整合專利資訊與TRIZ的創新設計程序

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—TRIZ創意問題解決及公理設計之產品開發應用
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徐業良個人簡介

Education

- National Taiwan University, Mechanical Engineering, B.S., 1981/09-1985/06.
- Stanford University, of Mechanical Engineering, M.S., 1987/09-1988/06.
- Stanford University, Mechanical Engineering, Ph.D., 1989/07-1992/06.

Experience

- Professor, Department of Mechanical Engineering, Yuan Ze University, 2001/02-present.
- Secretary General, Yuan Ze University, 2005/08-present.
- Director, Gerontechnology Research Center, Yuan Ze University, 2000/08-present.
- Chairman, Department of Mechanical Engineering, Yuan Ze University, 1999/08-2005/07.
- Director, Office of Physical Education, Yuan Ze University, 2002/08-2005/07.
- Columnist, Car Magazine, 1995/06-present.
- Dean, Office of Information Services, Yuan Ze University, 1997/08-1999/07.

Research Interest

Mechanical Design, Design Optimization, Gerontechnology

Systematic product design processes

- Systematic product design processes often start with ***need finding***, ***specification development***, ***conceptual design***, ***detail design***, to ***production***.
- Such design processes are very useful for ***innovative design***.
- Innovative design methodologies such as analogy, brain storming, TRIZ are often used to ***generate the design solutions***.

