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ASSUMPTION OF TOTAL ASSEMBLY PROCESS CONTROL (TAPC) IMPLEMENTATION

ABSTRACT:
Studies under the TAPC system have been undertaken in order to develop the system which allows the companies of automotive industry for broad and detailed assembly process control and development. The system is to incorporate existing tools like SPC, CAPP, MA but also it will introduce some new elements or modifications of the aforementioned, regardless whether it would be the tools themselves, procedures for tools utilization in company or introduction of new departments purposely created to maintain the TAPC in the company. Studies towards TAPC invention will range from searching for simple and cheap solution, like human based MA introduction or SPC worksheets for data gathering, to more advanced and expensive areas like error proofing device for example, vision systems readings data transfer for capability studies purposes or studies under central computer database for dynamic, generative CAPP proper utilization. The studies will be carried out in two ways, theoretical activities and practical tests at Thule Company.

KEYWORDS:
Process Planning, SPC, CAPP, Changeover, Automotive

INTRODUCTION

In the modern automotive industry, where the will to be better than competitors and meeting specific customer demands are so important, the fact of having products of highest quality is extremely important, but not only that, the general income of the company is one of the main interest as well therefore within the automotive industry both technological and quality issues should stand on the same level for the process controlling engineer or manager. In order to achieve that, production process must be flawless, fully controlled and predictable which can be translated for example into detection of any abnormal process behavior well in advance before such a situation occurs. That gives time to the designated personnel to take preventive actions in order to maintain whole process in line.

Having said that it wouldn't be in place not to mention that different control tools and techniques already exist and are in common use within automotive industry, but many of them have been introduced to the companies only because of the demands of ISO-TS 16949.

ISO-TS 16949 certificate is a must for a company that wants to be recognized on the international market. That demand creates a situation which is an obvious paradox, as the managers who want to obtain and maintain that certificate for their companies, have to initiate new procedures for documentation keeping, broad the volume of necessary documentation and introduce new tools to the production process and many more obviously. That is unquestionably good, but nine times out of ten it ends with stacks of data on the shelves or computers with no one to make a proper use of it and that is a whole point of gathering that information, to use it in order to analyze and control the process. It could be well used for example for SPC, which should be a standard way of process control in automotive industry of twenty-first century or dynamic process planning, based on computer software and existing process data outcome, like generative or dynamic CAPP [3, 4]. Further to that, another dangerous situation may occur.

As mentioned before there are many tools, techniques available for managers and engineers to make the process reliable, predictable, cost-effective, that would give a high quality product [8, 11]. This is the point where all problems begin. ISO-TS 16949 can explain what should be controlled, what areas need special attention, but that is about that. It doesn't say what tools should be used, in what areas of technological process, what exact information should be gathered, what should be analyzed, how the outcome of analysis should be translated into the improvements. It won't help with the choice of tools combination, as one process control tool is never

enough and last but not least it won't help with establishing the procedures of how, where and by whom all those tools and techniques should be used.
Technological process, for example an assembly process is only a part of whole production process, but many areas should be watched over there, like, workforce use, equipment efficiency, breakdowns, maintenance time, process flow and all product related quality issues like nominal measurements keeping. Nowadays, each department has their own tools and own ways of controlling or detecting and gathering that information as well as translating it into the actions that need to be taken to preserve uninterrupted process flow. Many departments, many tools, many employees, there is no common language within the company, the coordination of actions and information exchange is in the best case sufficient. That situation isn't that bad as the one, when a manager decides to introduce some tool, with all the good intentions, but the fact of lack of experience, mismatched judgment of usefulness of the that tool, could bring an enormous waist of time and money and the implementation wouldn't succeed or the tool wouldn't meet the expected outcome. It is not a problem to introduce, for example a SPC, the problem is what to do with all that information that it would collect, shall it be used for DoE (Design of Experiments), and shall it be used for process control or maybe for process planning and what kind of process planning, CAPP maybe, or Dynamic or Generative CAPP? How the information should be transferred and who should it be transferred to, the managers, agents, maybe a multi agent system should be introduced and if yes, shall it be human based or computer based. How all that information should be stored and compute in order to obtain the final action plan that needs to be undertaken? The questions like those are endless.
An answer to that question is simple and so obvious that other systems used that before. For example TQM, it is a set of rules and procedures that describes the responsibilities of different bodies within the company in order to achieve the goal of highest quality product and customer satisfaction. It also explains what available tools should be used, how, when and by whom. It couldn't be simpler.
Therefore, why not create the similar system for assembly process control, where, advisable tools are described, the way of using them, who should use them, how the information should be gathered, stored, transferred, analyzed, optimized and how the outcome should be implemented in the main goal of having the process fully controlled and of highest quality. That is the intention for creating Total Assembly Process Control (TAPC)that can be fully implemented as a uniform system and that would, in a few words, control and optimize the process in order to predict abnormalities for flawless, cost effective production and to maintain high quality of products, meeting customer demands.
TAPC system will be designed as a process control and process planning aid.

