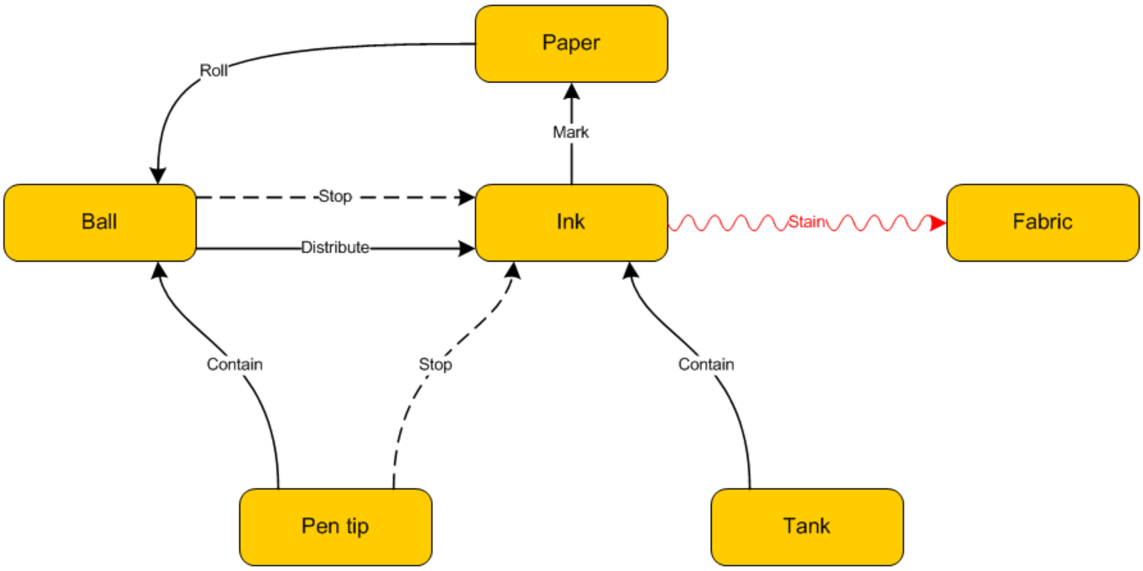


***Fig. 2**: Functional model describing the situation in the Sub-System Past box of the System Operator*

As you can see there are three critical functions: two insufficient and one harmful that is the main problem to solve. At this point we can formulate the IFR of the situation, starting from the element that causes the harmful function, the ink. ARIZ (chapter 3) suggests that this element, by itself and without worsening the system, at the time requested, solve the problem generated; in our specific situation this becomes: the ink, by itself without worsening the pen, when writing isn't needed, avoids coming out from the tank. This is our goal, our best result even if it could seem slightly fanciful. Now we have to ask why it is not possible to reach the IFR, taking into consideration all the available resources we have, in order to find one or more contradiction to be solved. Focusing the attention on the ink, one of the cause of its leakage is the ink fluidity: in fact if the ink wasn't liquid, it won't leak from the tank and so it won't cause the stain, but the main useful function won't be developed any more, or not as well as we want. We have a contradiction, as represented in figure 3.

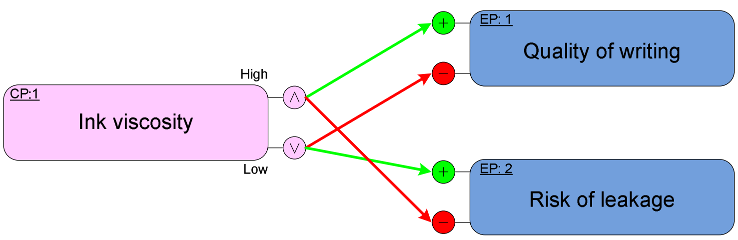


**Fig. 3**: the OTSM contradiction model (paragraph 5.1.2)

We can represent the two sides of the contradiction also with a functional model, in order to see which element and sub-functions of the system are involved by the modification of the control parameter.

