Developing a collaborative framework for Make in India capabilities

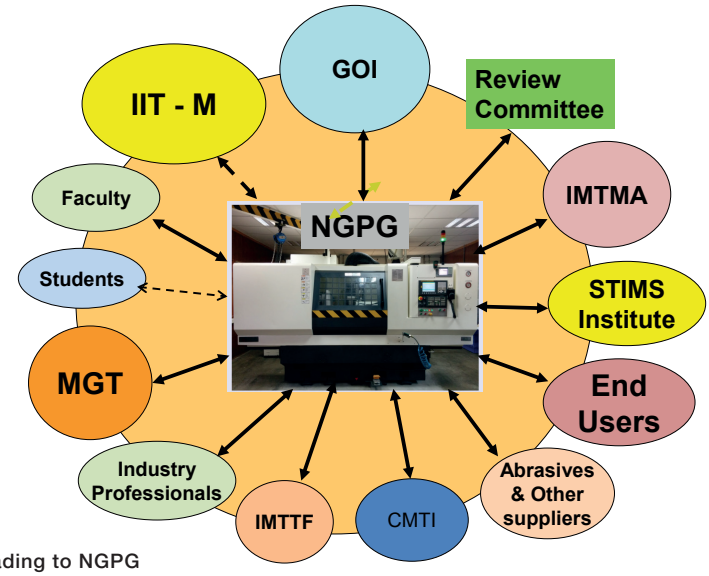
To address the limited capability among Indian machine tool manufacturers to produce high precision machines, a model on Next Generation Precision Grinder (NGPG) has been developed. This project also illustrates the development of a collaboration frame work to integrate the expertise available with the Indian machine tool manufacturers, academic resources, etc with the knowledge available from across the globe.

Next Generation Precision Grinder (NGPG) is an indigenously designed and manufactured grinding machine tool to achieve higher precision and tolerances. More specifically, it is an external cylindrical grinding machine with sub-micron precision capabilities of form & geometric accuracies on the ground component. Currently, requirements of high precision components used in several sectors like automobile, defence, aerospace, etc are met through 'high cost imported machine tools', where technology is not available for purchase by Indian machine tool manufacturers.

As per recent reports, more than 40% of the machine tools purchased in India each year is imported and it is rapidly increasing due to the technological advancement taking place elsewhere. Also, it is observed that the requirement of high precision machines in the Indian manufacturing sector has been rising rapidly over the last decade.

Development of NGPG

After sustained discussions between Micromatic Grinding Technologies (MGT), Indian Machine Tool Manufacturers Association (IMTMA), Indian Institute of Technology Madras (IIT–M) and Science-based Technology Innovation and Management Solutions (STIMS Institute), it was decided that the development of cylindrical grinding machine would be taken up as a case study for developing higher precision



Eco-system leading to NGPG

machine tools, as it is widely used in the automotive sector. A formal proposal for the 'Development of Next Generation High Precision Cylindrical Grinding Machine Tool' was submitted to the Office of Principal Scientific Adviser (OPSA) to the Government of India and the same was sanctioned in November 2011.

IMTMA: IMTMA facilitated the interaction of members from academia (IIT Madras) with its members (grinding machine tool manufacturers) and helped to identify a suitable industrial partner for the project.

