Advanced Product Quality Planning Through Critical Path Technique

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***Abstract*— Advanced Product Quality Planning (APQP) is used to complete the project /product on time with first time right quality to avoid delays in the project/product development, to avoid rework, to avoid corrections and to satisfy the customer. Cross Functional Team (CFT) is a team of people from all the departments like production, quality, maintenance, stores, development and HR along with the top management. The role of CFT is to execute the project/product/process development as per the defined timelines and as per their roles and responsibilities. The steps in APQP are represented in a form of a network diagram with the duration of each step. Critical path and different floats-Total float, Free float and Independence float are calculated in this paper. The data is taken from the company 'Srivaru TQM Consultancy Services'.**

- **The critical path for the project is**

  1-2-3-4-5-6-7-10-11-12-13-14-15-16-17.

- **The time duration is 356 days.**

***Index Terms*—APQP, APQP through network diagram, CFT, Critical Path, Free float, Independence float, Network diagram, Role of CFT, Total float**

I. INTRODUCTION

APQP (Advanced Product Quality Planning) is a project which is used for developing any product. There are certain steps to be considered for planning, on time delivery and First-right quality to avoid customer dissatisfaction, wrong deliveries and defective parts delivery to the customers.

Here in the APQP project CFT (Cross functional team) is involved from the beginning to the end. Cross functional team which involves all the members from all the departments like-Quality, Development, Production, Stores, Purchase, Maintenance and Human Resource.

During this development CFT meets once in 15 days or a month to discuss the progress as per the plan. If everything goes right there is no issue, if some activities are not as per the plan, the concerned department team members would give the action plan with the target days. The same will be reviewed in the next meeting by the CFT team. At each phase the summary will be reported to the top management along with the action plan. During every meeting, minutes of meeting will be generated and circulated to the CFT. These meetings are conducted till project completion. Once the project is completed on receipt of the approval from customer/client project will be handed over to production from development team with the handover procedure.

The above-mentioned project information is collected from the company 'Srivaru TQM Consultancy Services' which was started by Mr. T.S. Gupta in the year 2021 with a mission to offer consultancy services to small and medium enterprises and to individuals to meet the world class systems and standards for the organisation as well as individual growth.

The steps involved in the APQP project are:

1) Receipt of Enquiry- In this step the customers will ask or enquire the suppliers whether they can produce the product.
2) Kick of Project- The supplier will look at the feasibility, if it is okay, he will end the quotation. Based on the quotation the customer will send the purchase order. On receipt of the purchase order, the project will be started by the supplier.
3) Planning and defining the project/product- Review and plan on how the product will be prepared and planning of the activities with time and responsibility.

4) Define process flow-Define, review and finalize the process steps to get the required output.
5) Define critical characteristics-Any review of the criticality of the product parameter.
6) Design layout, machineries and gauges-For the manufacturing of the product, review will be done on the layout changes required. Any special machines to be purchased and gauges/Inspection instruments to be purchased.
7) Design process development-Review and plan the process to be carried out with responsibility and lead time.
8) Poke yoke development-Review of the mistake proofing in the process of product manufacturing.
   Poke yoke-The mistake which is committed intentionally or unintentionally the process will not allow to do that mistake.
9) Plan product capability-Planning of the product capability.
10) Validate product and process-Testing of the product and process inline with the design or drawing requirements.
11) Product sample manufacturing-After designing the process and the product, taking the trial to check the conformity.
12) Product testing-After taking the trial, part to be checked for conformity as per the design or customer requirements.
13) Product submission-After inspection/testing, submission of the parts/products to the customers as per the required documents.
14) Product approval-Once after submitting the product to the customer, customer will review as per the drawing requirements, if everything is okay, the customer will send the approval report.
15) Start of production-After the part approval, customer will send the schedule for the parts, based on the schedule, the product production will start and supply as per the schedule to the customer.
16) Updating the lessons learned -At the end from receiving the order to obtaining the approval all the failure actions are to be taken or recorded to avoid same issues or development during the next development.
17) Project completion-Here the project is completed.

II. OBJECTIVES

- To understand about the project APQP and its importance in every company.
- To collect the data about APQP and draw the network and understand the duration of a project.
- To determine the critical path.
- To calculate floats.