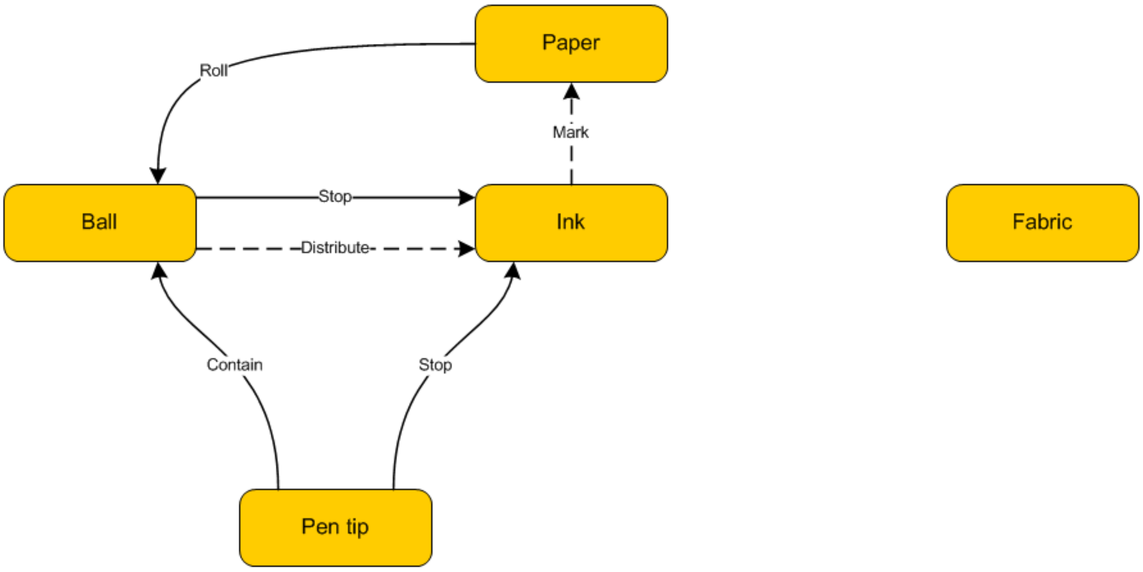


Fig. 4: Functional model with the CP "ink viscosity" at the opposite value than actual

Now we can try to solve this contradiction starting from the definition of Operational Zone and Operational Time. The Operational Zone can be considered as the sum of the external surface of the ball, the internal surface of the point, the amount of ink near the ball, the rest of the ink into the tank and the surface of the paper. While the Operational time is the interval when the ball rolls, i.e. the time when we want to write, and the period when the ball doesn't roll, i.e. when we don't want to write. The next step, following ARIZ suggestions, is the exaggeration of the conflict: to overcome some psychological barriers it is needed to bring the opposite values of the Control Parameter in contradiction at their extreme, thus the ink viscosity must be imagined as infinity or equal to zero. What does it mean an infinity viscosity? We can translate it as the ink wasn't fluid anymore, i.e. the ink is solid. This could suggest to the use of a pencil instead of a pen. On the other side we have to imagine a viscosity very low almost zero, i.e. as a gas. We can imagine a mixture of a transparent alcohol with solid particles: the alcohol evaporates in contact with air and the solid particles create a stopper on the point for the rest if the ink.

Other solutions could be suggested by the application of the Separation Principles (paragraph 5.3). Start with the separation in time. Is it true that a high value of the viscosity is needed in the whole operational time, and a low value of the viscosity is required during the whole operational time? It is obvious that the answer is "No", so we can apply the separation principle. We would desire a high value of ink viscosity when the ball doesn't roll in order to prevent accidental leakage of ink, and we want a low value of ink viscosity when the ball rolls, so when the pen is writing. Any idea? Let's continue…

To apply the separation in space we have to answer "No" also to this question: is it true that we need a high value of ink viscosity in the whole operative zone, and we want a low value of this viscosity in the whole operative zone? This time the answer is "Yes", so we can't separate in space.

The third principle is that of the separation on condition: in which condition do we want a high ink viscosity, and in which one do we want a low viscosity? If the pen is writing, i.e. if the pen is moving, we need a low ink viscosity, while if the pen is still viscosity has to be high. Is it possible to change viscosity with movement? Taking into consideration the Effect Database, a tool of the TRIZ Knowledge Base, we can find that some fluids could have a property called "tixotropy": if some kinetic energy is provided viscosity of the fluid decreases, and it increases again if the fluid is still. In lifetime we use a lot of substances with this property: toothpaste, honey, ketchup and paint. Even if this could be a strange solution, one of the famous brands of ballpoint pen uses this kind of ink (see figure 5).

