A Comparison of Tools Based on the 40 Inventive Principles of TRIZ

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Abstract

A comparison was made of four tools that are based on the 40 inventive principles of TRIZ, *viz* (1) the classic Contradiction Matrix, (2) a 4-Attribute Matrix, (3) a Contradictionless Matrix and (4) the 6 most commonly used inventive principles (Top6). In order to assess their relative predictive capabilities, each tool was applied to a suite of 60 physico-mechanical engineering patents.

The 4-Attribute Matrix is a tool that was developed by re-categorisation of the 40 Inventive Principles in terms of the dominant inventive *mechanisms* and physico-mechanical system *attributes* that underpin each. This tool achieved the highest *success rate* (79%), i.e. in more than three quarters of the cases it would have enabled the inventor to have reached the eventually patented solution. This compared favourably with the 51% achieved by the classic Contradiction Matrix, the 41% of the Top6 and the 32% of the Contradictionless Matrix.

A second parameter, the *strike rate*, is an indicator of how time-consuming the exercise would have been, and expresses the successful solutions as a percentage of the total number of principles that the inventor would have had to investigate to achieve them. Here, the Contradiction Matrix was most efficient at 26%, followed by the 4-Attribute Matrix with 23%, the Top6 with 12% and the Contradictionless Matrix with 9%.

The product of the success rate and the strike rate provides an indication of the overall usability of each method. It was thus concluded that, of the four tools evaluated, the 4-Attribute Matrix provided the best performance, followed by the classic Contradiction Matrix, the Top6 and the Contradictionless Matrix.

Introduction

The TRIZ invention heuristics is based on the notion that most problems that engineers and technologists face contain key elements that have already been solved in other applications. Inventive principles embedded in a large body of patents have been generalised over many years to guide inventors and problem solvers in potentially useful directions. The Contradiction Matrix is one of the most popular TRIZ tools, and is the first original instrument that was developed for technical systems that can be in conflict, i.e. have technical or physical contradictions. The classic matrix suggests, for each parameter that is to be improved, up to four Inventive Principles that may help to overcome the associated worsening parameter and thus solve the problem inventively.

Whilst defining a contradiction can often be an important part of resolving it, this can sometimes be problematic, and often it does not lead to a solution. Research by Mann (2002) on a random selection of 130 mechanical engineering patents worldwide has for instance put the overall effectiveness of the classic matrix at 48%. This appears to be a representative average for the particular context in which it was applied and was expressed as the number of principles suggested by the matrix, and actually used by the inventor, as a percentage of the total number of principles used by the inventor (as derived from an analysis of the patents).

Furthermore, due to the fact that an inventive principle has to recur in many high-level patents in various engineering fields before it can become a TRIZ heuristic (according to Savransky (2000, p.221) this figure varies between 10 and 500), for some contradictions the Contradiction Matrix does not suggest any principles. In such a case the inventor therefore may have to try out a fairly large range of options on a number of problem parameters before a solution is attained.

Tools

In order to investigate alternative options that may be available to inventors, the efficiency of the classic Contradiction Matrix was compared to those of three other tools that are also based on the 40 Inventive Principles. These included the following:

4-Attribute Matrix

The 4-Attribute Matrix is a tool that was developed by re-categorisation of the 40 Inventive Principles in terms of the dominant inventive strategies, or *mechanisms*, and physico-mechanical system *attributes* that underpin them. As shown in Table 1, five such mechanisms have been identified from an analysis of the 40 Inventive Principles (Ross, 2006). These mechanisms have been applied to the attributes of a physico-mechanical systems model, resulting in a new categorisation of the Inventive Principles as per Table 2. A key consideration of this re-categorisation, as should be clear from the Table, was to ensure that each mechanism-attribute pair (referred to as an Ideation Domain) retains a strong conceptual identity. In some instances, a Principle could be categorised into more than one Ideation Domain (the same is true about the way in which the 40 Principles are configured); however, at this stage it was decided against duplication and a Principle was thus represented only in the Ideation Domain with which it was deemed to have the strongest commonality.