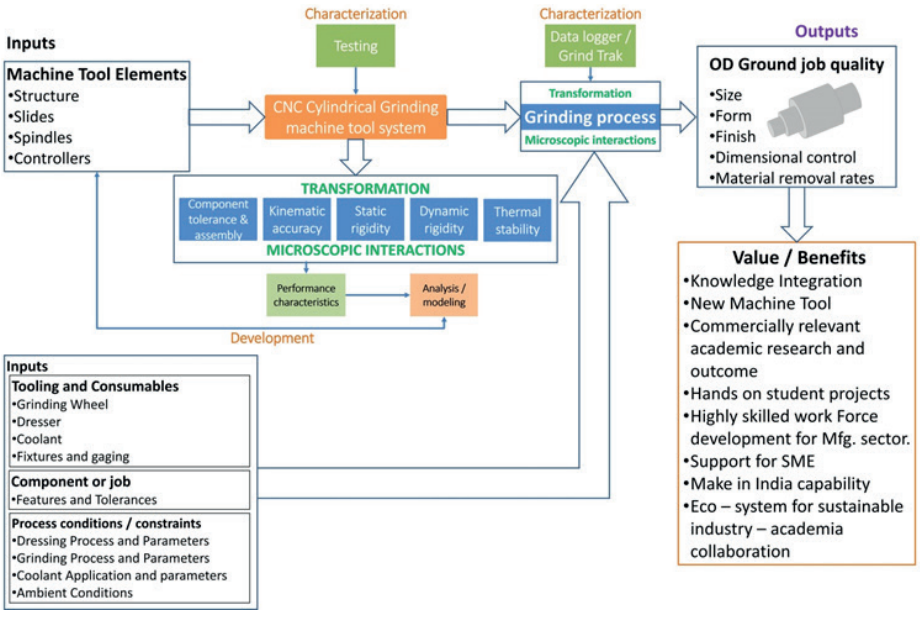
STIMS Institute: STIMS Institute provided active support, training and mentoring on System Thinking and Transformational Skills through all phases of this project. Also educated the project team on "System Approach" as applicable to precision grinding processes.

IIT-Madras & MGT: Teams from IIT-M and MGT formed the working base for the successful execution of project. Team of students (PhDs, M.Techs and B.Techs) from IIT-Madras worked on various aspects of the project, such as systematic experimental studies to characterise the performance of existing machine tools; developing various models that identified technical pathways for the development of NGPG machine, etc.

Government of India: It has steered the project by providing a team of experts to review the progress periodically. The team comprised of eminent experts from the machine tool industry as well as academic institutions.

According to PJ Mohanram, Senior Scientific Advisor, following are the learnings of the project:

1. Cooperative R&D is entirely possible between industry and academic/R&D institutions in India as long as everyone is focussed on the same common goal (i.e.) advancement of academic knowledge that supports commercially viable end results.
2. Such an approach is most appropriate for medium to long term R&D projects (3-5 years), not those requiring immediate development.
3. At higher reaches of technology, the scientific inputs can only be brought by academia, since industry mostly does not have the needed resources.
4. There are tools and resources available from facilities like AMTTF that could be deployed by students and industry professionals. Developing such eco-system enhances efficiency and reduces the total cost and investments needed in such projects.
5. A structured project with system thinking leading to clearly laid down quantified objectives stands a good chance of success.
6. There must be a driver each from industry and academia, who make it their personal mission to complete the project successfully.
7. It is essential for the industry and academic institution to continuously interact and jointly work on the project at every stage. Such collaboration also benefits from engagement of organisations, such as IMTMA and international experts in knowledge integration.
8. A free exchange of information and data is essential, without being worried about Intellectual Property (IP) confidentiality at every stage. This can be secured through a mutual Non-Disclosure Agreement (NDA) at the start.
9. If properly reviewed and managed periodically (as by the



System approach framework for development of NGPG

Features	O.D. Grinder (Initial)	NGPG (New)
SIZE		
Process Scatter - 6σ (Microns)	6.5	2.5
Tolerance Grade (IT)	5	3
FORM		
Circularity (Microns)	>1.0	0.5
Cylindricity (Microns / mm)	3 / 300	1/ 300
SURFACE QUALITY		
Surface Finish (Microns)	0.40	0.25

NGPG performance results and comparison

PRMC), it is possible to complete such projects within the time and budget allotted.

System approach for knowledge integration

The main focus of this project was to integrate the knowledge available with the Indian machine tool manufacturers, academic resources like IIT–M and any other resources available inside of India and combine it with the knowledge available from across the globe. To characterise the performance of the machine tool, it was necessary to develop a diagnostic tool for the grinding process. This characterisation tool developed at IIT–M is now in commercial use.

Machine tool is a complex interacting system, with various factors affecting its precision capability. But any machine tool and its use can be conceived as an 'input-transformation-output' system to simplify and standardise the characterisation and developmental process. The figure shows a schematic representation of the characterisation and development of cylindrical grinding machine and its use as an input/transformation/output system. This system approach framework has been used throughout this project.

