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Creativity, Innovation and Problem Solving

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Abstract : Global market and open competition forced organizations to rediscover the importance of innovative approaches to problem solving. While it is innovation that gives fillip to technology, trade and development, it is creativity that holds the key to good innovation. The combined and coordinated development of motivation, ability and creativity leads to the success of an innovation. The dawn of the information age has made innovators to look for solution methodology to their problems even in fields that are very different. This has revolutionized the way problems are seen, understood and analyzed. Several innovative problem solving techniques/tools have evolved over the years. The paper aims to present some of the innovative problem solving approaches that have come into existence. The paper also presents some the key elements like creativity and innovation, which have now become a part of inventive problem solving approaches.

Keywords : *Creativity, innovation, ideation, inventive engineering, problem solving, TRIZ.*

INTRODUCTION

Most problem solving approaches are based on the premise that solutions lie in the problem itself. There is a natural tendency to solve hitherto unsolved problems either through known solutions, or through the knowledge base acquired over the years, or a combination of both, within the problem domain. Therefore the road to development has always been a steady progress from known to unknown. Recent advances in electronics and telecommunication have heralded the dawn of the information

age. The information age has revolutionized the problem solving approach. With the fund of knowledge and information readily available, researchers' world over, now look beyond their own problem domain for known solutions in other areas. This has resulted in several technological innovations during the past decade. The world is now witnessing the beginning of what is widely believed, the innovation age. Are we equipped to welcome this age? The answer lies in understanding the key players of this age: creativity, ideation, innovation and inventive problem solving. The paper aims to provide an understanding of these key players.

CREATIVITY: THE KEY TO INNOVATION

Creativity and innovation are inseparable and their relationship and effects on each other are mutual. According to Nyström: "In the relationship between innovation and creativity, no one way definitiveness can take effect: creativity does not directly generate innovation, nor does innovation automatically establish creativity, but the unity, degree of mutuality incorporates the possibilities for further development and higher quality level." While it is innovation that gives fillip to technology, trade and development, it is creativity that holds the key to good innovation. The combined and coordinated development of motivation, ability and creativity leads to the success of an innovation. The importance of creativity and innovation is being recognized world over and several organizations have developed procedures to use them as instruments for corporate decisions. This perhaps is the reason why the recent recession failed to decrease the intensity of innovation. On the contrary, some organizations have used innovation as a tool to wriggle out of the difficult times. These organizations viewed recession as an opportunity to experiment on innovative problem solving approaches to introduce new value-added products into the market.

Globalization has brought about a significant change in the way products, processes and concepts are developed and conceived. The fierce competition that resulted due this brought to focus the creative human. Creative people are no longer confined to the disciplines of art, music and science. There are professionals in other disciplines as well who have the creative ability to find new ideas to solve the problems that they encounter in their

profession. Creativity, which perhaps is the most valuable personal trait, is spurtic in nature and needs to be harnessed and channeled at the correct moment. To quote Gale Peterson, "Creativity is a muse of the most demanding sort. When it whispers in your ear, you sit down and write what it says to write. If you ignore it, there's a good chance it won't come back." People tend to be creative if they are driven by ambitions. For awakening ambitions, an environment that motivates people to stretch their imagination far and beyond is necessary. Progressive organizations strive to provide the right environment to encourage and culture creativity. Though it is difficult to measure or judge creativity, it can be cultured through cognitive factors (for example: association, abstraction, combination of intuitive abilities etc.). In most cases, it is the standard of the intellectual creative work and its acceptability that determines the culture of an organization.

The concept of creativity can be examined through a multitude of sciences. However all sciences view creativity as the ability which promotes the creation of something new. Creativity comprises the following elements:

- *Creative process :* The creative process according to Findlay-Lumdsen and MacKinnon, is either a new solution or a simplified definition of an ambiguous problem. Perkins believes in the concept that the creative process is a search process that leads to the most adequate solution. Nyström divides the creative process into four stages i) preparation: it refers to the intuitive ability and receptiveness or acceptance of new concepts, ambiguity and divergent thinking methods; ii) maturity; iii) identification: the ability to change an analytical thinking method; and iv) proof.
- *Product of creativity :* The product of the creative process is the 'creation,' which may be a new product, process or solution. In a broader sense the product can be intellectual or physical.
- *Creative person :* The creative person embodies the very essence of creativity and is the key player for the creation.
- *Creative environment :* Environment is an important element to creativity since it motivates and awakens ambi-

tions. The creative environment includes the workplace and the national & international factors influencing creation.