The four system attributes that are used most commonly to improve each of the 39 engineering *parameters* were identified by multiplying the frequency with which an Inventive Principle is used in the Contradiction Matrix to improve the said parameter by the number of times that the Inventive sub-Principle appears in a particular attribute (as per Table 2). The four attributes with the highest cumulative scores were included in the 4-Attribute Matrix. Table 3 shows the parameters and the corresponding attributes, in decreasing order of priority, that are most likely to lead to solutions.

Table 1. The 5 mechanisms underlying the 40 Inventive Principles.

Mechanism	Function
1. Segment	Break something down into smaller, more flexible or independent parts, modules or functions, make it segmentable.
2. Re-move-ment	1. Remove: Extract useful / interfering property / part or discard used or waste parts, or make something removable. 2. Movement: Make something movable, allow for, restrict or eliminate the need for movement.
3. Change	Change (increase, decrease, reverse, invert, re-orientate etc) one or more attributes of the system.
4. Add	Group, merge or integrate objects or features with that of others, introduce something new or multiply an existing function or feature.
5. Other - Use	1. Other Use: Use something for a purpose, or in a context, different to what it was intended for. 2. Use: Exploit available or natural phenomena or resources to good effect. 3. Use Other: Employ anOther (practical) version or format of something.

Table 2. Attributes, inventive mechanisms and corresponding Inventive Principles.

Action	
1. Segment	Instead of continuous action, use intermittent action, e.g. periodic or pulsating (19A).*
2. Remove	Remove from object or environment: Perform, before (or after) necessary or normal, a required change of the object (10A).
3. Change	1. Type of motion, e.g. linear to rotary or swirl motion (14C).
	2. Direction of motion: Invert or use opposite action (13ABC).
	3. Change from static to dynamic fields, structured to unstructured etc. (28C).
4. Add	1. Subject something to the same action or conditions it will be experiencing during operation, provide emergency means to compensate for low reliability (09B, 11A).
	2. Eliminate idle time or intermittent actions, use pauses between actions to perform similar or different actions (20B).
	3. Harmful: If an action has both harmful and useful effects, add anti-actions to control harmful effects. Eliminate a harmful action by adding another harmful action (09A, 22B).
	4. Introduce feedback / feed forward to improve a process or action (23A).
Object	
1. Segment	1. Divide, or make segmentable, an object or system into independent parts or individual functions, e.g. for easy or quick removal or assembly. If already segmented, increase the degree of segmentation (01ABC).
	2. Segment Object and/or Environment such that each part functions in different conditions, e.g. that are most suitable for its operation (03AB).
2. Re-move-ment	1. Allow relative *movement* between objects or parts; make it movable or adaptable e.g. to find the best operational position or condition (15ABC).
	2. Limit (need for) *movement* (distance or position changes), e.g. pre-arrange required objects close to action (10B, 12A).
	3. *Remove* : Separate or extract a useful / functional or interfering / undesired part(s) or property from the object or its environment (02A), discard / disperse / dissolve things that have fulfilled their functions (34A).