To characterise the performance of the machine tool, it was necessary to develop a diagnostic tool for the grinding process. This characterisation tool developed at IIT–M is now in commercial use. With the performance benchmark established, detailed testing of the machine and its sub-assemblies were carried out. Resources in India, such as AMTTF have been of great value in the machine tool characterisation methods techniques and the necessary instrumentation for that.

From these tests, the performance characteristics of the machine and the various factors affecting the precision were identified. These observations were then used to analyse and model the interactions and determine the modifications required to the inputs to meet the targeted specifications of high precision grinder. However, the interactions in a system as complex as machine tool can only be understood by a combination of both experimental and analytical techniques.

Role of machine tool precision

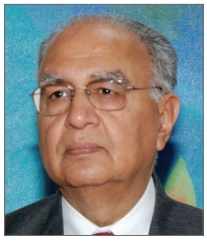
The following factors affect the precision of the cylindrical grinding machine tool and in turn the quality of ground component:

Geometric and kinematic accuracy: A combination of errors on a cylindrical grinding machine usually affects the size and form of ground component. In the NGPG machine, these errors were minimised and kept within certain optimum levels. Volumetric accuracy model and sensitivity analysis were used to identify critical errors and their limits.

Structural rigidity: Static and dynamic compliance of

"To solve problems, the knowledge and resources are available in India. Each resource looks at the problem through a peep hole – their vantage point only. The challenge is to harness all this knowledge through a simple framework where relevant science, engineering and management issues can be integrated."

Dr Subramanian,
President, STIMS Institute Inc, USA



"Active hands on collaboration between IIT–M students and our engineers were a key element for the success of this project."

NK Dhand,
Chairman, Micromatic Grinding Technologies Ltd

"Each aspect of machine tool development is well known to the academic researchers, pulling them all together as a system for a well-defined goal and commercial outcome is not a traditional practice. But such goal-oriented system integration is essential for commercially-relevant research outcomes in a highly-practice oriented area, such as manufacturing technology."

Prof Ramesh Babu,
IIT – Madras

"We needed an industry-university collaborative framework, such as ones in countries like Germany. NGPG has been an excellent example of developing such collaboration using resources available entirely within India."

PJ Mohanram,
Senior Scientific Advisor, IMTMA

different assemblies in the machine tool affect the form and finish of the ground component. During the development of NGPG machine, the compliance of critical subassemblies were identified and improved. The improvements include the design of structural interfaces as well as the design of certain critical features of the subassemblies, such as carriage and table system, wheel head, workhead and tailstock assemblies.

Thermal stability: These include quasi static deformation/drift of machine tool structure, linear axes, spindle, etc. These usually manifest to affect the size and form of ground component and also affect both, short term and long term process capability and tolerance control. In the NGPG machine, such thermal deformation/drift were controlled by improvements to the design of linear axes and wheel spindle.

Mechatronic and controller system: The performance of the mechatronic systems in the machine tool affects its mechanical performance and can affect the size, form and finish of the ground component. Various aspects of the mechatronic system were fine tuned to improve the stable performance of the machine tool.

Consistency of grinding process: The performance of the grinding process was optimised with the development of diagnostic tool and associated analysis techniques. This allowed the design of grinding and dressing cycles that can meet output requirements on a consistent basis.

Addressing transformational skills

Developing the NGPG from a concept to commercially viable machine (end-to-end innovation) was formulated and executed based on the system approach framework. In fact, the NGPG machine in itself shows that a 'transformational' output and the required 'skill' set are already available if anyone is willing to leverage them.

Going forward…

The success of NGPG project, i.e. converting an industry-academia collaborative research and development effort into a commercially viable product, enabled the team to pursue with the government to set up a centre for Advanced Manufacturing Technology. With the help of the Department of Heavy Industry (DHI), Government of India, a centre called Advanced Manufacturing Technology Development Centre (AMTDC) is set up at IITM Research Park, as an independent registered society to take up collaborative efforts with the industry. Currently, 11 projects, related to machine tools, robotics and drives and controls, from six different companies have been taken forward. □