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Tools of product quality planning in the production part approval process

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ABSTRACT

Purpose: The article concerns the analysis of the applicable normative requirements in the field of product quality planning in the process of approving parts for production.

Design/methodology/approach: The analysis, in particular, concerns the correlation of appropriate methods and quality management tools in the quality planning process.

Findings: Correct use of quality planning tools in product and process development determines the effectiveness of implementing individual phases of APQP (Advanced Product Quality Planning).

Research limitations/implications: It is important that the organisation skilfully and consciously uses the quality tools required by APQP; they usually require multiple uses during the project implementation time, which depends on the specificity of a particular project.

Practical implications: The study presents how core quality planning tools are related, proving that they cannot be treated as an individual tool, but only their correct use can protect the project/organisation against nonconformities or misunderstandings between the supplier and the customer.

Originality/value: The study's originality and novelty show the relations and dependence between APQP phases and core quality tools/evidence developed in the PPAP (Production Part Approval Process), according to PPAP level 3. The article presents a practical approach to the use or multiuse of particular core quality planning tools according to APQP phases.

Keywords: Quality management, Quality planning tools and methods, Production process

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MATERIALS MANUFACTURING AND PROCESSING

1. Introduction

In industries characterised by large-scale production with a simultaneous global dispersion of suppliers in the supply chain, it is extremely difficult to maintain universal quality standards for all partners in the production chain. The automotive industry is an example of this because the final product, a car, is made of parts and components whose suppliers are located worldwide. Therefore, the quality of individual components directly affects the final product quality, which is currently one of the indicators of the company's evaluation (next to financial, marketing and environmental criteria). By proactively engaging the company in activities related to quality planning, the quality of manufactured products is improved, which allows the company to increase its revenues and market share and build customer loyalty and its image [1,2].

To standardise the quality requirements for products and processes, it was necessary to adopt a global standard for quality planning, which would universally define the phases of the product design and production process, along with the requirements that must be met in a given phase, so that the product could be approved for production [3,4].

The answer to the above needs was the American automotive association AIAG (Automotive Industry Action Group) development of five main quality planning tools, which have been published as "Reference Manuals", initially only for the automotive market and now also for use in other industrial sectors. An alternative to the AIAG quality planning methodology is the methodology developed by the German association of the automotive industry VDA (Verband der Automobilindustrie).

The following quality manuals are used in the automotive industry:

- APQP and CP (Advanced Product Quality Planning and Control Plan) [5];
- PPAP (Production Parts Approval Process) [6];
- MSA (Measurement Systems Analysis) [7];
- SPC (Statistical Process Control) [8];
- FMEA (Failure Modes & Effects Analysis) [9].

FMEA can be divided into DESIGN FMEA (DFMEA), focusing on the possible errors occurring in the product development process and PROCESS FMEA (PFMEA), which is used to investigate potential failures and problems in the manufacturing process.

Product quality planning tools (APQP, PPAP, FMEA, MSA, SPC, CP) presented in Figure 1 allow for effective management of all product and process development aspects between organisation and customer. Additional product and process development items are CSR (Customer Specific Requirements), legal requirements, supplier feasibility and customer expectations. Tools such as FMEA, CP, MSA, and SPC in the PPAP process are the core of the APQP methodology. The client's approval of the PPAP documentation is proof of the correct understanding and fulfilment of customer requirements. Currently, in the automotive industry, every organisation certified IATF 16949 must have implemented the production part approval process (PPAP) that meets the requirements specified by the customer; it is one of the basic tender requirements, meaning reliability for business partners [10-12].

