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Quality Control & Risk Mitigation

Group 2

Subsystem Requirements

Priority performance parameters:

- Quality (being right)
- Dependability (delivery on time)

From the 5 performance parameters we decided to prioritize these parameters over the others. This is based on Etone's preferences because customer satisfaction is of top priority to them. Based on that, the subsystem's requirements are defined as follows.

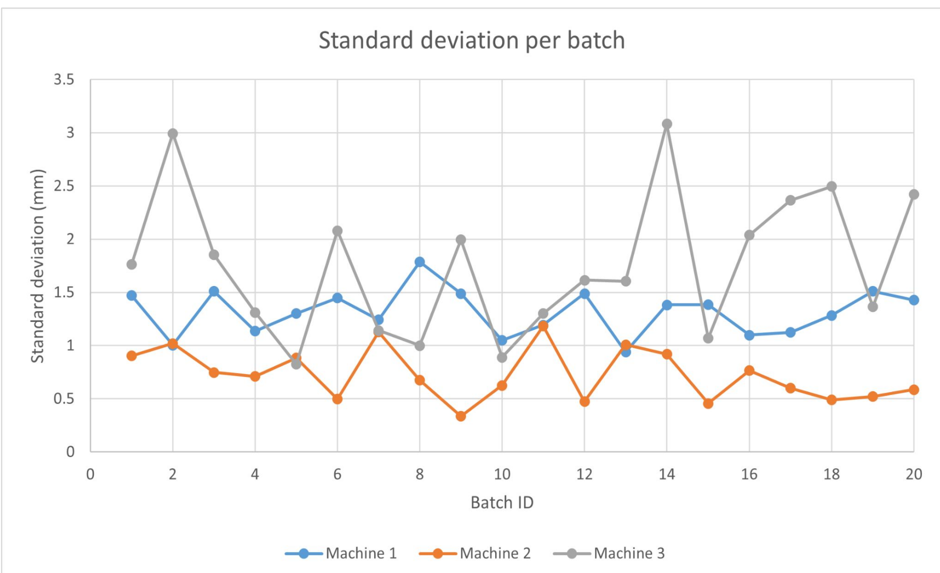
Requirements:

- Maintain quality standards of the product (Cpk-values > 1.5)
- Maintain machinery (maintenance & defects, OEE > 90%)
- Risk management

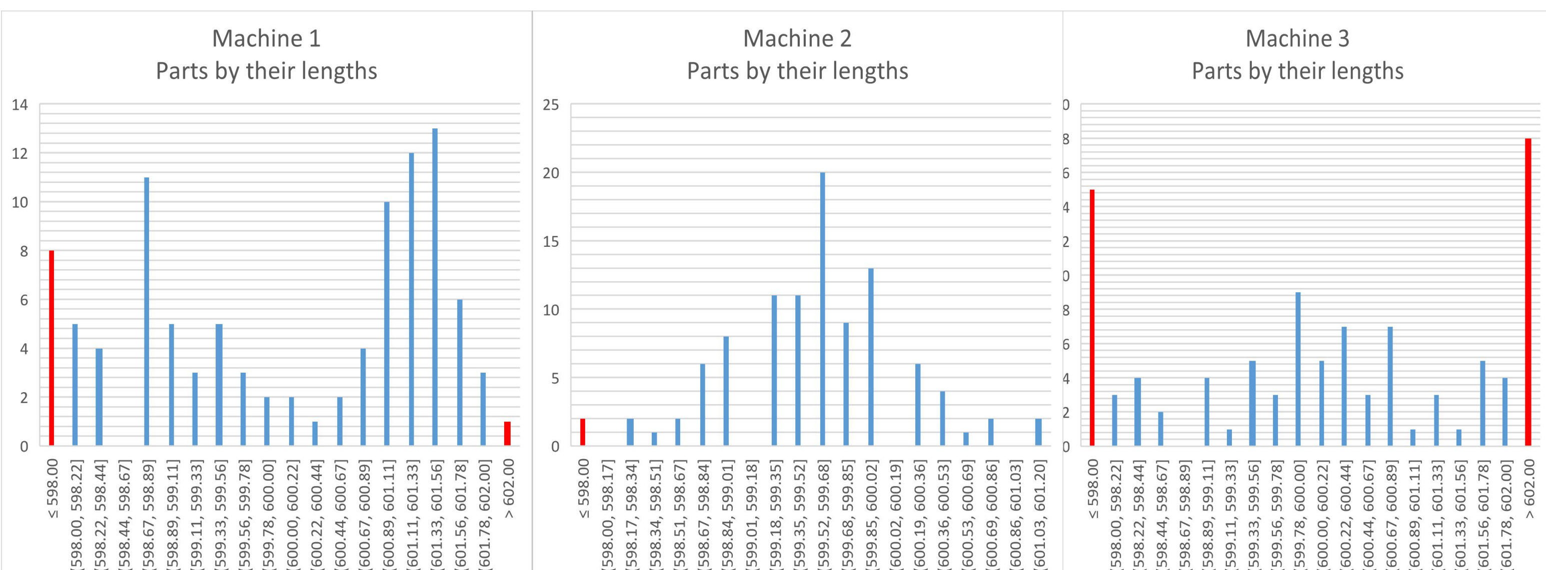
Our first requirement is analysing the quality of our product and maximize it for optimum customer satisfaction and enhancing production reputation of Etone. This requirement is fulfilled under section **Quality Control.** As for the second requirement, which is slightly dependent on the first one which focuses on optimizing a maintenance schedule in order to maintain the quality target set for our products, this requirement is discussed further under section **Maintenance Strategy.** For the third requirement we analyze risks in our system in the form of an FMEA analysis, this is shown in section **FMEA analysis**. At last an **FEM analysis** was performed to determine if any elements could be eliminated.