4. Add	1. Add or use together, sequentially or in parallel, a group of uniform objects or principles instead of a single one (05A).
	2. Restore or repair (consumable) parts while in operation, or use easily replaceable parts (34B).
	3. Use an intermediary (temporary) carrier article or process, merge one object temporarily with another which can easily be removed (24AB).
5. Use Other	1. Use an Other format or version of something. E.g. replace mechanical or physical means by sensory (optical, acoustic, taste or olfactory) means (28A).
	2. Replace an (unavailable, expensive or fragile) object or process with optical, UV or IR copies (26ABC).
Duration	
1. Segment	Replace something durable (long-lasting / expensive) with a number of short-lived (replaceable / inexpensive) ones (27A).
3. Change	Conduct a process (e.g. hazardous or harmful) or stages at high speed (21A).
Properties	
3. Change	1. a) State: Use a gas, aerosol, liquid or gel instead of a solid, change the physical aggregate state (29A, 35A). b) Porosity: Make a solid porous or use porous elements, use spume or foam as a combination of liquid and gas properties (29D, 31A). c) Material: Use composite or smart materials instead of uniform ones (40A).
	2. Make objects interacting with others of the same material or properties (e.g. polarity) (33A).
	3. Change the degree of flexibility, temperature, pressure, humidity etc. (29C, 35CD).
5. Use	Exploit inherent properties, available or natural phenomena to good effect, e.g. resonant frequency, phase transitions, thermal expansion or contraction, heat capacity, thermal conductivity, sources of energy, etc. (18C, 36A, 37A)
Quantity	
3. Change	1. Amount: If 100% is hard to achieve, use slightly less or more of the same method, space or substance (16A).
	2. Load: Make all parts perform at full load all the time (20A).
	3. Harmful effect: Amplify a harmful factor to such an extent that it is no longer harmful (22C).
	4. Feedback: Change the magnitude, speed or influence of feedback (23B).
Frequency	
3. Change	1. Oscillate or vibrate object; if oscillation already exists, change the frequency. Use piezoeletric vibrators instead of mechanical ones (18ABD).
	2. If an action is already periodic, change its amplitude or frequency (19B).
Curvilinearity	
3. Change	Change from rectilinear to curvilinear parts, surfaces and forms, use rollers, balls, cones, spirals and domes (14AB).
Sensory	
3. Change	Change the colour / transparency of an object, parts or its environment (32AB).
4. Add	Add coloured or luminescent tracers for things that are difficult to see (32C).
Dimension	
3. Change	1. Instead of a line or plane, use a plane or space. Use a multi-storey/layer assembly instead of single, use another side of a given area (17ABD).
	2. Use flexible shells and thin films (2-D) instead of 3-D (solid) structures (30AB).
Orientation	
3. Change	Tilt, rotate or re-orientate object, part or process, turn it upside down (13D, 17C).
Symmetry	
3. Change	Change the shape or properties of an object, grouping or process from symmetrical to asymmetrical. If already asymmetrical, increase the degree of asymmetry (04AB).
Concentration	
3. Change	1. Change the concentration, composition or consistency, e.g. increase the degree of

	inertness, enrichment or purity (35B, 38AB, 39AB).
	2. Place objects within each other, make one pass through a cavity in the other. Store a substance in the pores or capillaries of another (07AB, 31B).
Function	
4. Add	1. Make an object or parts perform multiple useful functions (03C, 06A).
	2. Make an object serve or organize itself by performing auxiliary helpful functions, supplementary and repair operations (25AB).
Environment	
4. Add	1. Make an object interact with its medium, use buoyancy or Archimedes forces (29B).
	2. Merge object with others in its environment, e.g. that provide lift (08AB).
	3. Use fields (electric, magnetic, etc.) to interact with object, e.g. in conjunction with field-activatable particles (28BD).
5. Other Use	Use something for a purpose other than intended for. E.g. use waste, useless or readily available resources to achieve a positive or desired effect or function (22A, 25C).
Order	
3. Change	Make operations parallel, bring them together in time (05B).

* Inventive Principle(s) that matches the particular Ideation Domain most closely. In the interest of brevity, no separators are used, e.g. 08AB represents sub-principles 08A and 08B.

The 4-Attribute Matrix, being in effect a contradictionless matrix, guides the inventor only according to the engineering parameter to be improved, and not the deteriorating (worsening) parameter as well. Taking for instance example 4 in Table 4 (patent no. 5493580), the parameter to be improved was identified as #23 (Waste of substance). The inventor would use this information to identify, from Table 3, the four attributes that could most likely lead to a solution. In this particular example, these are Object, Properties, Frequency and Duration. A first solution is found in Segment Object (Inventive Principle 01ABC), whilst the second and third matching principles are found in Change Properties (Inventive Principles 35ACD and 31A), e.g. use a gas, liquid or gel instead of a solid, make an object porous or use porous elements, change the degree of flexibility or the temperature.