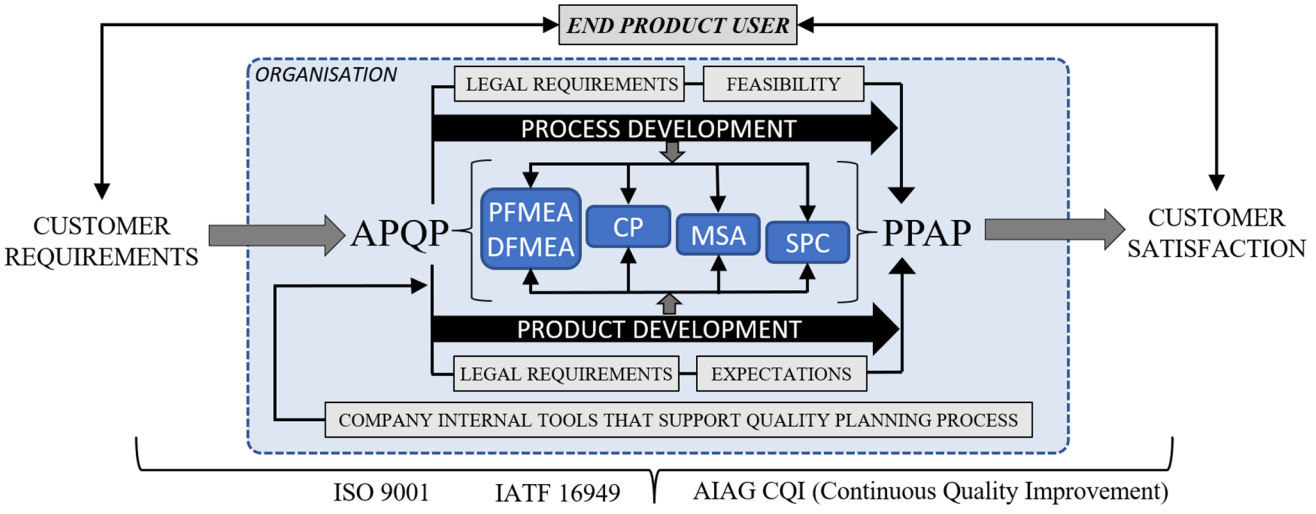

Fig. 1. Diagram of dependencies between main quality planning tools in relation to customer, organisation and end product user (own elaboration based on [13- 15, 17])

2. Characteristics of PPAP requirements

The subject of this article is the analysis of PPAP as one of the products and process quality planning tools. The first publication of the PPAP Manual was in 1993 by AIAG. By the APQP methodology adopted, the submission of PPAP documentation by the supplier to the client takes place in phase 4. However, the development of the individual quality documents required during the submission begins in phase 2 (phase of product design and development) [16].

The PPAP process standardises the relationship between the customer and the supplier; the diagram shown in Figure 2 defines the roles between both parties in the product and process development process, acc to a continuous loop of Planning, Doing, Checking and Acting (PDCA cycle). Open communication between both sides guarantees a correct understanding of customer requirements and proves the competencies of the supplier.

2.1. Basic PPAP requirements

Submission of PPAP documentation for customer approval before shipment of production parts is defined as a requirement in the PPAP manual in the following situations:

- for a new part or product;
- in connection with the correction of non-conformities in part previously submitted to the client;
- for a product modified by a technological change in the design records, specifications or materials;
- in the event of changes in the design, technological process or location of the product's production;
- as a result of production downtime longer than 12 months.

All deviations from the initially approved quality plan must be communicated to the client to determine the next steps and how to approve the change. In special cases, when detecting non-conformities in the delivered product, the customer may request a resubmission of the PPAP. If any customer requirement cannot be met, the organisation must prepare a problem-resolution plan and contact the customer to agree on corrective actions.

Production parts intended for PPAP must be taken from a production series minimum of 300 consecutive parts and takes 1 to 8 production hours. This requirement may be changed after prior agreement of new rules for approving parts for production with the customer. This usually applies when the product is expensive or produced in limited quantity.

PPAP records, regardless of submission level, must be kept for as long as the parts are active, plus one calendar year. The part is active until the appropriate customer department approves the tool's scrapping or the part's deactivation [6].

2.2. PPAP documentation submission and assessment

PPAP records, regardless of submission level, must be kept for as long as the parts are active, plus one calendar year. The part is active until the appropriate customer department approves the tool's scrapping or the part's deactivation.