There can never be a unilateral thinking process for solutions to various problems. Rawlinson categorizes them into:

- *Analytical thinking process :* Analytical processes depend on logic. This process approaches the problem for solutions in a vertical dimension with a view to converge to one (few) answer(s).
- *Creative thinking process :* Creative thinking processes rely on imagination. These processes make a horizontal search for divergent solutions with a view to arrive at numerous possible answers or ideas.

Though there are significant differences in the two processes, in practice, the two are employed in a combination and complement each other. The result of focused analytical thinking is usually the starting point for the creative thinking processes.

UNDERSTANDING INNOVATION

Recent studies have shown that two-thirds of innovations are the results of demand-pull requirements while the rest are technology-push induced. However, for an innovation whether demand-pull or technology-push, to be successful, it is important that it percolates down to all interconnected processes and procedures. At a macro level all innovations appear to be different, but if these innovations are observed closely at a micro-sphere, many believe that the same challenges can be found, where competitiveness is fundamentally determined by many-sided renewal capabilities. There is another school of thought that believes that innovation is not just the renewal of material-technological factors of manufacturing, but includes new ideas and methods introduced in production and sales as part of innovation. According to Schumpter, for a manufacturing company innovation means production of new goods, or adding better quality to existing goods; development of new manufacturing processes or procedures; new supply source of raw materials or intermediate goods. It also means new distributional possibilities and the creation of new organization, more suitable to a given set of tasks. Schumpter's interpretation considers innovation either

as absolute novelty (production of new product, procedure or processes) or as relative novelty (value addition, introducing techniques previously unknown to a particular application). Valenta, Perlaki and Pietrasinski and others broadened Schumpeter's theory. They consider not only fundamental changes as innovations, but also include slight improvements in existing products and in employed technologies under their definition of innovation. According to them innovation can be differentiated as per the following groups :

- *Basing innovations :* new breakthroughs that open up entirely new areas.
- *Developmental innovation :* can be realized in already discovered areas.
- *Phantom innovation :* innovations that merely serve to improve marketability and do not change the essence of the product or the employed technology.

Depending on the group to which the innovation belongs, one has to make use of different policy. All base innovations make use of the Initiative technological development policy. The objective of this policy is to create breakthrough innovations, which open a wide spectrum of solutions to new problem areas. Products of this genre being new, promise huge profits form the new development. The costs incurred by this policy are predominantly intellectual. Highly qualified and motivated professionals are an essential perquisite for this policy. The developmental costs are considerably high and involve high-risk investment options. Hence this policy must be used for strategically important innovation.

For developmental innovation, companies usually employ the Follower technological development policy. The profits, risk and investment are relatively lower compared to base innovation. The emphasis according to this policy is not to attain world-class products and solutions but to add more value at a lesser cost to an already existing product, service or solution. Companies with good engineering skill with limited R&D prowess use this policy.

The Adaptive technological development policy is best suited for phantom innovation - a frequent variant of the follower path.

Here a company aims at purchasing from a world-class firm, complete manufacturing documentation for a specified intellectual product. The task of the company is limited to adaptation and introducing innovative problem solving tools to increase the marketability.

According to D.J. McIntyre, innovation is a state of mind. Innovations do not just happen and solutions do not just appear overnight. The state of mind traverses through the following five stages before a solution is arrived at.

- *A period of preparation :* In this stage the problem is identified. The problem definition takes shape either in the subconscious or conscious mind. The problem could be one, which is totally conceived by the innovator, or one, which is posed to him.
- *A process of incubation :* This is the period of apparent lull during which the human mental faculties are at work. During the incubation stage, which often is a subconscious mental activity, the mind tries to assimilate all known information in its search for possible solutions to the problem. It seeks a solution by matching the problem to all the information in the brain's databank.
- *The moment of inspiration :* This is the stage when the subconscious finds a "best fit" between the problem and its vast database of knowledge, experiences, and trans-domain interests, the solution pops into the conscious mind, where it has a fleeting presence.
- *A process of evaluation :* This is the stage where the conscious mind takes over from the subconscious. The solution must be analyzed and critically evaluated and tested for its trueness.
- *The requirement for elaboration :* This stage requires persuasive skills. The solution at this stage is promoted to find acceptance from all concerned. Promotion is often done through presentation and publication. Suggestions of sufficient merit can be incorporated wherever possible.