Contradictionless Matrix (CLM)

As mentioned earlier, potential drawbacks in the use of the Contradiction Matrix seems to be the fact that a contradiction has to be defined and that in a few cases it does not suggest any problem solving strategies.

To overcome these obstacles, Liu & Chen (2001) for instance developed a Contradictionless Matrix which describes, for each of the 39 engineering parameters, the frequency with which an Inventive Principle appears in the classic Contradiction Matrix. In other words, instead of the deteriorating parameter, the inventor now focuses on the frequency with which a particular Inventive Principle is used. As shown in Table 4, for the purposes of the work described in this paper, the 6 most frequently used principles listed by their Contradictionless Matrix for each engineering parameter were employed.

Most frequently used principles (Top 6)

A method similar to the Contradictionless Matrix was devised by simply using the 6 most common Inventive Principles in the classic Contradiction Matrix, namely 35, 10, 01, 28, 02 and 15 (Savransky, 2000, p. 228). The top 6 Inventive Principles were chosen specifically so as to facilitate direct comparison with the Contradictionless Matrix. As shown in Table 4, in each case the Inventive Principles used by the inventor were compared to these 'Top6'.

Table 3. The 4-Attribute Matrix.

Parameter to be Improved	**Attributes most likely to lead to a Solution**			
1. Weight: moving object	Properties	Object 5,2 *	Environment	Concentration
2. Weight: binding object	Properties	Object 5,2	Action 1,3	Duration
3. Length: moving object	Object 1,2	Properties	Symmetry	Orientation
4. Length: binding object	Properties	Object 5,1	Curvilinearity	Frequency
5. Area: moving object	Object 1,5	Dimension	Action 3,1	Properties
6. Area: binding object	Frequency	Properties	Concentration	Dimension
7. Volume: moving object	Properties	Object 2,1	Symmetry	Function
8. Volume: binding object	Properties	Object 2,1	Frequency	Curvilinearity
9. Speed	Environment	Properties	Action 3,2	Object 2,1
10. Force	Properties	Object 2,5	Frequency	Action 3,1
11. Tension, pressure	Properties	Object 2,1	Curvilinearity	Frequency
12. Shape	Object 2,1	Action 2,3	Curvilinearity	Properties
13. Stability of object	Properties	Object 2,1	Concentration	Action 3,4
14. Strength	Object 2,1	Properties	Curvilinearity	Duration
15. Durability: moving object	Properties	Frequency	Object 1,2	Duration
16. Durability: binding object	Quantity	Properties	Object 2,1	Concentration
17. Temperature	Properties	Frequency	Object 2,1	Environment
18. Brightness	Action 1,3	Sensory	Object 1,2	Properties
19. Energy: moving object	Properties	Frequency	Object 2,1	Function
20. Energy: binding object	Object 1,2	Properties	Frequency	Symmetry
21. Power	Properties	Frequency	Object 1,2	Sensory
22. Waste of energy	Properties	Object 2,1	Frequency	Concentration
23. Waste of substance	Object 2,5	Properties	Frequency	Duration
24. Loss of information	Object 2,1	Properties	Environment	Sensory
25. Waste of time	Properties	Object 2,5	Frequency	Symmetry
26. Amount of substance	Properties	Object 1,2	Frequency	Action 2,3
27. Reliability	Properties	Object 2,1	Environment	Duration
28. Accuracy: measurement	Sensory	Object 5,1	Function	Action 3,2
29. Accuracy: manufacturing	Sensory	Object 5,2	Frequency	Properties
30. Harmful factors on object	Environment	Properties	Object 2,1	Frequency
31. Harmful side effects	Concentration	Environment	Object 2,1	Frequency
32. Manufacturability	Object 1,5	Properties	Duration	Action 3,4
33. Convenience of use	Object 1,2	Action 3,1	Properties	Sensory
34. Repairability	Object 2,1	Properties	Action 4,3	Sensory
35. Adaptability	Properties	Object 2,1	Quantity	Action 3,1
36. Complexity of system	Object 1,5	Action 3,2	Properties	Duration
37. Complexity of control	Properties	Object 1,2	Duration	Action 3,1
38. Level of automation	Properties	Object 5,2	Action 3,2	Frequency
39. Productivity	Properties	Object 2,5	Frequency	Curvilinearity
Version 1.1				