After collecting all the documentary evidence compliant with the requested level of submission, the PSW (Part Submission Warrant) document is completed; it is a document containing all the necessary information about the supplier, customer, approved part and supplier's declaration on the compliance of the part with requirements. Then the complete set of documents with samples (if required by the submission level) is sent to the customer for verification and approval. The PPAP status assigned by the customer can be:

- APPROVED: This means that parts or material, including all sub-components, meet all customer requirements. Approved PPAP means the organisation can ship production parts to the customer according to his needs without additional time and quantity constraints.
- INTERIM APPROVAL: this status allows materials to be shipped to the customer within a limited time or number of parts (as agreed with the customer). Interim approval is only accepted if the organisation:
  a) clearly identifies inconsistencies that prevent PPAP from being approved;
  b) prepared an action plan and agreed with the customer on how to correct non-conformities.
- REJECTED: It means that the submitted PPAP does not meet the customer requirements based on the production batch from which it was taken, in which case non-conforming items must be corrected to meet the needs.

In most cases, OEMs (Original Equipment Manufacturers) and their suppliers describe their special quality or procedural requirements in the form of instructions for suppliers called "Supplier Quality Manual". Documents of this type refer directly to AIAG or VDA manuals, further detailing some elements and adjusting them to the company's profile.

In most cases, the Supplier's Quality Book is an open document on the company's official website. These documents describe the procedure for submitting PPAP documents. Usually, it is linked to the appropriate web portal where the provider publishes the individual elements of the PPAP documentation in a structured manner.