III. LITERATURE REVIEW

According to the author [1] Planning, Organizing and Controlling are the three important functions of the executive and mentions that planning is on demand and also explains about Gantt chart and its uses. There were 25 activities and the activity duration was estimated on weekly basis, codes were given. Normal time was extracted from the chart. Crash time was extracted and a percentage value was allocated to each activity, critical paths and floats were also determined for the project. The article discusses the benefits of using CPM in Project Management.

According to the author [2], the implementation of the metric has detected that improvement can be made on the production of new parts and mentions that the APQP process starts from understanding what the customer's requirements are and how to achieve them.

In the paper [3] the authors proposed a tool of APQP working with an Agent based knowledge management system which builds an organisation's knowledge resources and knowledge management systems as well as the APQP concept.

In the paper [4] the author has started with giving the problem statement, that rating is based on the competition prevailing in the market and this can make the market inefficient and continued by giving the benefits of APQP and the goals of APQP. The author describes products should have paid more attention to APQP as customer satisfaction will be based on the quality products the company offers.

According to the author [5], the products which are efficient and effective leads to organisation growth and competitiveness. The more knowledge that is present and shared within a company, the better the process and product gets created which directly leads

to customer satisfaction and organisation performance.

According to the author [6] if the input, target, KSI, KPI are done in each process and if it is clearly defined in APQP, mutual organic and effective systems can be initially achieved.

In the paper [7] the authors have taken an initiative to apply APQP in a small organisation which is involved in manufacturing an EMB for Automotive sector. The results showed that APQP is a strategy for achieving productivity and has a lot of potential to quality.

The authors in the paper [8] implemented APQP on experimental basis in a project named Solar Array EV. AB Pop, GI Pop, C Oprean [9], the aim of this research is to implement APQP to reduce the defects in the organisation.

According to the author [10], APQP and Control plan helps in organisation, customers and organisation to communicate product quality requirements to suppliers.

The author in the paper [11] represents a new knowledge-based framework which helps in integrated quality control planning. It is based on APQP and it employs Quality Function Deployment for the selection of the features which has to be controlled.

In the paper [12] the author used questionnaire with indicators to measure the awareness of APQP tools. This was conducted among professionals in Polish and Romania and it was concluded that APQP tools were better known to them.

The authors in the paper [13] developed a survey questionnaire and used it to survey the company's capabilities to offer solution related to product failures and producing the products that are free from defects. The results obtained showed that there is a need of establishment of Quality Management Systems which help the organisation in growing and adding value to the organisation.

In the paper [14] the authors adapted the IAC, NPI and IAC design and development to design the safety motorcycle backrest seat.

According to the authors [15] APQP is the only methodology that incorporates all the factors related to the product.

IV. METHOD OF DATA COLLECTION

The source of the data is primary, the number of activities in the project are 17 and the activity duration was estimated on daily basis.

ACTIVITY RELATIONSHIP AND CLASSIFICATION

Activities	Description	Duration (in days)
1	Receipt of Enquiry	1
2	Kick of project	30
3	Planning and defining the product	6
4	Define process flow	6
5	Define critical characteristics	3
6	Design layout, machineries and gauges.	12
7	Design process development	20
8	Poke yoke development	4
9	Plan product capability	3
10	Validate project and process	30
11	Product sample manufacturing	10
12	Product testing	12
13	Product submission	4
14	Product approval	20
15	Start of production	15
16	Updating lessons learned	6
17	Project completion	-

Table 1 -List of activities

The table has 17 steps for a project to complete.