* The two numbers following the Object and Action attributes indicate the mechanisms that are most relevant for the particular engineering parameter and may thus be tried out first. 1 = Segment, 2 = Re-move-ment, 3 = Change, 4 = Add, 5 = Other–Use.

Comparison

The predictive capability of each tool was determined by applying it to 60 physico-mechanical engineering patents extracted from the analysis by Mann (2002). The results of the comparison are shown in Table 4.

In each case, a *success rate* was calculated by expressing the number of matching principles as a percentage of the total number of principles used by the inventors (i.e. 106). [Note: The 'success rate' used here is the same as 'effectiveness' defined by Mann (2002)]. Likewise, a *strike rate* was calculated by expressing the number of matching principles to the total number of principles suggested by the particular tool (i.e. 210 in the case of the Contradiction Matrix, and 6x60 = 360 in the case of both the Contradictionless Matrix and the Top6). The strike rate is an indicator of how laborious the application of the tool would be, assuming that the inventor would have exhausted all the suggested principles and not have stopped after a first solution has been obtained.

Whilst the strike rate is straightforward to calculate in the case of the Contradiction Matrix, Contradictionless Matrix and Top6 (all three being based on the original definition of inventive principles), this was more problematic for the 4-Attribute Matrix since each Ideation Domain now involves different sub-principles. For example, as shown in Table 2, the Ideation Domain of Add Object spans sub-principles 05A, 24AB and 34B.

An analysis of the 4-Attribute Matrix (Table 3) indicated that, collectively, the four attributes that are associated with each engineering parameter involve the equivalent of approximately 6 Inventive Principles. This figure was established taking into account the fact that, on average, an Inventive Principle consists of about 2 sub-principles (i.e. 40 Inventive Principles divided into 83 Inventive sub-Principles), but also allowing for deviations from this average, especially by the commonly used principles (e.g. Inventive Principle #35 contains 5 sub-principles, Inventive Principle #28 contains 4 and Inventive Principle #15 contains 3). Thus, an estimate of the equivalent number of Inventive Principles that would have had to be investigated in the 60 patents was put at 6x60 = 360, the same as the Contradictionless Matrix and Top6.

Of the four tools, the 4-Attribute Matrix achieved the highest *success rate* (79%), i.e. in more than three quarters of the cases it would have enabled the inventor to have reached the eventually patented solution. This compared favourably with the 51% achieved by the classic Contradiction Matrix, the 41% of the Top6 and the 32% of the Contradictionless Matrix under the same conditions. Table 4 also shows that in situations where the 4-Attribute Matrix was not able to match the principles used by the inventor, complementing this approach with the Dimension attribute (namely Inventive Principles #17ABD and #30AB) could increase the success rate for the chosen suite of examples to 93/106 = 88% (refer to examples 17, 19, 20, 26, 27, 34, 39, 47, and 48).

Whilst 60 patents clearly do not constitute a statistically representative sample, it is interesting to note that the Top 6 Inventive Principles achieved a higher success rate than that of the equivalent Contradictionless Matrix. More work in this area seems to be is required to provide a better understanding of the merit and value of the different approaches.