Quality Control

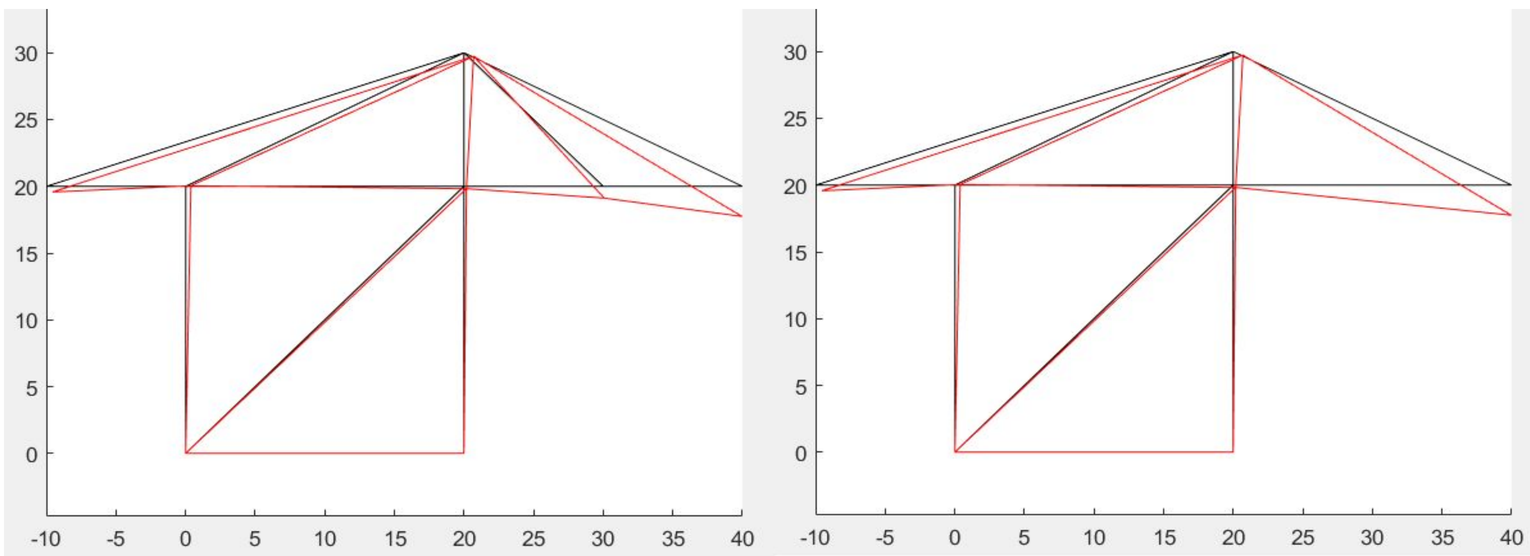
A quality analysis has been performed on the three lates with the data that was provided. The graphs below show the Standard Deviation, Cpk- & Cp-values, as well as the amount of parts with their length, for all three machines.



	Efficiency (%)	$\sigma_{AVERAGE}$ (mm)	C_p (-)	C_{pk} (-)
Machine 1	95	1.31	0.57	0.55
Machine 2	99	0.73	1.14	0.88
Machine 3	71	1.76	0.42	0.37



FEM Analysis



In the figure above the undeformed (black) and deformed (red) frames of the original structure (left) and the modified version without element 13 (right) are displayed.With the help of ANSYS [1], the deformations at the boom tip were found, see table below. The maximum allowed displacement at the tip of 4mm is not reached, so element 13 can be safely removed. Also the highest stress in the structure does not exceed the materials yield stress. We also tried removing element 12, but the deformations were not acceptable.