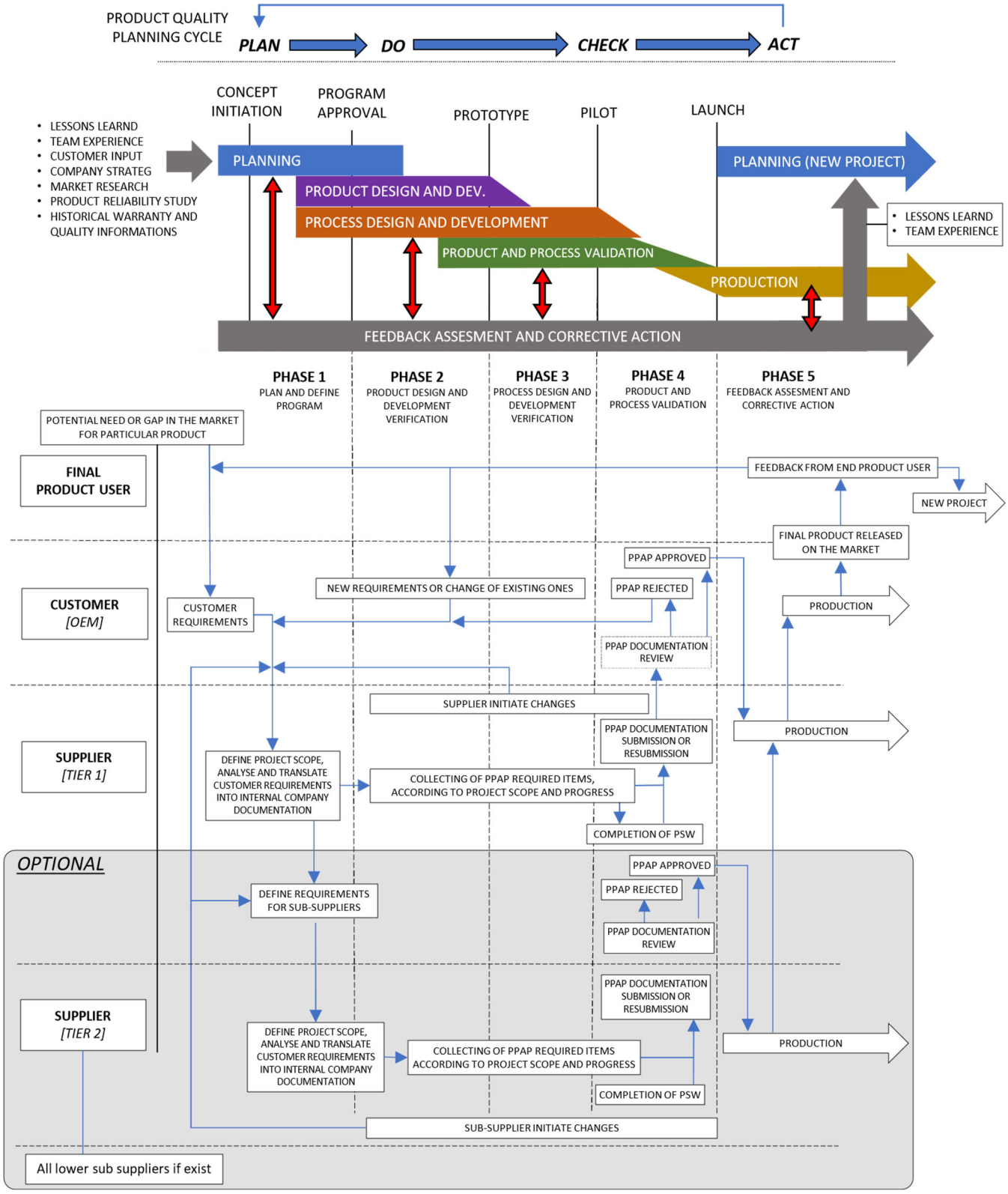

Fig. 2. Interaction between OEM and supplier acc PDCA cycle (own elaboration based on [5, 6, 18])

3. Quality planning tools in the PPAP process

The PPAP process includes 18 pieces of quality evidence necessary to submit to the customer to prove that the organisations fully understand the design assumptions and the possibility of launching serial production of parts per the customer's requirements. The amount and method of submitting the evidence presented in Table 1 are defined and imposed on the supplier by the customer, who takes into account:

- the impact of the part on the safety and relevance of the part/subassembly in the final product;
- legal requirements;
- supplier experience and opinion;
- having certification for compliance with IATF 16949 or ISO 9001.

If the customer does not clearly define the submission level, the supplier defaults to level 3. The tools and qualitative evidence presented in Table 1 should be well-known to the organisation and used in each project regardless of whether the client requires evidence. Omission or incomplete use of the main quality tools, such as FMEA, SPC, MSA, and control plan, is inappropriate.

Organisations need to understand that it should be in their best interest to use main core tools and all other available company internal quality planning tools and processes effectively and adapt their use to a specific project and product [20].

PPAP is required not only by the OEM on their direct suppliers but also by tier 1 suppliers to use PPAP for their suppliers.

Table 1.
Submissions and retention requirements depending on the level of PPAP submission [6]

	REQUIREMENT	Submission Level					APQP phase that item shall be available*
		LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5	
1	Design record - for proprietary components/details - for all other components/details	R R R	S R S	S R S	x	R R R	PHASE 2
2	Engineering change documents, if any	R	S	S	x	R	PHASE 2
3	Customer engineering approval, if required	R	R	S	x	R	PHASE 2
4	Design FMEA	R	R	S	x	R	PHASE 2
5	Process flow diagrams	R	R	S	x	R	PHASE 3
6	Process FMEA	R	R	S	x	R	PHASE 3
7	Control plan	R	R	S	x	R	PHASE 3
8	Measurement system analysis studies	R	R	S	x	R	PHASE 4
9	Dimensional results	R	S	S	x	R	PHASE 4
10	Material, performance test results	R	S	S	x	R	PHASE 4
11	Initial process studies	R	R	S	x	R	PHASE 4
12	Qualified laboratory documentation	R	S	S	x	R	PHASE 4
13	Appearance approval report (AAR), if applicable	S	S	S	x	R	PHASE 4
14	Sample product	R	S	S	x	R	PHASE 3/4
15	Master sample	R	R	R	x	R	PHASE 3/4
16	Checking aids	R	R	R	x	R	PHASE 4
17	Records of compliance with customer-specific requirements	R	R	S	x	R	PHASE 4
18	Part submission warrant (PSW) Bulk material checklist	S S	S S	S S	S S	R R	PHASE 4

S – the organization shall submit to the customer and retain a copy of records or documentation items at appropriate locations.
R – the organization shall retain at appropriate locations and make available to the customer upon request.
x – the organization shall retain at appropriate locations and submit to the customer upon request.
* – in some projects, due to low product and process complexity, items from phase 4 can be available in phase 3.