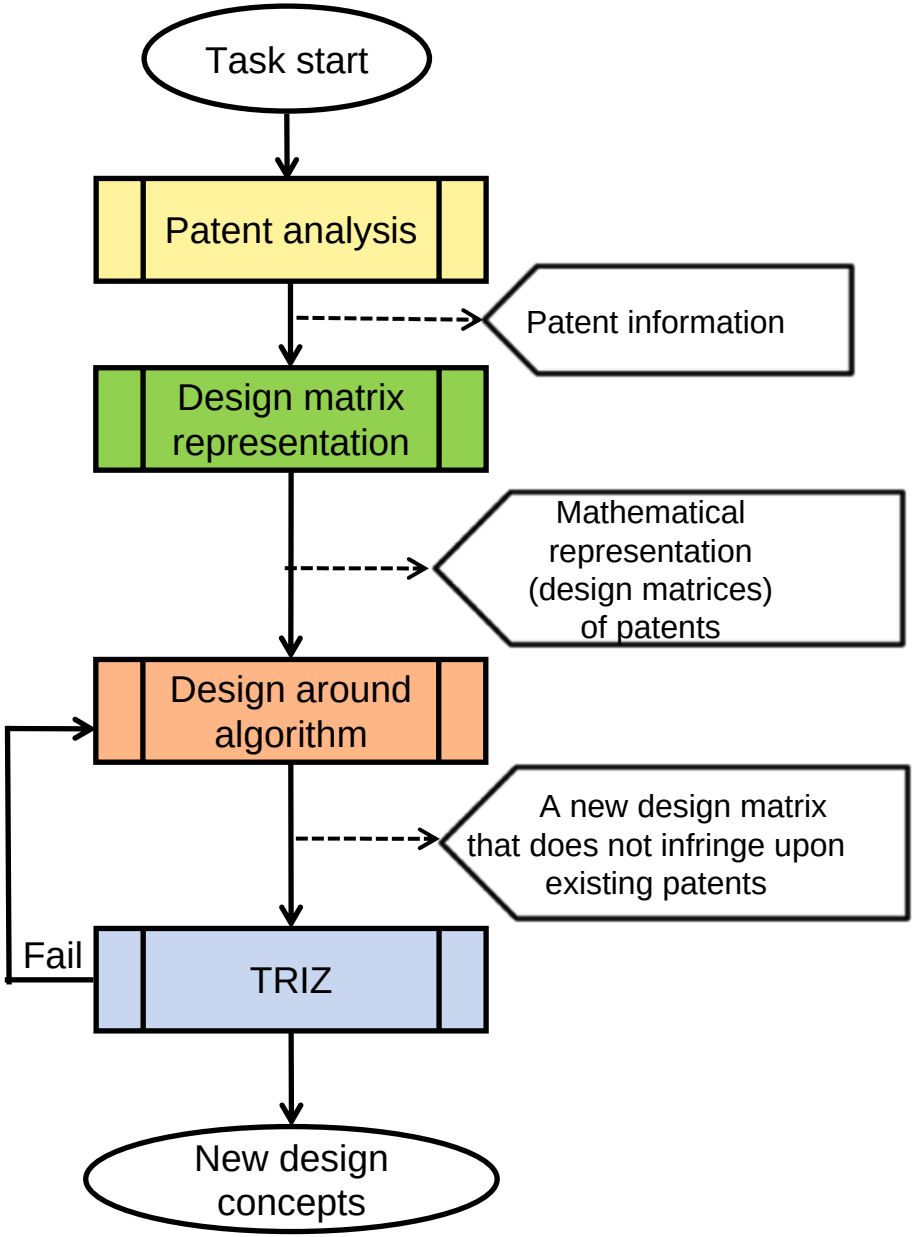
Design problem faced by industries

- ***Patent infringement*** has become an important issue for industries when developing products.
- The design problem constantly faced by engineering designers across industries is ***how to design around existing patents***.
- This type of design problem is often a ***local innovation*** of an existing patent.
- The ***rules of patent infringement judgment*** present the major constraints to such design problems.
- In the mean time, patent information is often not fully utilized by engineering designers.

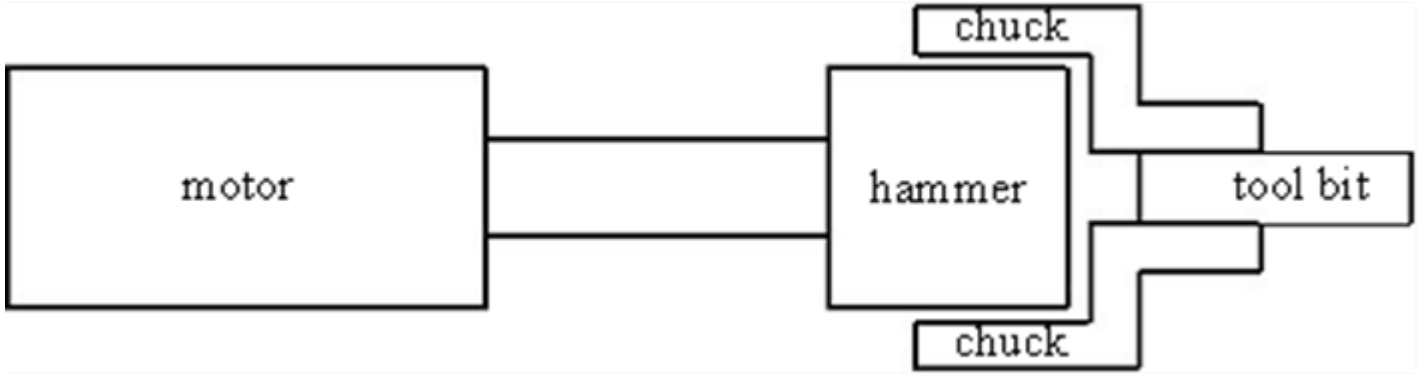
Purposes of the research

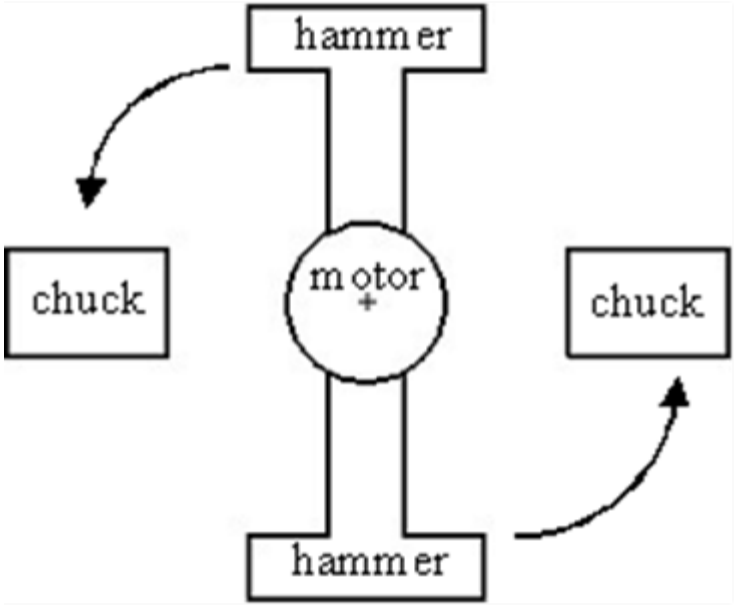
- This research proposes a ***patent-based design process*** by systematically integrating patent information, the rules of patent infringement judgment, strategies of designing around patents, and innovation design methodologies.
- The purpose of the process is to generate a new design concept that is ***a slight variation of one of the concerned patents*** but does not infringe with existing patents.
- The basic idea is to consider patent infringement before engineering design concepts are actually generated.
- Think of “What” before “How”.

