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X Betriebsmitteilung Internal Message	Besprechungsbericht Meeting Report	Besuchsbericht Visit Report	Telefonat Telcon	[redacted]
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Report – Exploratory Data Analysis: Tyco Pinning Force Insertion.

1.0 Scope:

This report details a data analysis proof of concept to assess Tyco pinning process condition.

2.0 Status:

The preliminary use of data analysis tools and techniques has demonstrated that process monitoring and improvement is technically possible and should be further explored.

3.0 Details:

An improvement project for Tyco pinning related defects was undertaken by Oliver Walsh, with input from [redacted] and [redacted].
During this project I was tasked with conducting an exploratory data analysis review on the Tyco machines, primarily to examine if any opportunities existed to conduct further analysis.
A review of the Tyco platform was conducting using a CRISP-DM methodology (As outlined in Appendix).
The preliminary review was conducted on Tyco 44 P350 pinning machine on Bay3 in the [redacted] plant.

Data Analysis Solution:

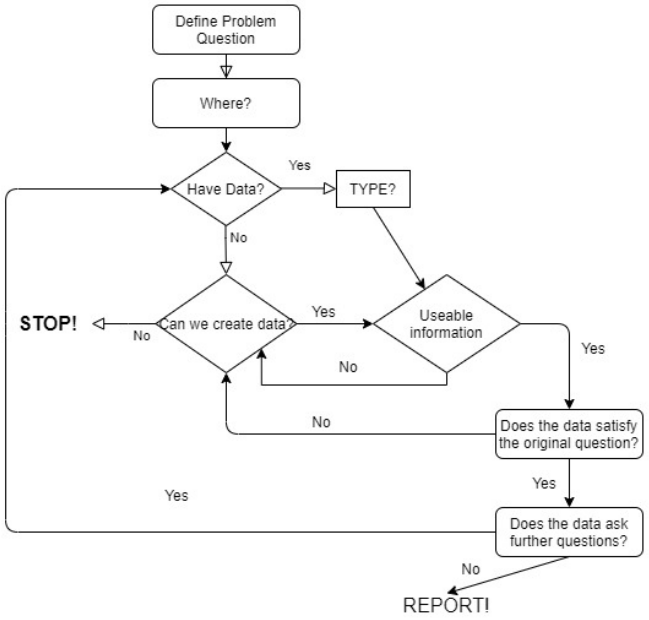
- Tyco 44 P350 machine was reviewed. During production the machine displays the pin insertion sequence, the applicable force limits and the actual measured values from the force sensor in real time.
- As the machine can display the data it follows that there may be a companion log file. A search on the machine drives found time-sequenced XML files.
- A single XML file was examined to review the contents. Initial review found that force information was contained within the body of the file. This was enough to prompt further exploratory data analysis. (Sample data overleaf)
- A python program was written to parse the contents on a single XML file to review. (Sample data overleaf) This program was then subsequently modified to parse the entire collection of XML files from the time period under review and output to a single (large) data repository.
- The data was then analysed and plotted to illustrate the process performance for each pin insertion across the entire sample range in the form of run charts and force distributions.
- The XML files from Tyco machines 42 & 43 were also analysed to compare the (identical) equipment sets. Tyco 42 displayed a clear divergence from the values from Tyco 43 & 44. As a result of this analysis the force sensor was found to be giving intermittent spurious readings (and associated faults) which may have been a contributor to machine performance losses and / or defects. The randomly occurring nature of this fault would have been difficult to identify without the larger scale data analysis.
- Additional analysis was conducted on a single article within the larger data set. The X/Y positional information for each insertion was plotted against insertion force readings to generate a heat-map of insertion force measurements in 2D space. This illustrated that specific areas of the nutzen are exposed to higher forces during insertions. While within the current process limits a more fitting solution would be to have a normalised distribution of insertion forces across the nutzen, however this topic is currently outside of the scope of this report.

4.0 Further development and requirements:

- As a proof of concept the programming and analyses techniques employed in this exercise have demonstrated that exploratory data analysis can lead to insight into process performance. Additionally the use of graphics can help to visualise process problems.
- As an organisation we should invest in data analysis at an exploratory level to examine what may be possible. A CRISP-DM or similar approach should be employed to assess areas of potential improvement.
- Significantly the transforming of isolated "**information**" into bulk "**DATA**" and output in actionable "**INSIGHT**" is an important progression. The heat map of double KKS insertion shows that the lower right side of the nutzen experiences higher insertion forces in the region where the nutzen is mechanically clamped by the forward index pin, but not in the region where the rearward clamp is (at approx. X200).
- This should be further investigate to determine if the force measurement is being influenced by the mechanical setup of the clamping pin, or if a possible misalignment on the table is a contributor to higher forces on the right hand side.
- The above are example of the "additional questions" that exploratory data analysis raises.