TOOLS AND TECHNIQUES FOR TAPC SYSTEM AND ITS STRUCTURE

One of the main problems that stand on the way of creating total assembly process control system is frankly very obvious. It is a decision on what tools, techniques, engineering rules or solutions in general, should become a part of that system. In order to make an appropriate choice some investigation within the automotive industry must be undertaken. For example, the quality demands which are so specific for this area of production must be considered vital for future system structure.
All the tools should be individually analyzed as well, in respect of having their usefulness and areas of application as understandable as possible. Only such an approach could bring an answer, what should be applied into the structure of the TAPC system.

AUTOMOTIVE INDUSTRY – MAIN ASPECTS AND CONTROLLED PARAMETERS

Quite easy to spot are of highest interest for the companies of aforementioned industry. They can be recognized as: time, money and quality. All the other aspects result from those three. It is vital to understand that those three usually stand in opposition to each other, and that is a problem which process control unit has to work with and work it out. Now, it is important to dig deep down to get to those less obvious aspects or not so obvious at all. Let's pay a little more attention to that. For example what could be directly connected to quality in automotive industry, well, the answer would be: demands of APQP (Advanced Product Quality Planning), ISO-TS 16949 and customer specific demands [2]. Following that thought, what could be connected to those, let's name them. Firstly, final products must comply with all conditions stated in the signed PPAP (Production Parts Approval Process), like measurements, materials, shape, performance and many more. In order to achieve that the process itself must provide solutions that will secure the correctness of final product assembly. There are four basic matters to be focused on, which divide into many others of course, but in general there are four, like people, equipment, materials and information. To be able of keeping first three in hand the fourth must be properly gathered, analyzed, optimized and the outcome perfectly implemented. Having said that, it must be declared now that, for example the machines itself are not so much important as the control over them, for that purpose the constant information flow must be provided. Readjustments of the sensors, re-programming, re-layout, etc are not a requirements, those are results, that happen as a result of a need to do so, but an information about such an need must come to a proper person and in due time. Apart from the quality, there is a profitability aspect, which can be easily disrupted by poor work cell or line layout, poor material flow, time consuming changeovers and set-ups and other.

What can be done about that, well, yet again, good information from inside the process is a must, from operators, from and about the equipment and materials. So it is all about information.
A good system which helps with direct and streamed data gathering speeds up the next step of the analysis and optimization. It helps to transfer the data to the person who is designated by the system to work with that particular matter and finally it allows for swift reaction, desirably preventive not corrective.
To summarize, the most important aspects to be controlled are people, machines, materials in order to provide high quality final product that complies with customer demands and all of that needs to be controlled with well designed and functional system which allows for proper data gathering, data analysis, data optimization and outcome implementation. That system allows the company to become more profitable.

PERFECT CANDIDATES AND THEIR ROLE IN TAPC SYSTEM

- *As aforementioned, work towards creating the TAPC system is in the very early stage, but never the less some tools and techniques for process control and planning are being closely analyzed. Process planning matters are under the scope together with inseparable CAPP (Computer Aided Process Planning) nowadays. Next would be statistical methods like SPC (Statistical Process Control), DoE (Design of Experiments) and other statistical analysis [1, 6, 9]. That can be a very powerful tool when properly used, not to mention that for customers within an automotive industry it is highly desirable that a supplying company has got them implemented into their system. The MA (Multi Agent) system will be looked closer at in the near future, as it forces the different way of problem solving, and in definition excludes one person as an ultimate problem solver.*

Apart from that many other smaller, in a way subjects will be approached, like error proofing devices, vision systems, laser systems, PLCs, Kaizen rules and solutions, information technologies as well. All of that is necessary to be studied, to be able to create any process control system what so ever.
One might thing that any of aforementioned tools is nothing new well could not be more correct, but the example of IVHS (Intelligent Vehicle/Highway System) on the central artery/tunnel project in Boston, Massachusetts, USA proves that the key is a perfect combination of existing tools, which leads to a creation of state of the art control system [10]. Of course some of the tools implemented into that system were improved, which is a logical behaviour from system creators, and so shall TAPC system elements develop for improvements, in order to maximize the benefits running from their implementation into the system. The best example is a ATMS (Advanced Traffic Management System), it uses computers, sensors, basically electronics to control signal system, ramp meters, automated toll collection facilities, all of that have already existed, but now it is combined together and overlooked by common ATMS, which further more is a part of bigger IVHS.
Now, the question is which tools and how combined could benefit best and how to the company. Let's briefly describe the advantages of having certain tools working within the system and a vision of tools combination and specific way of their usage within TAPC system.