The patent-based design process

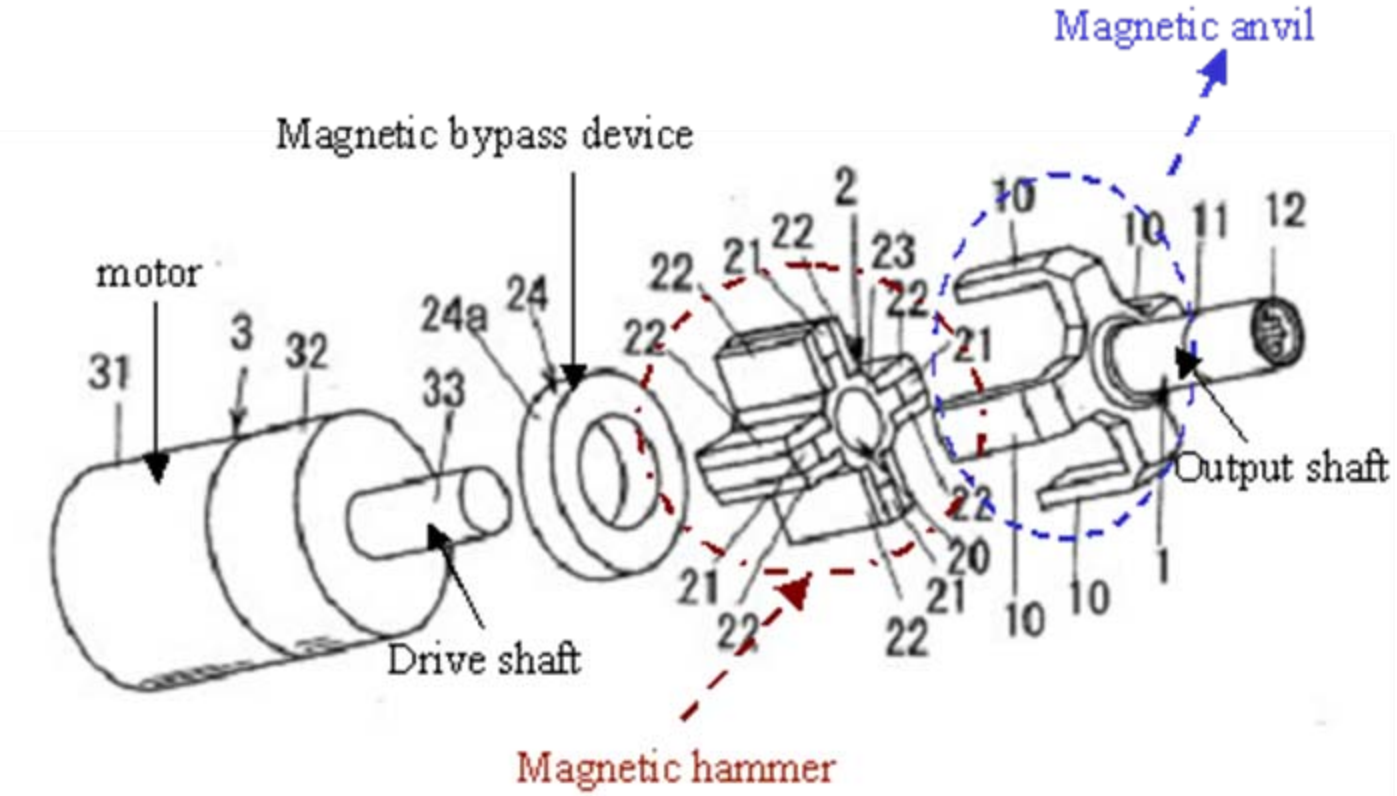


The portable magnetic impact tool design problem





U.S. Patent 6,918,449



Patent analysis

Patent search and screen → **Develop the abstract lists of patents** → **Develop technology/function matrix**