4. Errors occurring in the PPAP process

In most cases, the most common errors that appear when submitting PPAP to the customer result from improper understanding or definition of requirements (customer expectations for the product). The most common misconceptions are the result of the following:

- Not correct part approval procedure. PPAP is a global standard developed by AIAG and PPA according to the VDA manual (Production Process and Product Approval) used mainly for German OEM customers. Therefore, the part approval procedure for PPAP or PPA production is always defined by the customer.
- Use of an inadequate level of PPAP. If the customer does not define a PPAP approval level, the default is level 3. The same item produced in different supplier locations can have different PPAP approval levels.
- Supplier must maintain PPAP records as long as the part is active, plus one calendar year. Depending on the level of PPAP, the organisation does not have to send the relevant documents to the client but only has them and can provide them at the client's request or during an audit. Suppose the organisation cannot document the possession of the documents required by PPAP. In that case, it may have legal and financial consequences, or if it is detected during IATF recertification, it will be recorded as non-compliance.
- The insufficient number of production samples that are part of the PPAP. Suppose, for whatever reason, the organisation is unable to guarantee the quantity and time of production required by the customer. In that case, this must be communicated to the customer at the appropriate time.
- Use of incorrect PPAP forms. Individual customers may require different forms for similar PPAP elements. If the organisation submits PPAP documents in other formats than needed for the client, the PPAP will not be approved, even though the parts comply with the requirements.
- Not respect commitments set when PPAP is interim approved. Interim approval is usually limited in time or by the number of parts the supplier can produce and ship to the customer. If the supplier exceeds the agreed number of parts or the conditional approval time has expired, then the shipped parts may be considered unaccepted for production.
- Supplier produces more parts before getting PPAP approval. This is very risky because, in the event of non-approval of PPAP, the customer may not allow using parts from a given production series, which entails additional costs for the supplier.

5. Conclusions

Correct use of quality planning tools in product and process development determines the effectiveness of implementing individual phases of APQP. Figure 2 shows in a simplified way the relationship between the APQP phases and the quality tools/evidence developed in the PPAP process (according to PPAP level 3).

The individual quality tools are related to each other, but only their correct use can protect the project against errors or misunderstandings between the supplier and the customer. For example, evidence of the proper understanding of the customer's requirements and taking them into account when planning the quality of the project is the customer's approval of the parts for production (PPAP documentation approval); if the customer does not approve the parts for production and the supplier does not agree with this decision or not understand it, this is evidence of improper quality planning and misinterpretation of customer requirements.

It is important that the organisation skilfully and consciously uses the quality tools required by APQP (Fig. 3, numbers 1, 2, 3, 4, 5, 6); they usually require multiple uses during the project implementation time, which depends on the specificity of a project. DFMEA analysis is an example of a tool that should be used proactively. Interdisciplinary meetings should be held regularly, starting from the product development phase and ending with the product approval phase; each time (regardless of the project phase), when something changes in the product, it should be included in the DFMEA analysis. From the DFMEA analysis, new information should be implemented into the PFMEA analysis, which should result in an update of the control plan (if necessary). Sometimes a "small" design change requires significant changes to the control plan. Verification of DFMEA records in the product and process approval phase is aimed at updating with data from product and process validation [19].

PPAP methodology and other quality planning tools allow the organisation to limit additional resources necessary to interpret customer requirements and expectations, which would lead to developing dedicated quality procedures and standards for each project.