It is not uncommon for companies to outsource their innovations. This is due to the reason that all necessary resources

may not be available with the company to convert an idea into a commercial product. In such cases it is quite likely that the innovation is also carried over to the outsourcing agency or supplier. In such collaborative product innovations it is necessary that both the parties define their roles and work together to achieve their objectives. The levels of involvement of supplier can range from design supplied to design shared or design sourced. However it is pertinent to involve the supplier at the conceptual stage so the benefits of innovation can be maximized.

The level of innovation may vary from organization to organization. Some may believe in innovation in their own product line. For companies, which thrive on satisfying the need of their customer's, innovation is attempted to keep the customer base happy. There are typically three distinct levels of innovation: linear, customer-driven, and radical.

- *Linear Innovation :* Linear innovation believes in steady and systematic levels of increment in the innovation being attempted. At each stage of this phase, manufacturers must complete a total functional product definition, synchronize supplier product developments, and validate the product's performance. As a result, a major percentage of a product's lifecycle costs are determined during the critical concept phase.

- *Customer-Driven Innovation :* While linear innovation is result of the urge of a company to excel in its own product line, customer-driven innovation is a response to the changing needs and requirements of the customer. This typically requires bringing together information from different applications, integrating with downstream manufacturing systems, and being able to include the customer throughout the process.

- *Radical Innovation :* The competitive landscape has forced companies to embrace the concepts of product differentiation and differentiated marketing. Executives now team up to brand their products as 'new and different' compared to the exiting ones. During this concept phase an incredible amount of collaborative interaction and "what-if" scenarios are needed to quickly iterate to a category-killer product definition.

For the success of an innovation, leading innovators balance their development efforts and program portfolios. Research has shown (Collaborative Visions, Inc) that for leading innovation companies the ideal balance comprises:

Inovation Ideal Index™ = 20% x Linear Innovation + 30% x Customer Driven

Innovation + 50% x Radical Innovation

Though this relation is not binding, this innovation mix helps in maximizing the benefits of innovation.

IDEAS - THE SEED CORN OF INNOVATION

As per a popular British survey, for one idea to lead to a successful innovation, approximately 3000 ideas need to be generated. Therefore organizations make conscious effort to generate ideas, which may later lead to a breakthrough innovation. Over the years, the generation of ideas has grown to a systematic science. Ideation is a process of deriving ideas through free-association and analogies. Ideas are also generated by challenging conventional ideas or by combining simple elements into new ideas. Ideation refers to the production of new ideas that have a bearing on the identification and resolution of a problem. Most idea generation strategies/tools belong to one (or more) of the following methods for ideation.

Brainstorming : This is one of the most popular and widely used methods for generation of ideas. For a specific theme or a problem, a group is encouraged to discuss and generate as many ideas as possible by free association. Association is through contiguity, similarity or contrast. All observations are carefully recorded and documented. Brainstorming is characterized by three main aspects:

- Elicitation/production of ideas by free-association (free-wheeling)
- Circulation/acceptance of any idea by positive attitude (free-playing, deferment of judgment)
- Selection/combination of ideas (parts, whole) for refinement and with a view to further generation of ideas

Synectics : This method is based on the systematic use of analogies for the generation of ideas. Analogies can be:

- Personal (identify yourself with the elements of the problem)
- Direct (apply solutions taken from other fields, e.g. natural world)
- Symbolic (play with images, e.g. metaphors)
- Fantastic (express wishes, desires, fantasies in pursuit of a solution)

Synectics is characterized by two contrasting dynamics: a) Making the strange familiar: compare/associate strange phenomena to familiar ones and b) Making the familiar strange: see/approach common phenomena under a new light and from an unusual perspective

Challenging : This method stems from the belief that the mental faculties tend to be creative when a person is challenged. Challenging is a way of pushing towards a reformulation of an idea by subjecting it to strong opposing views with the aim of either reinforcing or replacing the original idea. Challenging can refer to: assumptions (counter-views) specifications (counter-requirements) solutions (counter-proposals).