5.0 Appendix:

CRISP-DM flow to aid in data analysis methodology.



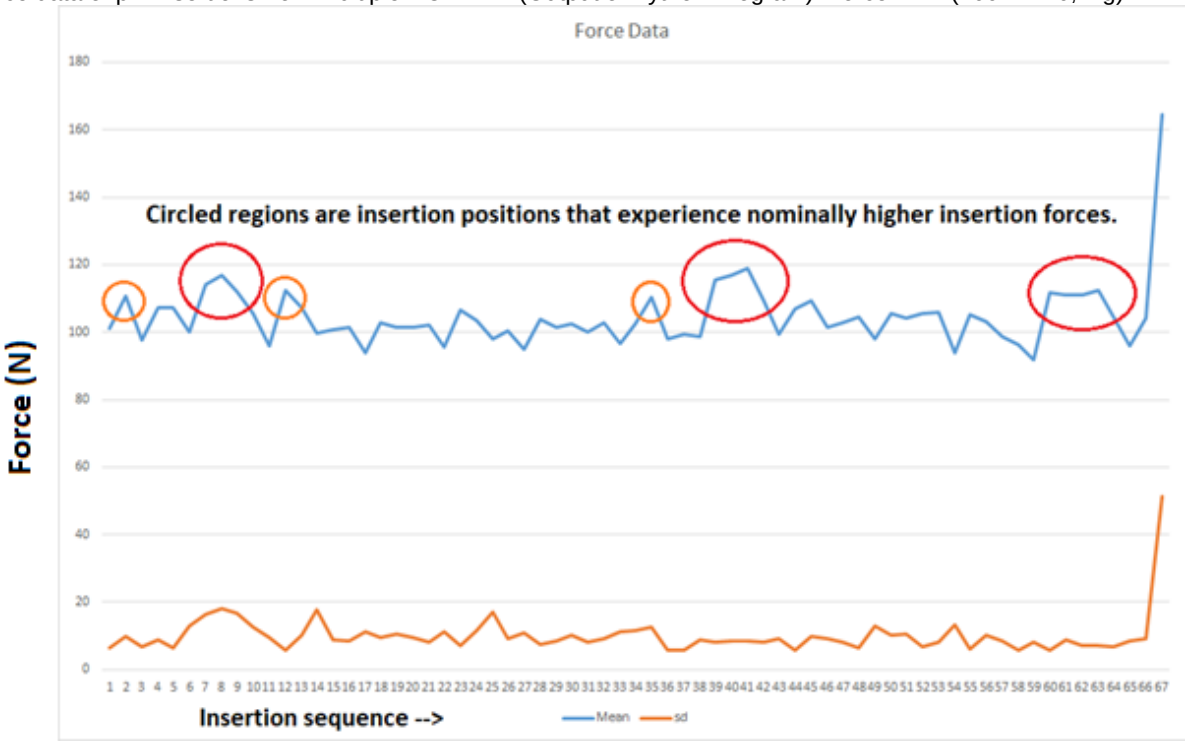
Contents (sample) of Machine XML file, showing **information** available on pin insertions.

```
- <Values>
    <Value desc="PCB location in panel" alarm="" unit="" llim="" ulim="" tval="" val="1" type="PCB"/>
    <Value desc="Pin Name" alarm="" unit="" llim="" ulim="" tval="" val="Pin12" type="Pin"/>
    <Value desc="max force" alarm="0" unit="N" llim="160" ulim="320" val="227" type="Force"/>
  </Values>
```

Sample of parsed data, showing sorted **DATA** on pin insertions from multiple NUTZEN. (Output of Python Program).

Pin	Timestamp	Program	Thickness	State	Force	Alarm	LowLim	UpLim	Group
Pin1	2021-02-22T15:07:26	33810400.ro	1.42	PASS	114	0	60	159	60159
Pin1	2021-02-22T15:08:43	33810400.ro	1.433	PASS	113	0	60	159	60159
Pin1	2021-02-22T15:10:20	33810400.ro	1.431	PASS	110	0	60	159	60159
Pin1	2021-02-22T15:11:37	33810400.ro	1.421	PASS	115	0	60	159	60159
Pin1	2021-02-22T15:13:00	33810400.ro	1.442	PASS	116	0	60	159	60159

Force data of pin insertions from multiple NUTZEN. (Output of Python Program). Force in N. (100N = 10,2kg)



Heat-Map of measured force. (R-Studio)
Filtered output of double 0.63mm KKS insertions. Tyco44 Program 33810800 sample size = 164 nuzten.

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