ECONOMIC AND ENVIRONMENTAL FOOT PRINT REDUCTION OF CT

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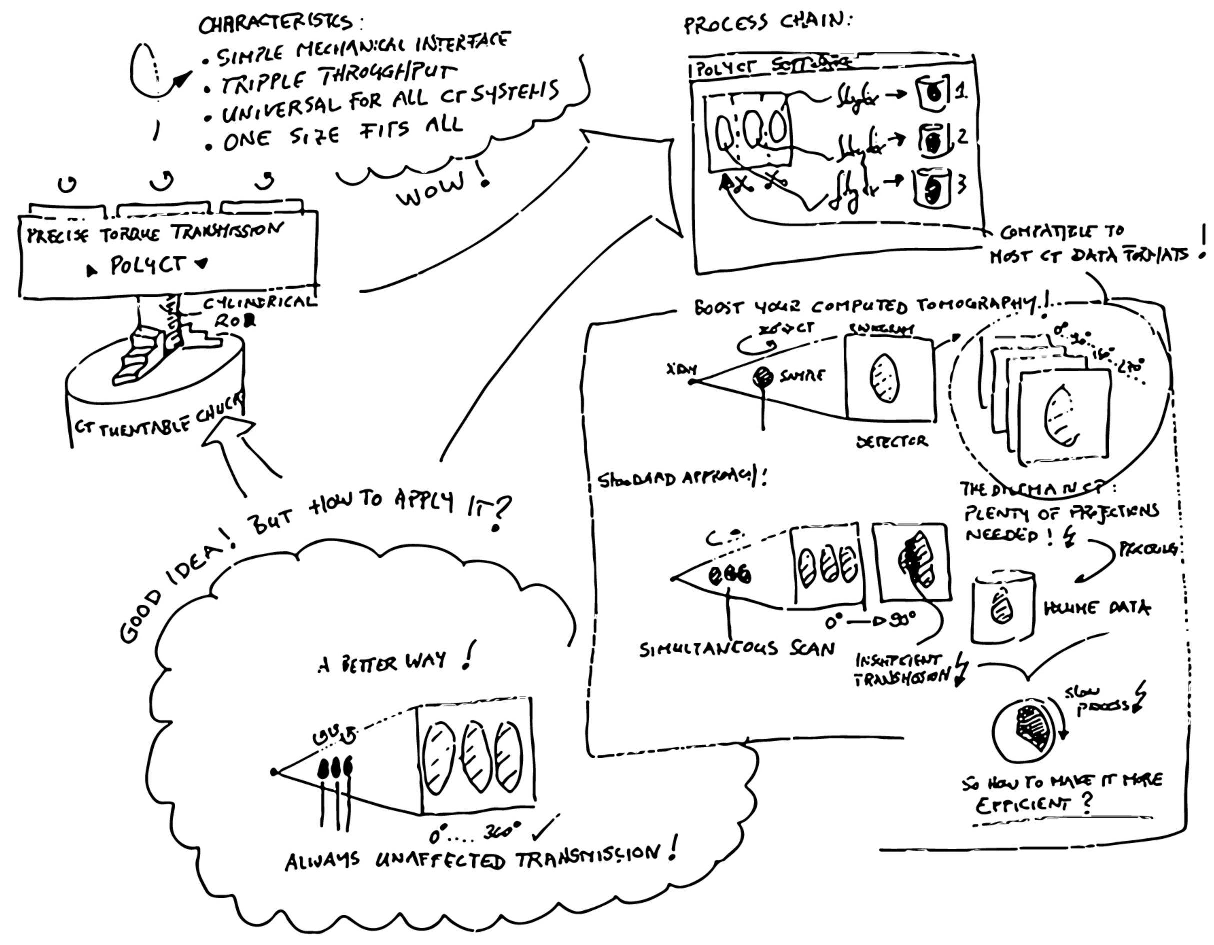
INTRODUCTION

In recent years, industrial micro-computed tomography has evolved from the "sharpest knife" in failure analysis to a tool for serial quality monitoring. With its regular use and the emerging environmental and geopolitical challenges, the resources required for operation of the CT play an increasingly important role. Be it the maintenance and servicing costs or the running costs for personnel, electricity and consumables. Beside the introduction of fully automated inline CT systems a further development under these aspects is currently addressed on the manufacturer side with the reduction of maintenance cycles through the use of long-life cathodes or through the introduction of maintenance-free sealed X-ray tubes with focal spot sizes below 100 µm [2]. Yet just rarely addressed is the potential to save resources by increasing the throughput of CT by a better usage of the X-ray cone beam and detector field.