Title	Magnetic impact tool				
Patent No.	U.S. 6,918,449	Date of field	2004/3/24	Date of issued	2005/7/19
Assignee	Matsushita Electric Works, Ltd.		Inventors	Shinagawa; Sou, Nakayama; Satoshi, Sekino; Fumiaki	
Analyst	David	Keywords	magnetic, impact, rotate		
UPC	173/2; 173/117; 173/176; 173/213; 173/93	IPC	B25B 21/02; H02K 7/14; H02K 7/10; H02 H02	Date of analysis	2006/7/1

Functions of the patent

- Tighten/ loosen screw
- Generate impact torque
- Change magnetic flux

Results of the patent

The present applicants have previously prop
screws are tightened by using magnetic coupling
and obtaining a tightening rotational impact force

Means for solution, composition and important fig

- During the screw-tightening work, when the load torque is initially low, the magnetic

Functions / Technologies	Tighten/ loosen screw	Generate impact torque	Change magnetic flux
Motor	●	●	
Magnetic hammer	●	●	
Magnetic anvil	●	●	
Drive shaft	●	●	
Output shaft	●		
Magnetic bypass device			●
Changing device			●

Design matrix representation (1/2)

Axiomatic design

Axiomatic design is a system design methodology using a ***matrix method*** to analyze the transformation of ***functional requirements (FRs)*** into ***design parameters (DPs)***.

$$FR_i = \sum_{j=1}^{n} A_{ij} DP_j$$ ⇐ **Design equation**

$$[A] = \begin{bmatrix} a_{11} & \dots & a_{1n} \\ \vdots & \dots & \vdots \\ a_{m1} & \dots & a_{mn} \end{bmatrix}$$ ⇐ **Design matrix**

(The components in the design matrix are either "0" or "1".)

Example:

$$\begin{Bmatrix} FR_1 \\ FR_2 \end{Bmatrix} = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \end{Bmatrix}$$

Design matrix representation

In the "technology/function" matrix, the "***technologies***" resemble the ***DPs***, and the "***functions***" resemble the ***FRs***.

$$FR_i = \sum_{j=1}^{n} (T_i A_{ij}) DP_j$$ ⇐ **Design equation in this research**

Where **T** is the ***transformation matrix*** which transfers the DRs into FRs.

Example:

$$FR_1 = T_1(DP_1 + DP_2)$$

This equation above means that transforming DP_1 and DP_2 to achieve function FR_1.

Design matrix representation (2/2)

FRs

FR_1 = Tighten/ loosen screw
FR_2 = Generate impact torque
FR_3 = Change magnetic flux

DPs

DP_1 = Motor
DP_2 = Drive shaft
DP_3 = Magnetic hammer
DP_4 = Magnetic anvil
DP_5 = Output shaft
DP_6 = Magnetic bypass device
DP_7 = Changing device