Morphological Approach : A Morphological Approach (mince and mix) is a way of generating ideas by decomposing a problem into sub-problems and listing, in a matrix, all the factors pertaining to it [mince]. Each possible combination (of factors in a sub-problem; of sub-problems in a problem) represents the basis for the generation of new ideas [mix].

INVENTIVE PROBLEM SOLVING

Engineering design process essentially consists of two components i) the conceptual design and ii) the detail design. Some parameters of engineering design are abstract and qualitative. Conventional design approaches, which are more analytical, may not always help in utilizing the qualitative information. This has motivated design researchers to introduce innovative approaches to problem solving. At present, as the importance of innovation in design becomes more apparent, a new sub-do-

main of Design Engineering is emerging: Inventive Engineering. This deals with the engineering design processes when innovation is a crucial factor, and is pioneered by research conducted at Ideation International Inc. in cooperation with several universities.

Though several examples of inventive problem solving could be found in history of inventions, it is only recently that it has emerged as a systematic discipline for innovators and designers. Prior to the 1960, descriptive approach was used to present various inventive problem-solving methods, which were basically intended for manual use. Computer started becoming popular during 1960 to 1980. Developing mathematical models and studying the computer simulation and implementation were the order of the day for inventive problem solving. With costs for computer time and space diminishing due to rapid advances in microelectronics and microminiaturization, online access to huge data and information base became a reality. Inventive problem solving presently is based on knowledge-based approach. Advances in networking technology would soon lead us to a virtual world, where problem solving would be conducted over computer networks, by teams with members located in different places and using intelligent agents for problem solving.

The theory of inventive problem solving dates back to late 1940's when Genrich Altshuller, a young and talented inventor, conceptualized it. He was working as a patent agent for the Soviet Navy. As a facilitator for filing of patents he was also involved in solving the inventive problems of his clients in various domains. This motivated to find a universal method that could help in finding solutions to various types of problems. Since no such method existed he made an exhaustive search of various patents and started comparing them. Surprisingly, he found many inventive patterns underlying inventions in engineering. This discovery led him to a vision of the Theory of Inventive Problem Solving (TRIZ a Russian acronym)), which would allow engineers to solve inventive problems in a systematic way. The evolution of TRIZ can be classified into three stages.

Classical Era 1946-1985: This was the period when the fundamental concepts were formulated. As in the case of inventive engineering during this period, the development of TRIZ was

based on descriptive approach to knowledge presentation. TRIZ during this period relied on development of independent tools for concept generation.

Kishenev Era 1984-1992 : This period started when Boris Zlotin, an accomplished inventive problem-solving expert, established, along with Alla Zusman, a TRIZ technical school in Kishinev. During this period, various independent TRIZ tools developed earlier were integrated. During this period the entire TRIZ Kishinev School was shifted to the United States.

Ideation Era 1992 until present : This period has seen the implementation of TRIZ tools to solve a number of complex and difficult inventive problems for several industries like car manufacturing, aerospace, textile, wood and petrochemical industries. The present era practices a knowledge-base approach. The emphasis is on developing comprehensive software packages for problems related to entire conceptual design process.

TRIZ research began with the hypothesis that there are universal principles of invention that are the basis for creative innovations that advance technology, and that if these principles could be identified and codified, they could be taught to people to make the process of invention more predictable. Over 2.8 million patents have been examined, classified by level of inventiveness, and analyzed to discover the patterns that predict breakthrough solutions to technical problems.

Based on the analysis of the patents he studied, Altshutter classified the levels of innovation into five categories:

- Apparent solutions are simply selected from a class of known solutions in a given engineering domain.
- Improved solutions are modified solutions from a given engineering domain or are obtained as a combination of known solutions from this domain.
- Inventions inside a paradigm are solutions produced as combinations of known solutions from different but related domains.
- Inventions outside a paradigm are solutions produced using knowledge from at least two much different domains.

- Discoveries are solutions based on new scientific principles.