One possible reason for this is the user attitude dating back to the origins of CT as a failure analysis method always aiming for maximum possible resolution. But at latest for objects with an asymmetrical aspect ratio, this attitude is often no longer feasible due to extensive scan times and thus resulting in minimum resolution requirements. At the same time for objects with an elongated aspect ratio mostly a large fraction of the scan field remains unused (Figure 1 (b)). For low absorbing samples experienced users are able to make use of the unused scan field by arranging a plurality of samples on the CT turntable and scan them simultaneously.
Once reconstructed the samples need to be extracted out of the volume and analyzed one by one. Yet this approach is just applicable to samples, which while superposing each other do not exceed the maximum material penetration thickness of the CT system and further do not contain high absorbing structures leading to local streaking artifacts that might affect the neighboring samples.

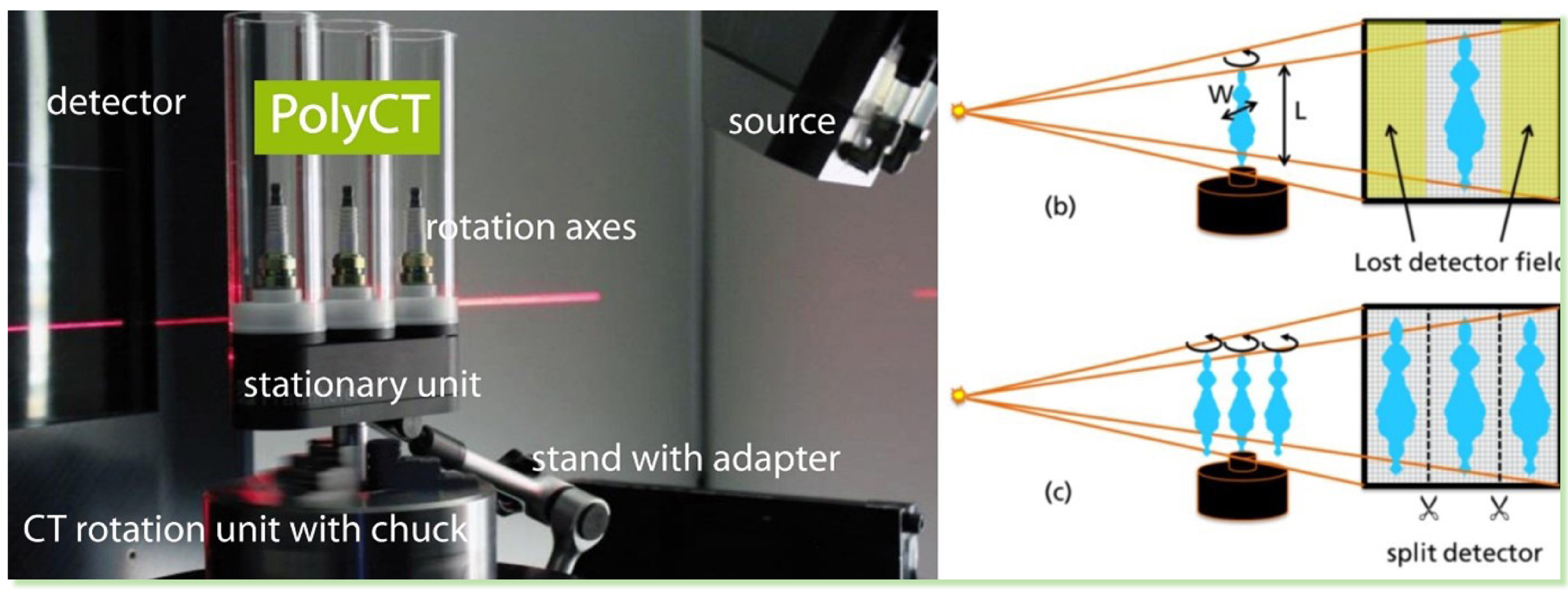
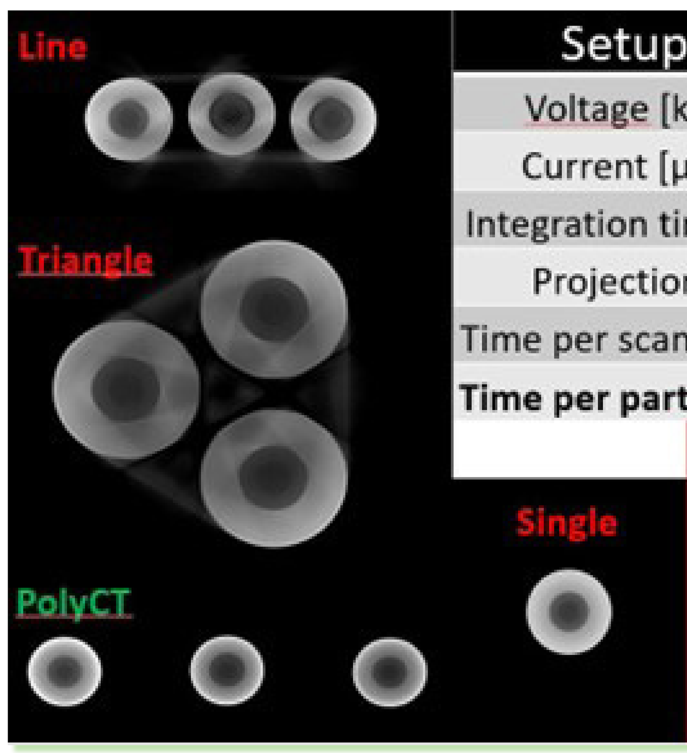