Design equation

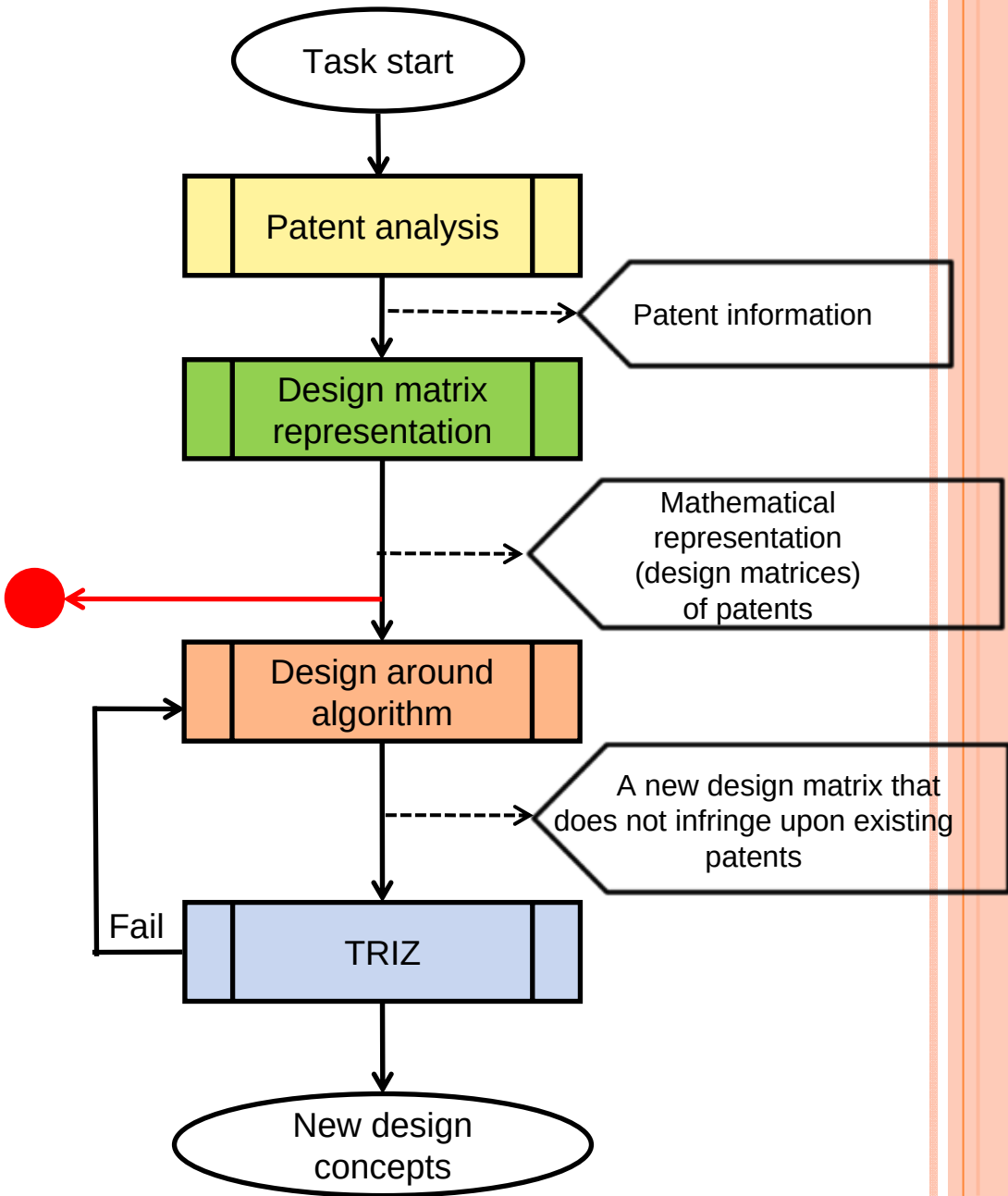
$$\begin{bmatrix} FR_1 \\ FR_2 \\ FR_3 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} DP_1 \\ DP_2 \\ DP_3 \\ DP_4 \\ DP_5 \\ DP_6 \\ DP_7 \end{bmatrix} \begin{bmatrix} T_1 & T_2 & T_3 \end{bmatrix}$$

$$\Leftrightarrow \begin{cases} FR_1 = T_1(DP_1 + DP_2 + DP_3 + DP_4 + DP_5) \\ FR_2 = T_2(DP_1 + DP_2 + DP_3 + DP_4) \\ FR_3 = T_3(DP_6 + DP_7) \end{cases}$$

Design around algorithm (1/7)

$$A_1 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix}$$

To generate a new design matrix $\overline{\mathbf{A}}$ that **is similar to** one of the existing matrices $\mathbf{A}_i$, but **does not infringe with** any of the existing design matrices.



Design around algorithm (2/7)

-Sort the design matrix

The priority of DPs to be designed around

- DPs have the least influence in design matrix A ⇒ DP_5, DP_6 and DP_7
- DPs have minimal interaction with other DPs ⇒ DP_6 and DP_7

Sort the design matrix ⇒ **Number of non-zero elements**

- Columns: most (left) → least (right)
- Rows: most (top) → least (bottom)

U.S. Patent 6,918,449 ⇒ **Priority list of DPs**

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \end{Bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \\ DP_4 \\ DP_5 \\ DP_6 \\ DP_7 \end{Bmatrix} [T_1 \quad T_2 \quad T_3]$$

$DP_5 DP_6 DP_7$

- 1st priority: DP_6 and DP_7
- 2nd priority: DP_5
- 3rd priority: DP_1, DP_2, DP_3 and DP_4

Design around algorithm (3/7)

-Design around operation

$$\overline{\mathbf{A}} = \mathbf{A}_{n+c}^{E} + \mathbf{D} = \mathbf{A} + \mathbf{D}$$

Design around operation matrix

Rules of patent infringement judgment	Design around strategies	
All elements rule		
A+B+C+D	A+B+C	(1) Elimination
A+B+C_1+D_1	A+B+$(CD)_2$	(2) Integration
Doctrine of equivalents		
A+B+C_1+D_1	A+B+C_2+D_2	(3) Replacement
A+B+C+D_1	A+B+C+D_2+D_3	(4) Decomposition

Design around algorithm (4/7)

-The design around operation matrix- Elimination

U.S. Patent 6.918.449

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \end{Bmatrix} =$$

Design problem 1: "How to design a transformation T_3^* to achieve the function FR_3 (change magnetic flux) using component DP_7 (changing device)?"