Based on these levels the three primary findings of this research are as follows:

- Problems and solutions were repeated across industries and sciences
- Patterns of technical evolution were repeated across industries and sciences
- Innovations used scientific effects outside the field where they were developed

These findings essentially mean that the problems could be wide and varied. The solutions to these problems however are limited and are repeated across various problem domains. Much of the practice of TRIZ consists of learning these repeating patterns of problems-solutions and patterns of technical evolution, and methods of using scientific effects, and applying the general TRIZ patterns to the specific situation that confronts the developer. In the application of TRIZ all three of these findings are applied to create and to improve products, services, and systems. Large and small companies are using TRIZ on many levels to solve real, practical everyday problems and to develop strategies for the future of technology. TRIZ is in use at Ford, Motorola, Procter & Gamble, Eli Lilly, Jet Propulsion Laboratories, 3M, Siemens, Phillips, LG, and hundreds more.

CONCLUSION

More and more of us believe that while science progresses from known to unknown, the world evolves through innovation. The basis for this optimism is the faith in human creativity and in scientific progress. Together they bring new solutions by utilizing the existing knowledge and combining the need for profit, moral norms and the principle of law in a new manner. As needs grew, the problem solving approaches began to rely on inventive engineering. The need was further enhanced due to global market and open competition, which forced organizations to rediscover the importance of innovative approaches to problem solving. The age of information technology has made it practical for innovators to search for solutions across the length and breadth

of various other problem domains. With the rate at which the world is now witnessing newer ideas and innovations, the present age could very well be the beginning of the age of innovation. Fortunately, due to the past five decades of research in inventive problem solving and tools like TRIZ, the world is now better equipped to welcome the innovation age.

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Panel discussion

IPR Management

Ideas to business

Since 3000 research ideas lead to one commercial success (according to a British survey), a progressive firm must try to stimulate people and get as many ideas as possible. We must encourage ideas to emerge through various sources, and means like brain storming sessions. We must not overlook the fact that the ideas generated through these sources need to be moderated or managed properly, otherwise we just end-up in chaos. To capitalize an idea to its full potential, it is important to solicit these ideas from lead users. Many a time unsolicited and unsubstantiated ideas are encouraged, especially if such ideas come from top brass. Such practice results in most ideas fail at a later stage. Hence, new evolution and evaluation strategies must be evolved to convert ideas into areas of business strength.

Managing intellectual assets of an organization

A mechanism/process must be evolved identify the impact or productivity of an intellectual asset. Some of them may or may not have an immediate impact. But any idea or innovation with good potential must be patented immediately. If the complete specifications necessary for filing a patent need further research, it is important to apply with provisional specification. This helps in at least registering the idea before others can register. While devising business plans the intellectual assets must be considered. An intellectual assert also involves experts and efforts must be made to retain them during the product development cycle.

How to identify early and capture the technology at early stages

The first and foremost thing to do once an idea, innovation or technology is looks promising is to initiate efforts to acquire it. To identify the potential of an idea/technology it us necessary to involve people all disciplines eg. design, production, marketing and the end-user. If the idea/technology is in-house, it must be patented to obtain legal rights. This helps in preventing others from using your idea or innovation. If it is already patented, it must be acquired before others do. After acquiring the asset, technical & marketing experts, and the end-user must be involved in devising a conceptual plan. Product life cycle must be drawn and final detailing must be done. Having completed all these stages, the idea/innovation must be launched commercially.

Contract research : Sharing of IPR

Some laboratories outsource a part of their research to other laboratories. In such cases it is important for the two laboratories to come to an understanding about the nature of sharing of intellectual property. This must be done before

an agreement is signed and must be included in the MoU to avoid conflicts later-on.

Commercialization of idea/innovation

An international patent usually takes one year before it is sealed, while national patents take much larger time. This duration could be too long for its commercialization considering the present day competitive world. Should one wait until the patent is sealed before trying to commercialize the idea/innovation? The innovator must carefully study the market to decide whether to commercialize the idea as soon as possible. If it is not possible for the innovator to commercially launch the idea, it might be worthwhile to enter into licensing agreement with entrepreneurs. However, the licensing agreement must be carefully drafted to prevent the entrepreneur infringing on the IP of the innovator.