- *Firstly, the statistical tools, how they can benefit? In order to maintain flawless technological process, we need to prevent and foresee rather than carry out corrective actions [5, 7]. Also, we need not to interrupt the process, so the optimization hypothesis could be tested; there is no time and money for that. Statistical tools can help us, plan, optimize and test the process in a virtual way without any interruptions into the workfloor. For example, information gathered from the process like changeover and set-up rates, followed by other information like how many materials on pallets or plastic boxes had to be delivered into the work cell or line, information about the timings of that operations, how many operators were involved in those operations, all of that can be analyzed in order to find correlations between them and prepare input for statistical experiments. By doing so we can find out what can be changed to help us improve the operations of changeover, which particular elements should be taken care of, minimized or maybe maximized etc. Let's take a real life example from Thule Sp. z o.o. where on some workcells there are up to five changeovers per shift each taking forty-five minutes, a waist of time and money in the process is more than obvious. The DoE run by an appropriate engineer could bring him an answer what to do to shorten that time without having to field test many solutions in order to chose the best one to do the try out. In that way the production run is not interrupted but the optimization activities are being performed. Then, when decisions are made, it is only the matter of time for final implementation of the best solution statistically chosen and verification of the feedback from production. Data for statistical analysis and control can come from many places within the process, mentioned changeovers, product measurements, machine performance; OEE (Overall Equipment Effectiveness) needed data in general etc. [5, 7]. Each and single aspect can be controlled in order to find variations within the process and after some time of data analysis many situations can be prevented from occurring, as the statistical probability of something to happen in certain time and place in the process is already known. For example, let's assume that after analysis of certain product assembly process, we found out that fixtures with laser sensors of the workbench gets worn after time 'X', so we can inform the Maintenance Department about that in order to plan adjustment activities in time 'X-1' when, the workbench is not needed for production. This is very simple example, but it describes the idea of statistical tools usage. We can find bottle necks, we can define periods of time after which something*

wrong may happen, we can basically control any measurable characteristics and we can use them for existing process alterations and new processes planning. Such a broad spectrum of data collection, analysis and optimization requires a designated unit that would be responsible for process control, optimization and planning.

A unit that would base their actions on gathered, measurable data and an analyzed output of that. The unit would plan process improvements regardless whether they would apply to workforce, equipment, documentation or materials and their handling, it would analyze everything connected directly to the assembly process taking great advantage of many statistical tools. The unit propositions for process improvements would be directed to the appropriate departments, like to a Maintenance Department if improvements need to be applied to the equipment or Production Manager when it comes to changes of workforce usage etc. The unit would have a status of process design and advisory department of kind and at the stage of implementations the role of coordinator for designed improving actions. To summarize the Unit's main goal would be continuous process scanning for any variations in order to prevent them before they occur, distribution of certain data from the process to interested departments, work on process improvements projects based on gathered information from inside the assembly process and deeply analyzed with advanced tools, not only based on human experience, coordination of development actions and last but not least main part in new process planning projects. The implementation of such a unit into the company is one of the ideas of TAPC system, as it would be the coordinating body for TAPC system.

- *Second element of the system is process planning. Sounds very straight forward but it is not. The process planning procedures and sequencing is very complicated activity, if a company wishes to have well designed process that will meet all requirements. One of the tools that can be of the great advantage in this respect is CAPP (Computer Aided Process Planning), especially for the manufacturers with significant number of products, like in case of Thule Plant in Poland which has over 200 different types of products. Manufacturers have been pursuing the path to improve and computerize process planning, and as for now the five stages are recognizable, stage I – manual classification, stage II – computer maintained process plans, stage III – variant CAPP, stage IV – generative CAPP and last, stage V – dynamic, generative CAPP. Although the studies in this area are well advanced, many companies in the automotive industry still work at stage I or II. The Thule Company, that will be treated as a test field for TAPC development and implementation has its process planning at stage I, therefore it is a perfect choice for studies purposes. Manual process used in there is based on a manufacturing engineer's experience and knowledge of production facilities, equipment, their capabilities, processes and tooling. That kind of process planning is very time-consuming and the results vary depending on the person doing the planning. The studies under TAPC system assumes that at least stage II of process planning shall be used, but the system will be designed to be flexible in respect of implementing any of the higher stages of CAPP with stage IV and V as desirable. The basic improvement for process planning is parts coding and standardized process plans records in the database, when system can do 90% of work and remaining 10% is done by appropriate persons with their experience and knowledge. Further to that is a development of the system, where at process planning stage, system considers plant and machine capacities, tooling abilities, work centers and equipment loads and equipment status, for example maintenance downtime. It has been mentioned here, because all of that information shall be gathered, analyzed and maintained by designated Process Control United, described in previous indentation of this paper. The unit would provide data input for the CAPP system, which could work with the fully analyzed, therefore trustworthy information when planning for a new process.*
- *In order to combine the work of the Process Control Unit and CAPP system, a third element is required; a central computer system must be implemented into the company. A system that would have all information stored inside, measured, analyzed and optimized, where dynamic CAPP system could take particular data from. The maintenance of that central computer system, which is correctness of data stored in there or that all necessary data is available and in right place and form in the system would be also a responsibility of Process Control Unit. That is the basic idea for TAPC system but still in the very early stage; therefore much work must be done in this area.*