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \end{Bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \\ DP_4 \\ DP_5 \\ DP_6 \\ DP_7 \end{Bmatrix} \begin{bmatrix} T_1 & T_2 & T_3^* \end{bmatrix} \longrightarrow \begin{cases} FR_1 = T_1(DP_1 + DP_2 + DP_3 + DP_4 + DP_5) \\ FR_2 = T_2(DP_1 + DP_2 + DP_3 + DP_4) \\ FR_3 = T_3^*(DP_7) \end{cases}$$

New design problem 1

$$\mathbf{A}_1 \quad \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix} \quad \begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix} \quad \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -1 & 0 \end{bmatrix} \quad \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Design around algorithm (5/7)

-The design around operation matrix- Replacement

U.S. Patent 6,918,449

Design problem 2: "How to design a *transformation* T_3^* and a new component DP_8 to achieve the function FR_3 (change magnetic flux) using component DP_6 (magnetic bypass device) and DP_8, while the technological characteristics of DP_8 are different from those of DP_7 (changing device)."

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \end{Bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \\ DP_4 \\ DP_5 \\ DP_6 \\ DP_7 \\ DP_8 \end{Bmatrix} \begin{bmatrix} T_1 & T_2 & T_3^* \end{bmatrix} \longrightarrow \begin{cases} FR_1 = T_1(DP_1 + DP_2 + DP_3 + DP_4 + DP_5) \\ FR_2 = T_2(DP_1 + DP_2 + DP_3 + DP_4) \\ FR_3 = T_3^*(DP_6 + DP_8) \end{cases}$$

New design problem 2

DP_7 DP_8

$$\begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 1 & 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

Design around algorithm (6/7)

-The design around operation matrix- Integration

U.S. Patent 6,813,440

Design problem 3: "How to design a transformation T_3^* to achieve the function FR_3 (change magnetic flux) using a new component DP_8, while the technological characteristics of DP_8 are different from those of DP_6 (magnetic bypass device) and DP_7 (changing device)."

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \end{Bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \\ DP_4 \\ DP_5 \\ DP_6 \\ DP_7 \\ DP_8 \end{Bmatrix} \begin{bmatrix} T_1 & T_2 & T_3^* \end{bmatrix} \longrightarrow \begin{cases} FR_1 = T_1(DP_1 + DP_2 + DP_3 + DP_4 + DP_5) \\ FR_2 = T_2(DP_1 + DP_2 + DP_3 + DP_4) \\ FR_3 = T_3^*(DP_8) \end{cases}$$

New design problem 3

$\overline{\mathbf{A}_3}$ =

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -1 & -1 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Design around algorithm (7/7)

-The design around operation matrix- Decomposition

Design problem 4: "How to design a transformation T_3^* and two new components DP_8 and DP_9 to achieve the function FR_3 (change magnetic flux) using two new components DP_8 and DP_9, while the technological characteristics of DP_8 and DP_9 are different from those of DP_6 (magnetic bypass device)."

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \end{Bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \\ DP_4 \\ DP_5 \\ DP_6 \\ DP_7 \\ DP_8 \\ DP_9 \end{Bmatrix} [T_1 \quad T_2 \quad T_3^*] \longrightarrow \begin{cases} FR_1 = T_1(DP_1 + DP_2 + DP_3 + DP_4 + DP_5) \\ FR_2 = T_2(DP_1 + DP_2 + DP_3 + DP_4) \\ FR_3 = T_3^*(DP_7 + DP_8 + DP_9) \end{cases}$$

New design problem 4

$$\overline{\mathbf{A}_4} = \mathbf{A}_9^E + \mathbf{D}_4 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 1 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \end{bmatrix}$$

TRIZ -- transform the new design matrix back into a real engineering design (1/2)

Design Problem 3: "How to design a *transformation* to achieve the *function* FR_3 (change magnetic flux) using a *new component* DP_8, while the technological characteristics of DP_8 are different from those of DP_6 (magnetic bypass device) and DP_7 (changing device)."