Utilization of idea/innovation

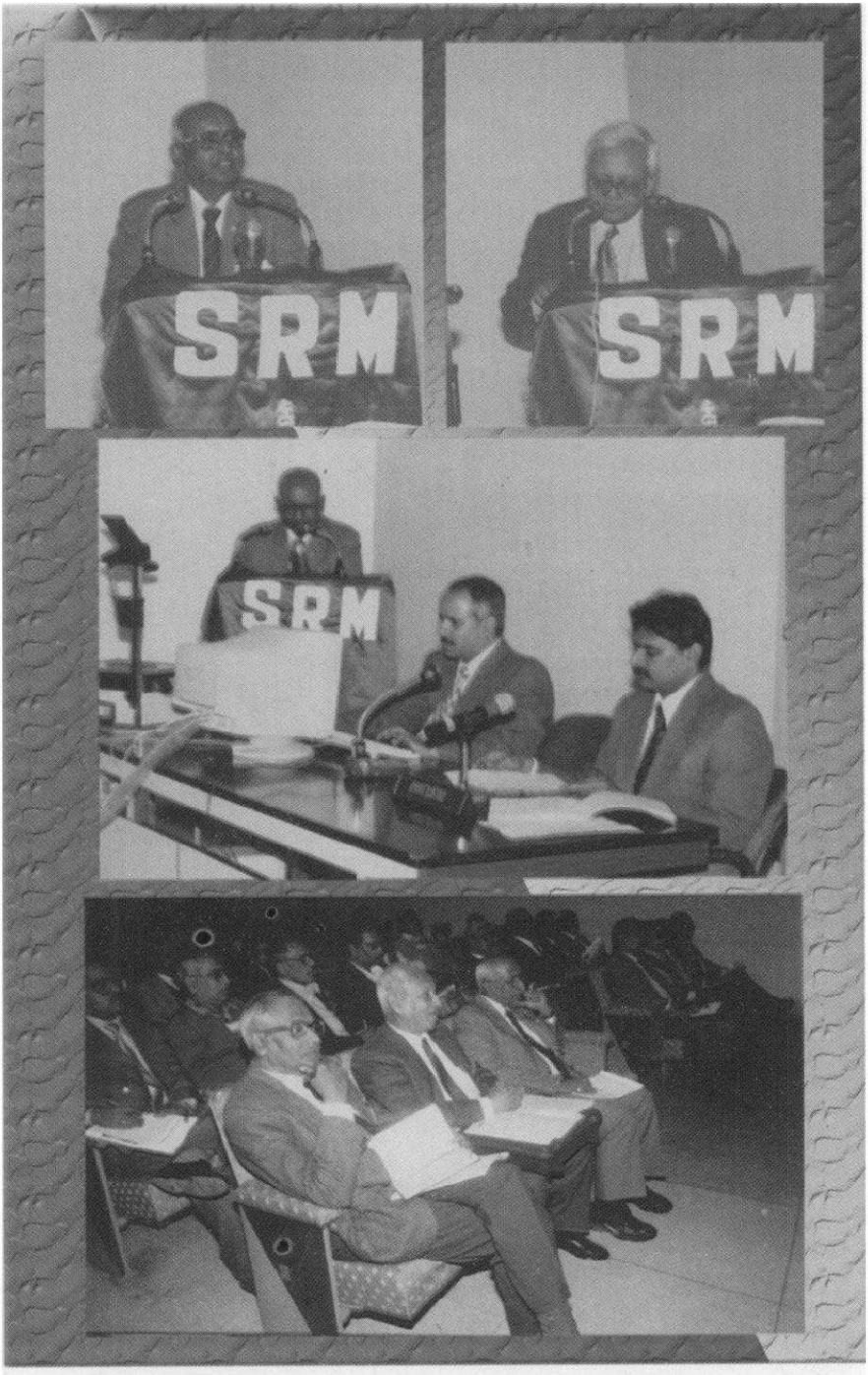
A company might acquire a patent conflicting its business interest and do nothing to utilize it. Unfortunately, the present law has no means to prevent this from happening. This is something that must be further deliberated.

What is not patentable

Safe guards do exist in the patent law to prevent patenting of naturally occurring substances like minerals. The patent law also prevents traditional knowledge like the cultivation of Basmati rice. However the laws are still not sound on life-saving drugs, which ideally must not be patented in the interest of the society.

Patent v/s Trade secret

Some companies prefer retain their IP assets through trade-secret eg. Coco-Cola. How they do it is again a secret. There is no law, which prevents companies to resort to such methods. But if the secret is out through some means, there could be no safe guard for its exploitation by others.



Technical session : IPR Management

Technical Session : Impediments in Technology Transfer