NETWORK DIAGRAM

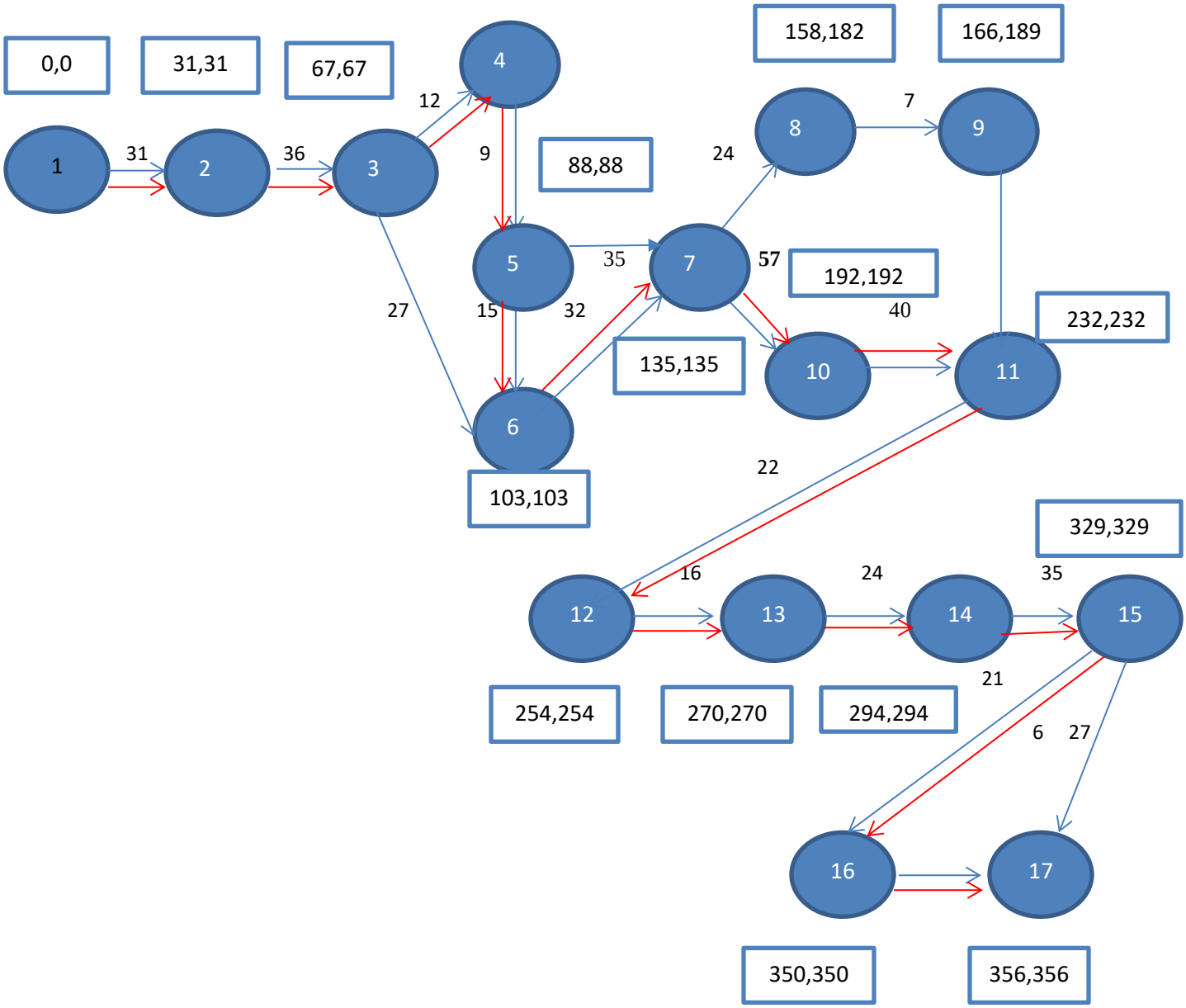

Figure 1-Network flow chart of the project on how many days will the project will take to complete.

Table 2 -Calculation of Float

Activity	Duration	Te or Ei	Ti or Lj	Float
1-2	31	0	31	0
2-3	36	31	67	0
3-4	12	67	79	0
3-6	27	67	103	9
4-5	9	79	88	0
5-6	15	88	103	0
5-7	35	88	135	12
6-7	32	203	135	0
7-8	24	135	182	23
7-10	57	135	192	0
8-9	7	159	189	23
9-11	43	166	232	23
10-11	40	192	232	0
11-12	22	232	254	0
12-13	16	254	270	0
12-14	26	254	294	4
13-14	24	270	294	0
13-15	39	270	329	20

14-15	35	294	329	0
15-16	21	329	350	0
15-17	21	329	356	6
16-17	6	350	356	0

Terminologies-

- EST-Earliest start time
- LST-Latest start time
- EFT-Earliest finish time
- LFT-Latest finish time
- TF-Total float
- FF-Free float
- IF-Independent float

Table 3-Total float, Free float, Independent float, Interdependence float.