- *39 design parameters* to find the ones matching with the *functions*

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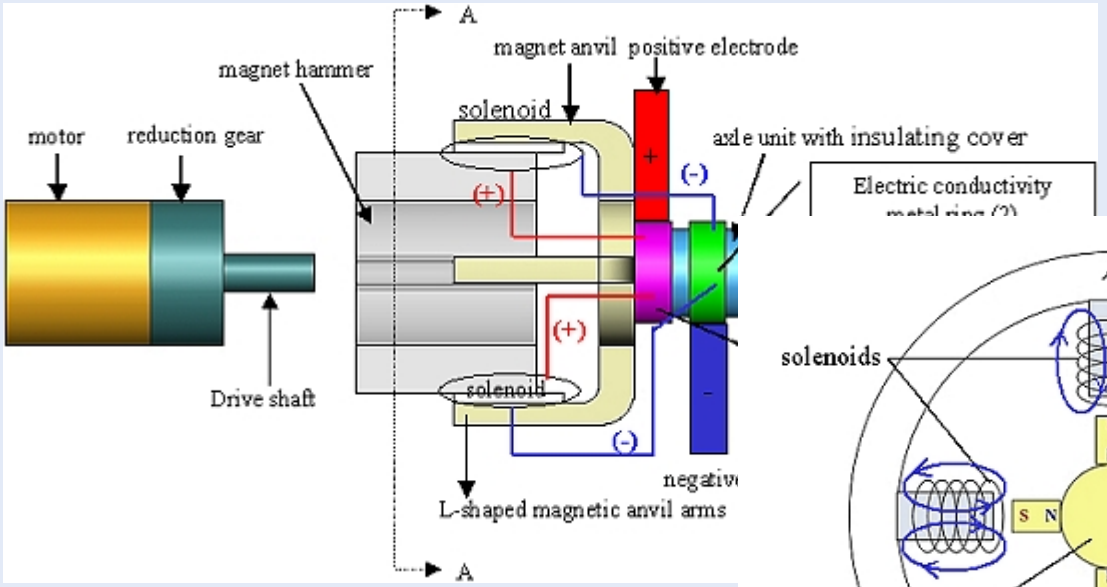
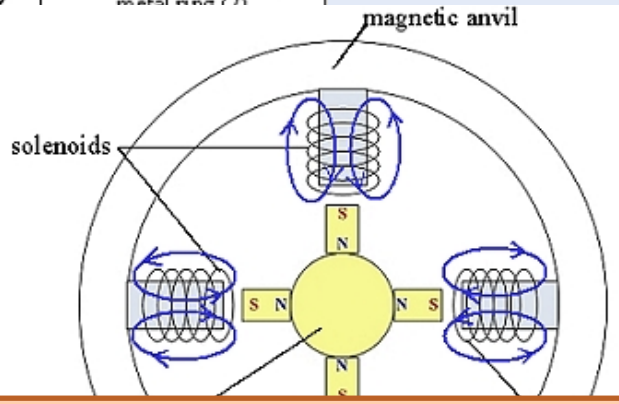
New concept of the portable magnetic impact tool





The new component DP_8 (four solenoids) has already integrated the function of the DP_6 (magnetic bypass device) and the DP_7 (changing device).

TRIZ -- transform the new design matrix back into a real engineering design (2/2)

- Transformation from a design matrix to an engineering design concept ***may fail*** because there ***may not be a feasible design*** corresponding to the new design matrix generated by the algorithm.

Design problem 1 (eliminate DP_6) : "How to design a transformation T_3^* to achieve the function FR_3 (change magnetic flux) using component DP_7 (changing device)?"

This transformation fails, because the component DP_7 (changing device) only performs the function "move magnetic bypass device", it is unable to change magnetic flux by itself.

Conclusions -- A patent-based design methodology

- The designer conducts standard patent analysis to identify the related patents to be designed around.
- Each patent is then symbolized by a “design matrix” converted from the technology/function matrix of the patent.
- A design-around algorithm is developed to generate a new design matrix that does not infringe with design matrices of existing patents ➔ A computerized program.
- Then the new design matrix is transformed back into a real engineering design using the “contradiction matrix” in TRIZ.

- This design process aims to assist enterprises to enhance the efficiency of product development, lower the possibility of patent infringements, and increase the potential to patent results of innovation.

Thank you for your attention!

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