Fourth element that is considered to be involved in the TAPC system is MA (Multi Agent). The TAPC system is being designed to have Process Control Unit as a leading department in this area of expertise, like TQM is overseen by Quality Department for example. Due to the central computer system, which will store huge amount of data and the fact that process plans shall be designed based on that data, possibility of data input should be restricted and the best way to do so is by assigning designated persons in different departments, which would be called agents. It will also simplify the communication between the coordinating Process Control Unit and other departments, as those agents will be fully engaged in the TAPC system activities. Some of the agents can be of non-human nature, using artificial intelligence, but due to the fact of development stage of that subject, costs of implementation it will be a possibility to be used for TAPC system but not a must. Some information can be gathered by sensors, transferred directly to the computer, an agent, where data shall be analyzed and stored into the central computer system automatically, right after analysis, without human interaction.

ADDITIONAL STUDIES FOR TAPC SYSTEM

Described, in previous paragraph, were four basic tools that should be a used within the TAPC system. The next step after the full analysis of their usefulness, shall be the definition of where, whom by and in what range they shall be used. In order to make that all clear for downstream users, the list of system requirements and implementation procedures shall be described as well. The cost analysis of system implementation will be performed for Thule Company, as the testing company, so the clear view for further benefits analysis of the introduced system can be accurately calculated.

Additionally, the technologies of equipment's error proofing devices will be studied to understand what information and how can be gathered form them or using them for process control purposes. The PLC, vision systems, laser systems and others will be approached in the process of TAPC system creation.

To achieve that point, certain resources will be more than necessary, like cross-functional team or at least consultants in the areas of CAPP, MA, Quality Planning, IT and automation, company to run the test at and obviously time.

CONCLUSIONS

The TAPC system in definition is about helping company's personnel control and plan assembly process. It is still a long way before it will obtain the close structure, as studies started in October 2009, but once it is done and tested its introduction into the automotive industry shall be translated into less time waste, more uninterrupted processes, better equipment usage and operators deployment on the shopfloor. Due to the fact that all described data will be analyzed and optimized with advanced tools, the human error will be drastically decreased and the new process plans will be more accurate for any particular introduced product. The improvement actions will not cause long production stops as development actions will be designed using DoE and the communication between departments will be tighter and more precise, which will be possible due to the fact of MA implementation. Advanced tools and introduction of Process Control Unit will help spotting bottlenecks and any process variations, in order to maintain flawless process and best quality products.

REFERENCES

[1.] *Aczel, A. D.: Complete Business Statistics. PWN SA, Warszawa, 2000, ISBN 978-83-01-15338-0.*

[2.] *Chrysler Corporation – Ford Motor Company – General Motors Company: Advanced Product Quality Planning and Control Plan - Reference Manual, 1995.*

[3.] *Chrysler Corporation – Ford Motor Company – General Motors Company: Potential Failure Mode and Effect Analysis - Reference Manual, 2008, ISBN 978-1-60534-136-1.*

[4.] *Chrysler Corporation – Ford Motor Company – General Motors Company: Statistical Process Control - Reference Manual, 1995.*

[5.] *Hansen, R. C.: Overall Equipment Effectiveness - A Powerful Production Maintenance Tool for Increased Profits. Industrial Press, 2001, ISBN 978-0831131388.*

[6.] *JMP Design of Experiments. SAS Institute Inc., 2005, ISBN 1-59047-816-9.*

[7.] *McIntosh, R. I. – Culley, S. J. – Mileham, A. R. – Owen, G.W.: Improving Changeover Performance a Strategy for Becoming a Lean Responsive Manufacturer. A Butterworth-Heinemann, 2001, ISBN 978-0750650878.*

[8.] *Ostwald, P.F. – Munoz, J.: Manufacturing Processes and Systems (9th edition). Wiley, 1997, ISBN 978-0471047414.*

[9.] *Polak, T.A. – Pande, C.: Engineering Measurements - Methods and Intrinsic Errors. Wiley, 1999, ISBN 978- 1860582363.*

[10.] *Sergiu, F.L.: Intelligent Vehicle/Highway Systems on the Central Artery (I-93) Tunnel (I-90) Project. Boston, Massachusetts, USA.*

[11.] *Zandin, K. – Maynard, H.: Maynard's Industrial Engineering Handbook (5th edition). McGraw-Hill Professional, 2001, ISBN 978- 0070411029.*

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