*Fig. 5*: the famous pen with tyxotropic ink

Now if we take into account again the functional model represented in Fig. 2, at the left side there are two insufficient functions: the ball and the point doesn't stop in a sufficient manner the ink. Why? What are the Control Parameters responsible of this failure? Among the others, one CP, that could be the same for both the functions, is the clearance between the pen tip and the ball: if it is too large, the ink could leak also when the pen is not writing. But what happens if the clearance is close? The ink doesn't come out any more, but probably the ball is no more able to distribute in a sufficient way the ink when it is requested and so the writing is no more fluent as before. So we have another contradiction, represented in Fig. 6.

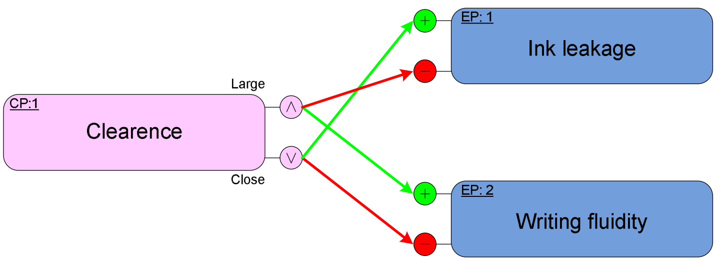


***Fig. 6:*** *the OTSM representation of the contradiction*

As already seen before we have to define the Operational Zone and the Operational Time of the contradiction: the first one is the sum of the internal surface of the pen tip and the external surface of the ball; while the Operational Time could be considered as the sum of the period when the ball is rolling and the period when it is still. The next step is the exaggeration of the conflict: how is it possible to write with the ball stuck to the point (clearance equal to zero)? Or how can we imagine a very large clearance between the ball and the point? For example we can trim directly the ball and to let completely open the channel within the point. Try to think some solution starting from these suggestions.
Now the Separation Principles are the tool to apply to solve the contradiction. The first one is that on time: is it true that the clearance is needed large and close during the whole operational



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time? The answer is “No”, because we need a large clearance when the ball is rolling, i.e. when the pen is writing, and a close one when the ball is still. How can we realize this separation? For example if a spring is put behind the ball, when the user pushes the pen on the paper the ball goes back creating a bigger clearance, and when the pen is not writing the spring pushes the ball against the cone of the point closing the clearance and so the ink cannot come out (see Fig. 7).

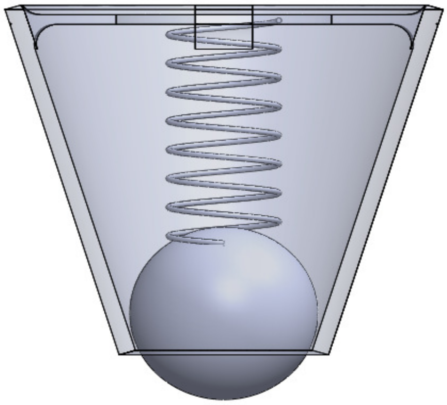

**Fig. 7**: a schematic model of the proposed solution

Such a preliminary concept can be further evolved by analyzing with a System Operator approach which resources already available within the system can play the role of the spring (e.g. thanks to internal elasticity?).

To apply the second separation principle (i.e. separation in space), the question “is it true that we want a large and close clearance in whole operational space?” must have a negative answer. This time yet, the answer is “yes”, so we can’t apply the separation principle.
We can apply neither the third separation principle, because there aren’t any different conditions in which it is better to have a large clearance than a closer one.
The fourth principle is that in system level, or macro to micro level: how can we have macroscopically a large clearance and microscopically a close one? Or better vice versa: can we have at macro level a closer clearance and at micro level a larger one? A possible way to reach this situation is to have a ball realized as a golf ball, i.e. a ball with some cavities on the surface: the diameter of the ball close any clearance with the pen tip and so the ink couldn’t leak, but if ball is rolling the cavities carry the ink from the tank to the paper so the pen could normally write.

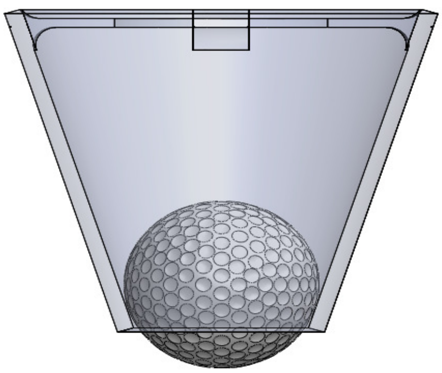

**Fig. 8:** the suggested solution – a cross-section of the point and the golf like ball