	Possible crane setup		
Properties	Complete crane	Removing element 12	Removing element 13
Deformation at the tip [mm] (x-direction)	-2.00	-36.56	-2.00
Deformation at the tip [mm] (y-direction)	-225.63	-3.58e+16	-225.63
Highest occurring Stress [MPa]	232.92	218.54	232.92

Maintenance Strategy

Based on quality control on the lathes, less time between preventive maintenance may be needed to achieve lower scrap rates and thus a higher quality rate. Another option is to use smart maintenance equipment to achieve optimal maintenance schedules. For now we stick to a time based maintenance of 1300 and 3900 hours for minor and major preventive maintenance respectively.

	Availability (% per shift)	Performance (-)	Quality (%)	OEE (% per shift)		Availability (% per shift)	Performance (-)	Quality (%)	OEE (% per shift)
LINE 1					*LINE 2*				
SM	0.99817	0.95	0.98304	92.87	SM	0.99817	0.89	0.98304	87.29
TM	0.99763	0.87	0.95151	82.46	MC	0.99517	1	0.92676	92.68
MM	0.99763	0.74	0.94134	69.46	GM	0.99817	0.9	0.97597	87.99
DM	0.99763	0.22	0.93937	20.8	CMM	0.99818	0.72	0.97174	70.15
GM	0.99817	0.95	0.97597	92.71	A	1	0.96	0.95814	91.66
CMM	0.99818	0.57	0.97174	55.55					
A	1	0.74	0.95814	71.32					
LINE 3					*LINE 4*				
SM	0.99817	0.54	0.98304	52.69	SM	0.99817	0.64	0.98304	62.77
MM	0.99763	0.69	0.94134	64.8	MM	0.99763	0.58	0.94134	54.03
DM	0.99763	0.78	0.93937	72.86	DM	0.99763	0.79	0.93937	73.62
CMM	0.99818	0.81	0.97174	78.24	A	1	0.73	0.95814	70.23

FMEA Analysis [2]

Process step or key input	*Potential failure mode*	*Effect on customer*	*SEV*	*Potential causes*	*OCC*	*Process controls currently used*	*DET*	*RPN*	**Recommended measure**	*SEV*	*OCC*	*DET*	*RPN (improved)*
Maintenance (7/10)	the machine is not maintained as it should be which can result in inaccuracies or even delays in case machine breaks down	faulty product (useless in some cases) or delayed delivery if process has to be done again	8	human error during maintanance / unexpected wear and/or damage	8	maintenance schedule based on statistical data and rechecks are done by supervisors after maintenance is done with an immediate response if product is outside control limits	4	256	train employees further on maintaining the machines and reduce intervals of maintenance so the chance of failure is less and also aiming for an SPC process control with a Cpk value of more than 1.33	7	8	2	112
drilling machines (5/10)	the factory only has two drilling machines and if one fails then all processes requiring drilling might be delayed	delayed delivery	4	unknown worn components of the machine may cause it to fail	6	precautionary maintenance is done for all machines. Minor maintenance after 1300 hours and Major maintenance after 2000 hours while everyday machines are cleaned and checked before shift start	2	48					
moving construction products from one conveyer belt to another one by lifting (8/10)	transporting the beam element to another conveyer belt by lifting can be dangerous since it can drop causing an injury to an employee or lead to a deformed product	poor quality or delayed delivery	10	caused by human error or by misuse of tools available or unorganized method of transport	6	no current method for preventing this or maybe slight employee training on how to use the tools needed for transport of the beam	10 (we cannot pre detect human error)	600	use conveyer belt with multiple axes rotating wheels so beams can simply either move on the Y-axis to be machined or on the X-axis to be transported to the adjacent conveyer belt for the next process and beams are processed in a maze-like fashion	6	7	1	42
machining center startup defects (6/10)	machining centers have the greatest value for start-up defects which might resonate throughout the whole flow of the process since the product from the start might defect	poor quality or unusable product	7	worn components or human error or not optimum conditions for operation	6	further training of employees on the machines to have less rate of startup defects and regular precautionary maintenance	5	210					
corrosion of parts in the warehouse	having corroded metal in the warehouse might make the product useless and unusable or it can hurt employees if it breaks while transporting	poor quality and no delivery of the product to customer so order delay	8	uncovered or unprotected products . not a controlled environment of the warehouse which leads to corrosion	7	packaging the products before stacking them in the warehouse to reduce its exposure to the warehouse air	5	280	We implemented FIFO for the pick up of orders from the warehouse which reduces the storage time of products by having the priority for products that are stored first to be the first out for delivery	6	4	4	144

References: [1] ANSYS (https://www.ansys.com/)
[2] FMEA (Failure Mode and Effects Analysis) Quick Guide", *iSixSigma*, 2022. [Online]

Conclusion

The achieved OEE is too low for most machinegroups in each production line, however there are some good things, such as a robust factory, availability for further expansion of the factory. Ways to improve the OEE could be to share certain machines between two different production lines.

By looking at the quality analysis (Cpk & Cp), one can conclude that maintenance should be done more often, perhaps by using a maintenance 4.0 approach.

After doing the FEM analysis, it is concluded that element 13 can be removed without any extra unwanted displacement.

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