With regard to the *strike rate*, the classic Contradiction Matrix was most efficient at 26%, followed by the 4-Attribute Matrix with 23%, the Top6 with 12% and the Contradictionless Matrix with 9%. A measure of the overall usability of each method is obtained by considering the success rate in conjunction with the strike rate. As shown in Table 4 by the products of these two factors, this lead to the conclusion that the 4-Attribute Matrix provided the best overall usability, followed by the classic Contradiction Matrix, the Top6 and the Contradictionless Matrix.

Conclusions

The Contradiction Matrix offers the technical inventor a usable method for problem solving. However, the need to define system contradictions can sometimes complicate matters when the inventor knows only the parameter to be improved or in situations where it does not suggest any solutions. In certain cases its effectiveness may also be a factor, recent research in a physico-mechanical context having put this figure at only around 50%.

In order to investigate alternative options that may be available to inventors and problem solvers, the efficiency of the Contradiction Matrix was compared to that of three other tools that are also based on the 40 Inventive Principles. These included a 4-Attribute Matrix, in which the Inventive Principles have been re-categorised in terms of physico-mechanical system attributes, a Contradictionless Matrix based on the 6 Inventive Principles that are associated most frequently with each engineering parameter to be improved, and the 6 Inventive Principles that are used most commonly overall (Top6).

The relative efficiency of the four tools was established by applying each to a suite of 60 physico-mechanical engineering patents. Of these, the 4-Attribute Matrix achieved the highest success rate of 79%, i.e. in more than three quarters of the cases the inventor would have reached the eventually patented solution. This compared favourably with the 51% achieved by the classic Contradiction Matrix, the 41% of the Top6 and the 32% of the Contradictionless Matrix. In cases where the 4-Attribute Matrix was not successful, complementing it with the Dimension attribute increased the success rate to 88%. Whilst the sample of patents was relatively small, the fact that a higher success rate was achieved for instance by the Top6 than the equivalent (6-principle) Contradictionless Matrix suggests that a better understanding of the merit and value of these approaches may be required.

With regard to the strike rate, i.e. a measure of how many principles the inventor would have had to investigate in order to achieve solutions, the classic Contradiction Matrix was most efficient with 26%, followed by the 4-Attribute Matrix with 23%, the Top6 with 12% and the Contradictionless Matrix with 9%. Considering the success rate in combination with the strike rate provides a measure of the general usability of the method. This led to the conclusion that the 4-Attribute Matrix was the most efficient overall. The fact that it involves 25 Ideation Domains instead of 40 Principles may also make it easier to teach or learn.

Further work is planned to also compare the 4-Attribute Matrix with the Matrix 2003 developed by Mann et al. (2003), in which extensive research on present day innovative practices has resulted in the expansion of the number of parameters and an updating of the priority sequencing of Inventive Principles for each contradiction.

References

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Table 4. Comparison of the Contradiction Matrix (CM), 4-Attribute Matrix (4AM), Contradictionless Matrix (CLM) and Top6.