Activity	Duration	EST	LST	EFT	LFT
1-2	31	0	0	31	31
2-3	36	31	31	67	67
3-4	12	67	67	79	79
3-6	27	67	67	103	103
4-5	9	79	79	88	88
5-6	15	88	88	103	103
5-7	35	88	88	135	135
6-7	32	103	103	135	135
7-8	24	135	135	159	182
7-10	57	135	135	192	192
8-9	7	159	182	166	189
9-11	43	166	189	232	232
10-11	40	192	192	232	232
11-12	22	232	232	254	254
12-13	16	254	254	270	270
12-14	36	254	254	294	294
13-14	24	270	270	294	294
13-15	39	270	270	329	329
14-15	35	294	294	329	329
15-16	21	329	329	350	350
15-17	21	329	329	356	356
16-17	6	350	350	356	356

Activity	TF	FF	IF	IFF
1-2	0	0	0	0
2-3	0	0	0	0
3-4	0	0	0	0
3-6	0	0	0	0
4-5	0	0	0	0
5-6	0	0	0	0
5-7	0	0	0	0
6-7	0	0	0	0
7-8	0	0	0	0
7-10	0	0	0	0
8-9	23	0	23	23
9-11	23	23	0	0
10-11	0	0	0	0
11-12	0	0	0	0
12-13	0	0	0	0
12-14	0	0	0	0
13-14	0	0	0	0
13-15	0	0	0	0
14-15	0	0	0	0
15-16	0	0	0	0
15-17	0	0	0	0
16-17	0	0	0	0

Determining the critical path-

The sequence of critical activity in a network is called as a critical path.

Critical path=

1-2-3-4-5-6-7-10-11-12-13-14-15-16-17

The project duration is 356 days

1) Network diagram-Network diagram is a representation of activities in the form of network with the duration of the event.
2) APQP through network diagram-The steps in APQP are represented in a form of network diagram with the duration of each step.
3) Critical path-Critical path is a longest path of the activities and it tells us the minimum time period required to accomplish the project.
4) Total float-Total float is denoted by Tf.
5) Free float-Free float is denoted by Ff.
6) Independent float-Independent float is denoted by If

- In table no 1, all the steps starting from receipt of enquiry to Project completion in the APQP project are given in an order with their duration in days.
- In table no 2, the steps/activities in the APQP are combined as starting event and ending event. Starting event is denoted as Te (Tail event) and Ending event is denoted as Ti (Tail event) and Total Float is calculated for all the activities.
  Float=Ti (Head event)-Te (Tail event)-Duration
- In table no 3, total float, free float, independent float, interdependence floats are calculated.

EFT=EST+ Duration or LST=LFT-Duration.

Total float=LST-EST or LFT-EFT.
Free float=Total Float-Head Slack.
Independent float=Free Float-Tail slack.
Interdependence float=Total Float-Free float.

V. FINDINGS AND SUGGESTIONS

1) The Advanced Product Quality Planning (APQP) takes about 6-12 months to complete. But here we can see that the APQP project takes about 356 days based on the project.
2) Critical path of the project is –
   1-2-3-4-5-6-7-8-9-11-12-13-14-15-16-17
   The total duration of the project is 356 days.
3) This APQP reference standard is made by AIAG (Automotive Industry Action Group). Approximately once in every 7 years the standards are revised.

VI. CONCLUSION

From the above analysis we can conclude that no project is easy without proper planning. Every step needs to be monitored carefully by the department head. If one step goes wrong in the development / production process the whole process or the whole product goes wrong and effort of each and every person involved in the production process goes for a toss. There should be meetings with CFT (Cross functional team) at regular intervals of time to supervise and ensure that there is no defect in the product / delay in the timelines. During the regular reviews if delay is found in any particular activity, the matter has to be escalated to the top management and an action plan has to be drawn to complete the targets on time.

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