Finding innovative solutions to engineering problems using CES and TRIZ

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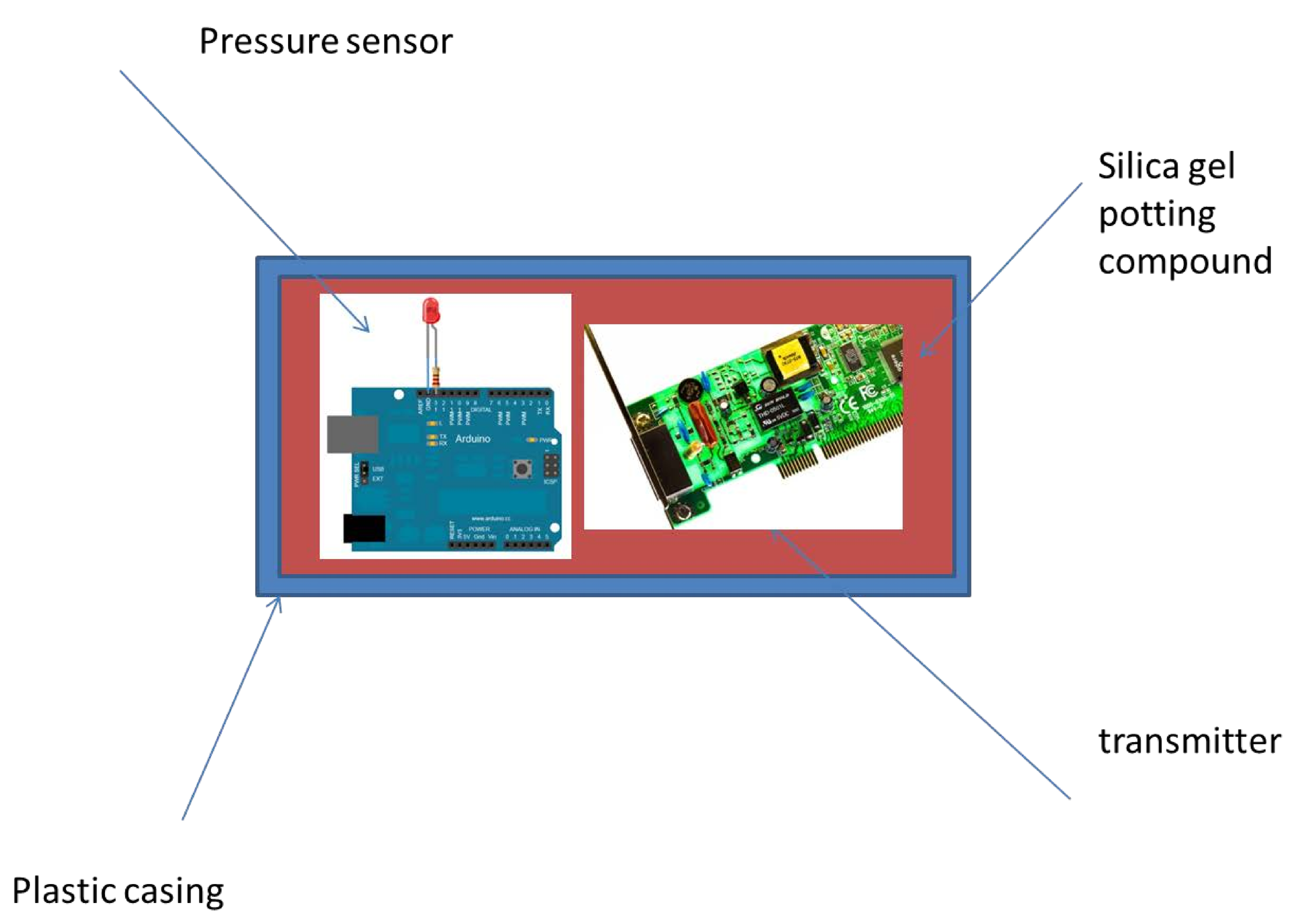
Problem

This work explores possible solutions to the failure in operation of a pressure sensing device. The device operates inside the tyre of heavy earth moving equipment and is subject to temperature variations and exposure to fluids such as antifreeze. During extended operation it was observed that the device started to read higher values of pressure in time.
The sensor and transmitter device are shown schematically below.