Ex. no.	Patent no. &	Contradiction &	Inventor used &	CM suggests	CM score	4AM includes	4AM score	CLM suggests	CLM score	Top6 # score
1	4966257	10, 05	15	19, 10, 15	1	15	1	35, 10, 36, 37, 18, 28	0	1
2	5485307	35, 12	01	15, 37, 01, 08	1	01	1	35, 15, 01, 29, 16, 02	1	1
3	5485359	18, 19	25	32, 01, 19	0	-	0	19, 32, 01, 13, 15, 35	0	0
4	5493580	23, 22	01, 35, 31	35, 27, 02, 31	2	01, 35, 31	3	10, 35, 28, 18, 31, 24	2	2
5	5543179	30, 14	16, 10, 01	35, 18, 37, 01	1	10, 01	2	22, 35, 02, 01, 33, 28	1	2
6	5568961	14, 01	01, 15	01, 08, 15, 40	2	01, 15	2	03, 35, 10, 28, 40, 15	1	2
7	5569009	27, 36	01	13, 35, 01	1	01	1	35, 10, 11, 40, 28, 27	0	1
8	5680467	28, 13	32, 25, 13	32, 35, 13	2	32, 35, 13	3	32, 28, 26, 03, 10, 24	1	0
9	5694827	15, 09	03, 35, 05	03, 35, 05	3	03, 35, 05	3	35, 19, 03, 10, 27, 28	2	1
10	GB2312704	01, 30	22	22, 21, 27, 39	1	22	1	35, 28, 26, 18, 02, 08	0	0
11	GB2315973	23, 17	31	21, 36, 39, 31	1	31	1	10, 35, 28, 18, 31, 24	1	0
12	GB2315980	12, 08	02, 35	07, 02, 35	2	02, 35	2	01, 10, 14, 15, 35, 29	1	2
13	GB2315994	26, 07	25	15, 20, 29	0	-	0	35, 03, 29, 18, 10, 14	0	0
14	GB2316044	10, 33	01, 15	01, 28, 03, 25	1	01, 15	2	35, 10, 36, 37, 18, 28	0	2
15	GB2350145	33, 35	15, 01	15, 34, 01, 16	2	15, 01	2	01, 13, 02, 28, 35, 32	1	2
16	GB2350268	24, 27	10	10, 28, 23	1	10	1	10, 35, 24, 26, 22, 28	1	1
17	WO01/13760	07, 05	17, 04	01, 07, 04, 17	2	-, 04	1	35, 02, 10, 29, 01, 15	0	0
18	WO01/70445	28, 03	05, 26	05, 16, 26, 28	2	05, 26	2	32, 28, 26, 03, 10, 24	1	0
19	5746360	07, 31	02, 30	17, 02, 40, 01	1	02, -	1	35, 02, 10, 29, 01, 15	1	1
20	5992588	10, 03	17	17, 19, 09, 36	1	-	0	35, 10, 36, 37, 18, 28	0	0
21	6099658	09, 31	24	02, 24, 35, 21	1	24	1	28, 35, 13, 34, 10, 38	0	0
22	6299550	03, 09	13	13, 04, 08	1	13	1	01, 29, 15, 35, 04, 17	0	0
23	6272687	14, 33	03, 15, 40	32, 40, 25, 02	1	03, 15, 40	3	03, 35, 10, 28, 40, 15	3	1
24	GB2307485	15,10	04, 18	02, 16, 19	0	18	1	35, 19, 03, 10, 27, 28	0	0
25	6296160	31, 36	08, 05	19, 01, 31	0	05, 08	2	35, 22, 02, 39, 01, 18	0	0
26	5493551	33, 36	17	32, 26, 12, 17	1	-	0	01, 13, 02, 28, 35, 32	0	0
27	6293565	09, 31	17, 14, 03	02, 21, 24, 35	0	03, 14, -	2	28, 35, 13, 34, 10, 38	0	0
28	GB2309876	36, 30	02	22, 19, 29, 40	0	02	1	01, 26, 28, 10, 13, 35	0	1
29	5999869	31,15	23	15, 22, 33, 31	0	-	0	35, 22, 02, 39, 01, 18	0	0
30	5651055	33, 24	10, 28	04, 10, 27, 22	1	10, 28	2	01, 13, 02, 28, 35, 32	1	2
31	5650990	10, 13	15	35, 10, 21	0	15	1	35, 10, 36, 37, 18, 28	0	1
32	5650983	02, 24	05	10, 15, 35	0	05	1	35, 28, 10, 19, 01, 26	0	0
33	5543179	37, 18	32, 23	02, 24, 26	0	23	1	35, 28, 27, 26, 02, 19	0	0
34	6220333	24, 27	17, 28, 13	10, 28, 23	1	-, 28, -	1	10, 35, 24, 26, 22, 28	1	1