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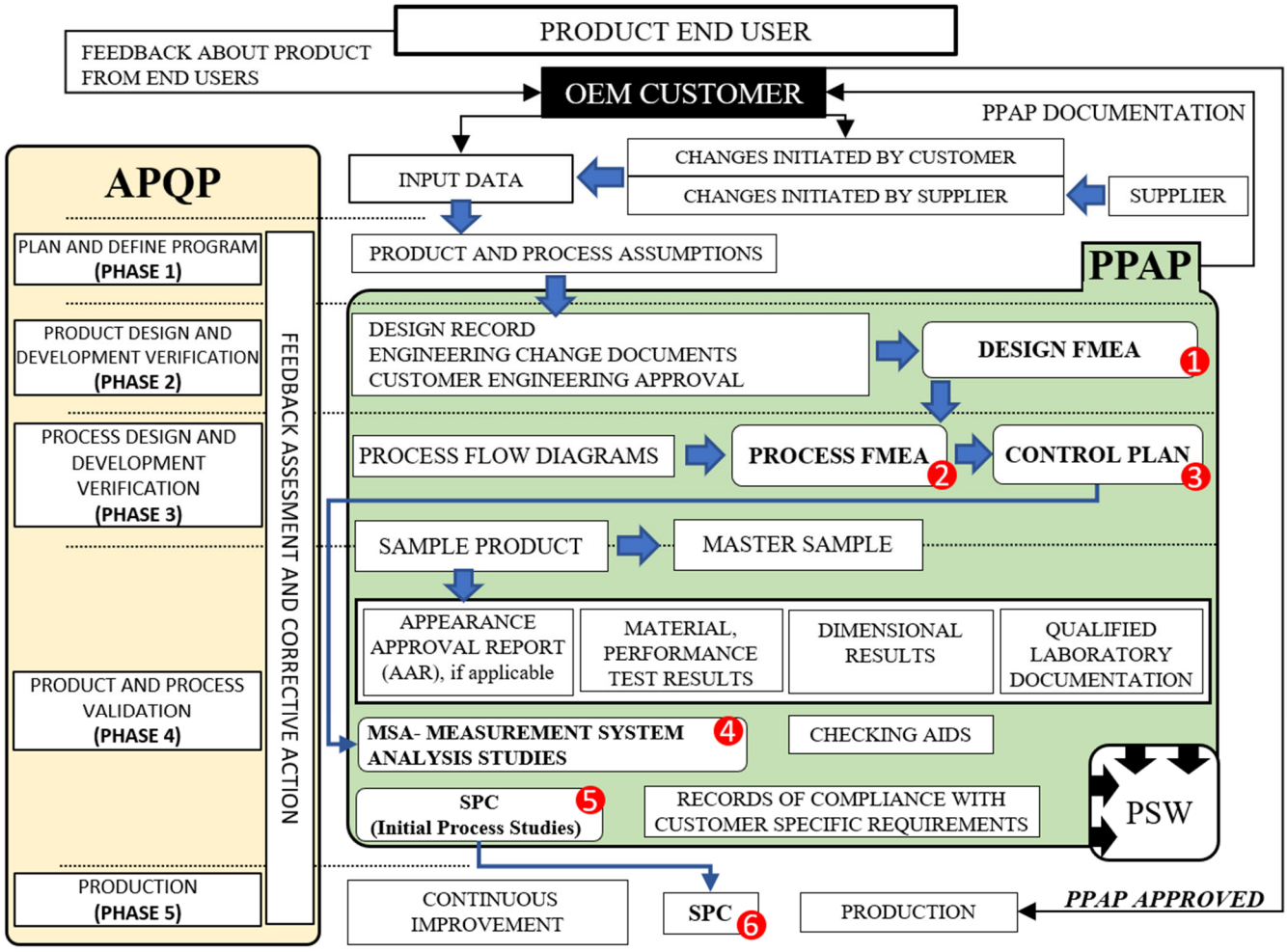

Fig. 3. Diagram of dependencies between main quality planning tools (own elaboration based on [21-24])

Additional information

The article was presented during the international scientific conference MATERIAL TECHNOLOGIES IN SILESIA'2022 in the form of a scientific poster. The abstract of the article was included in the conference materials, ISBN 978-83-65138-32-3.

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