Initial investigation of failed sensors appeared to show some corrosion on the pressure sensor and it was assumed this was the reason for the increase in its reading.

Cambridge Engineering Selector Edupack was used to select materials with increased resistance to antifreeze and moisture but further work looked for other solutions.

TRIZ Methodology

TRIZ is the Russian acronym for "Teoriya Resheniya Izobretatelskikh Zadatch" (теория решения изобретательских задач) meaning the 'Theory of Inventive Problem Solving. It was developed after 1946 by soviet inventor and science fiction author Genrich Altshuller and his colleagues.
TRIZ is

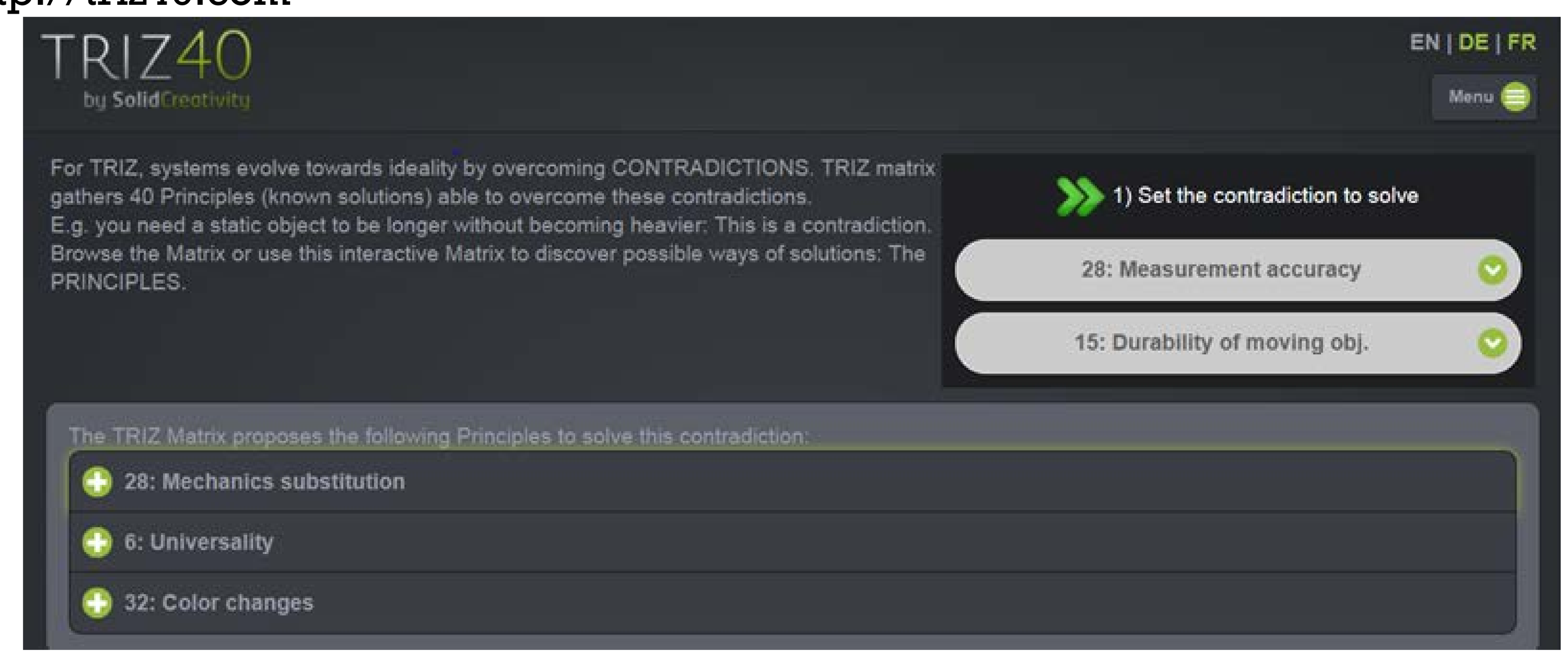
- A body of knowledge gained from the systematic examination of successful patents that can be utilised by problem solving teams
- A series of tools and publically accessible databases that can be used to help in the problem solving and innovation process
- A technique which has found applicability in many areas including engineering, architecture and construction, business management, product design and many more for problem solving and innovation

There are 40 so called Inventive Principles that can be adapted to many scenarios. These 40 principles are based on solutions which consistently appeared in the systematic evaluation of patents. They cover broad areas and databases give examples of how principles have been sub-divided and applied.