35	GB2303376	13, 26	35, 24	15, 32, 35	1	35, 24	2	35, 39, 02, 01, 40, 13	1	1
36	6176374	11, 14	09, 03	09, 18, 03, 40	2	09, 03	2	35, 10, 36, 37, 02, 14	0	0
37	6065555	19, 22	23	12, 22, 15, 24	0	23	1	35, 19, 18, 28, 02, 06	0	0
38	5824184	33, 03	03	01, 17, 13, 12	0	03	1	01, 13, 02, 28, 35, 32	0	0
39	6099018	31, 12	01, 17	35, 01	1	01, -	1	35, 22, 02, 39, 01, 18	1	1
40	6098208	05, 01	14, 30	02, 17, 29, 04	0	14, 30	2	15, 17, 26, 13, 02, 10	0	0
41	5569009	27, 36	01	13, 35, 01	1	01	1	35, 10, 11, 40, 28, 27	0	1
42	5569282	31, 33	07	-	0	07	1	35, 22, 02, 39, 01, 18	0	0
43	5570342	05, 36	01	14, 01, 13	1	01	1	15, 17 , 26, 13, 02, 10	0	1
44	5650591	31, 17	31	22, 35, 02, 24	0	31	1	35, 22, 02, 39, 01, 18	0	0
45	5667294	33, 35	15, 01	15, 34, 01, 16	2	15, 01	2	01, 13, 02, 28, 35, 32	1	2
46	5680468	16, 33	01	01	1	01	1	16, 35, 10, 01, 40, 38	1	1
47	5724415	07, 05	17	01, 07, 04, 17	1	-	0	35, 02, 10, 29, 01, 15	0	0
48	5724478	22, 06	01, 17	17, 07, 30, 18	1	01, -	1	35, 02, 19, 07, 15, 10	0	1
49	6099150	33, 15	40	29, 03, 08, 25	0	40	1	01, 13, 02, 28, 35, 32	0	0
50	6179727	35, 36	04, 20	15, 29, 37, 28	0	20	1	35, 15, 01, 29, 16, 02	0	0
51	6053805	26, 36	13, 03, 05	13, 35, 01	1	03, 05, 13	3	35, 03, 29, 18, 10, 14	1	0
52	6290196	03, 07	03, 07, 17	07, 17, 04, 35	2	03, 17	2	01, 29, 15, 35, 04, 17	1	0
53	6166359	17, 22	01, 28	21, 17, 35, 38	0	01, 28	2	35, 19, 02, 03, 10, 39	0	2
54	6203313	35, 14	01, 35	35, 03, 32, 06	1	35, 01	2	35, 15, 01, 29, 16, 02	2	2
55	5724625	09, 11	06, 01	06, 18, 38, 40	1	01	1	28, 35, 13, 34, 10, 38	0	1
56	6182299	14, 33	02, 03, 40	02, 28, 32, 40	2	02, 03, 40	3	03, 35, 10, 40, 15, 14	2	1
57	5900819	30, 33	01, 05, 35	02, 25, 28, 39	0	01, 05, 35	3	22, 35, 02, 01, 33, 28	2	2
58	6050219	15, 25	20, 23	20, 10, 28, 18	1	-	0	35, 19, 03, 10, 27, 28	0	0
59	6260276	35, 36	15, 06	15, 29, 37, 28	1	15	1	35, 15, 01, 29, 16, 02	1	1
60	6306040	07, 36	01, 15	26, 01	1	01, 15	2	35, 02, 10, 29, 01, 15	2	2
Total			**106**	**210**	**54**	**360 ***	**84**	**360**	**34**	**43**
Success rate %			**-**	**-**	**51**	**-**	**79**	**-**	**32**	**41**
Strike rate %			**-**	**-**	**26**	**-**	**23**	**-**	**9**	**12**
Success x Strike x100			**-**	**-**	**13.1**	**-**	**18.5**	**-**	**3.0**	**4.85**

[&] From the list of Mann (2002).
* See text for more detail on estimation of number of equivalent Inventive Principles.
# Top 6 Inventive Principles: 35, 10, 01, 28, 02, 15