Figure 1 Principle of Poly CT Add-On

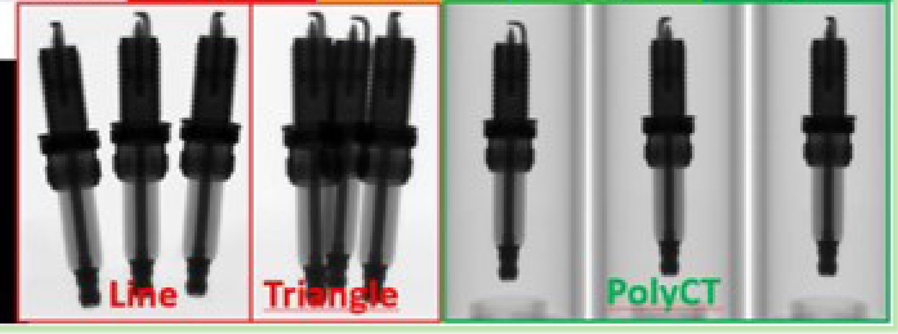
Furthermore the increased penetration thickness leads always to a decreased contrast and signal to noise ration within the reconstructed sample and thus is often compensated by a longer scan time. In summary, due to the property of CT that any signal must pass through the sample to be measured, it is logical that the highest image quality and measurement accuracy is achieved with a minimum transmission path, and this does not even take into account the widely known influence of high X-ray energies leading to lower contrast signal (Viel kV macht Grau).

METHOD

For an increased throughput, it therefore makes sense not to place all objects on a turntable, but to introduce a
separate turntable for each object. However, this is not feasible for a commercially available industrial CT system due to the bulk size of rotary axes.
In addition, the installation of further rotary axes increases the complexity of the system and makes it more difficult to operate. To overcome these limitations the PolyCT has been invented, allowing to maximize the output of the CT system and thus enabling saving of resources. In addition to the ease of use and interchangeability between various industrial CT systems already described [3], this paper derives the physical properties that form the basis for the functionality and its throughput enhancement potential.



Setup	Single	Line	Triangle	PolyCT
Voltage [kV]	210	210	210	210
Current [µA]	300	600	500	300
Integration time [s]	1,5	1,5	1,5	1,5
Projections	800	1600	1000	800
Time per scan [min]	27	55	43	27
Time per part [min]	≈27	≈18	≈14	≈9



RESULTS

We performed several CT scans with comparable settings to differentiate between the possible setups with three parts per scan. We deducted the ideal settings from a scan of a single part. Afterwards we adjusted these settings to scan three parts in two different setups line and triangle in order to get comparable results. After that we scanned three parts with the ideal settings with the PolyCT. The results of the line and triangle setups show significantly more CT artefacts compared to the PolyCT setup. Furthermore, a much higher current is needed in
order to compensate the increased penetration thickness of two or even three overlapping high absorbing parts. The PolyCT show comparable image quality to the single scan.

From these results we derive, that we can increase the sample throughput by a factor of 3, without loosing significantly on image quality utilizing the PolyCT, compared to single scans. With the other setups of three parts we also decrease the scan time per part by a factor of two and therefore increase the efficiency of the CT systems. On the other hand we will have to deal with streaking artefacts and an increased X-ray power. This will lead to an
increased wear of the cathode, which will lead to a higher maintenance effort. Considering the costs and time for a cathode change of several hours downtime of the CT system, the optimization of the X-ray power will have a
significant impact on the operating costs of the system.
In conclusion, we show, that the PolyCT add on is an efficient way to increase the sample throughput without loosing image quality, while keeping the operation costs constant.

OUTLOOK

In order to optimize the effect of the PolyCT on the sample throughput, it should be adapted to the certain use case. Depending on the aspect ratio of the parts one can consider adjusting the number of added rotation axis. In our opinion setups with up to six additional axis are feasible. To optimize the resolution for the certain use case, it is possible to change the distance and diameter of the single rotation stages.

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[2] A. Riedo, New MesoFocus NDT X-Ray tube concept, International Symposium on Digital Industrial Radiology and Computed Tomography – DIR2019.
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