Nos 1-10	Nos 11-20	Nos 21-30	Nos 31-40
1. Segmentation	11. Cushion in advance	21. Rushing Through (or Skipping)	31. Porous materials
2. Taking Out	12. Equipotentiality	22. Blessing in Disguise	32. Colour Changes
3. Local Quality	13. The other way around	23. Feedback	33. Homogeneity
4. Asymmetry	14. Spheroidality – Curvature	24. Intermediary	34. Discarding and Recovering
5. Merging	15. Dynamics	25. Self-service	35. Parameter change
6. Universality	16. Partial or Excessive Action	26. Copying	36. Phase transition
7. Nested Doll	17. Another Dimension	27. Cheap short-living objects	37. Thermal Expansion (or contraction)
8. Anti-weight	18. Mechanical Vibration	28. Replace mechanical System	38. Accelerate Oxidation (or use of strong oxidants)
9. Prior Counteraction	19. Periodic Action	29. Pneumatics and Hydraulics	39. Inert Atmosphere (or Environment)
10. Prior Action	20. Continuity of Useful Action	30. Flexible Shells and Thin Films	40. Composite materials

TRIZ 40 Inventive Principles

TRIZ methodology was used to investigate contradictions between measurement accuracy and durability. The best solutions from the 40 principles are easily found using a website http://triz40.com



The solutions offered below act as triggers

28: Mechanics substitution
- Replace a mechanical means with a sensory (optical, acoustic, taste or smell) means.
- Use electric, magnetic and electromagnetic fields to interact with the object.
- Change from static to movable fields, from unstructured fields to those having structure.
- Use fields in conjunction with field-activated (e.g. ferromagnetic) particles.

6: Universality
- Make a part or object perform multiple functions; eliminate the need for other parts.

32: Colour changes
- Change the colour of an object or its external environment.
- Change the transparency of an object or its external environment.

This prompted investigation into different ways of measuring pressure using a TRIZ effects database http://triz.co.uk/triz-effects-database

58 suggestions for Measure Pressure

Acoustic Emission	Elasticity	Newton's Rings	Shadowgraph
Acoustics	Electret	Optical Fibre	Speed of Sound
Adiabatic Cooling	Electric Spark	Pascal's Law	Spring
Adiabatic Heating	Electrohydrodynamics	Permeation	Suction
Auxetic Materials	Electromechanical Film	Photoelasticity	Surface Acoustic Wave
Auxetic Structures	Electropermanent Magnet	Piezoelectric Effect	Triboluminescence
Bernoulli Effect	Gel	Piezoluminescence	Turbine
Bourdon Spring	Hooke's Law	Piezoresistive Effect	Valve
Boyle's Law	Laser Microphone	Pitot Tube	Vapour Cone
Brillouin Scattering	Liquid Crystals	Plasticity	Villari Effect
Bubble	Magnetoelastic Effects	Pressure Gradient	Water Turbine
Capacitance	Microelectromechanical Systems	Pressure-sensitive Paint	Weak Point
Corona Discharge	Moiré Effect	Reaction (physics)	Wheatstone Bridge
Curie Point (ferromagnetic)	Moiré Interferometry	Regelation	
Elastic Recovery	Nagaoka-Honda Effect	Rubber Band Thermodynamics	

Concluding comments

Several options were explored. One intriguing solution involved the potential use of smart colour change materials which would do away completely with an electro-mechanical device. Internet research found a material from:

http://materia.nl/article/colour-changing-smart-material/

A colour change insert in the wall of a tyre could easily be used.

TRIZ has many other tools not discussed here.
- Nine boxes
- Trends in Technical Evolution
- Smart little people
- Ideal Final Solution
- Resources
- Function Analysis
- 76 standard solutions

The above techniques form part of a comprehensive toolkit for innovative problem solving.

TRIZ methodology in conjunction with other techniques can help students come up with innovative solutions to engineering and materials problems.

TRIZ is being adopted by several companies that the author has dealings with. It is even taught to Russian schoolchildren.

Maybe a TRIZ element in the CES Edupack could be of value.

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