RFS Handler Cone Chuck Simplification for Effective Handling Performance

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Abstract

In today's manufacturing world, higher equipment utilization and lower operating cost is the way forward. Newer machineries are usually well equipped to get the job done as they are manufactured with the latest available technology whereas the earlier generation equipments are usually phased off or go through a series of improvements to meet the goals but at the expense of higher cost. The RFS handler is a good example of older generation equipment, making an impact with the help of TRIZ or Theory of Inventive Problem Solving in this ever demanding manufacturing world.

The Cone area of the RFS handler is made up of 2 perpendicular chuck heads that is used to pick up units (vacuum strength) from a horizontal position, rotates 90° and sockets the unit vertically at the TIU (Tester Interface Unit) for electrical testing. However, the many connections present from the vacuum generator right up to the suction cup of the cone chuck, cause the suction strength to be low. This, coupled with the centrifugal force of the rotating chuck, causes the unit to potentially drop, leading to high assist and downtime. In addition, we see that the high maintenance cost of the RFS handler is specifically coming from the Nest.

By adopting TRIZ, we used 2 concepts to solve the issues faced. Merging was used to solve the many connection problems present by removing the excessive components through the trimming process. There was also a change in suction cups. By doing so the suction strength has doubled without even changing the vacuum generator and the number of missing unit cases has reduced significantly by 82 %. The Cone related jams has reduced by another 78 % which in other words increases the Mean Time Between Assist by 120 %. Next, we used Segmentation for the Nest. The Nest being an ESD sensitive material is one of the most expensive consumable parts in the handler. By breaking the Nest up into 3-pieces, we now only change the affected part that is worn off and not the whole piece. This simple modification together with the change in suction cup helps us save 35 % on our monthly Preventive Maintenance cost. In the larger picture, we are looking at a projected savings of >US$800K throughout other Intel sites.

Introduction

In our company's manufacturing lines, there are various types/models of handlers being used to support different products with different form factors. There are some handlers that have been in operation for more than 20 years whereas some have just been purchased recently. Naturally the handler that is newer uses the latest technology in the market and will definitely work more efficiently compared to the older technology based handlers. Therefore there is a constant effort being applied to improve these older handlers so that their contribution is at par with the newer handlers.
The RFS handler has been around in our Malaysia location for at least 15 years now and uses a lot of pneumatic controls in its application.

However in the Cone area of RFS handler, the area where the units are having the most movement, the assist and jam rate is high compared to any other part inside the handler. We see an average of 30% - 40% of cone related downtime (see Figure 1) from the overall handler downtime happening from week to week due to many factors. Some of the issues are due to weak suction strength and the small form factor products being tested.

As a solution, we opted to use Theory of Inventive Problem Solving (TRIZ). We used this application to help us achieve positive changes in terms of cost reduction and also lowering equipment downtime. The changes made will be discussed in detail in the next part of this paper where we will touch on the issues faced initially and the steps that were taken to arrive at the solution and the impact of all of it.

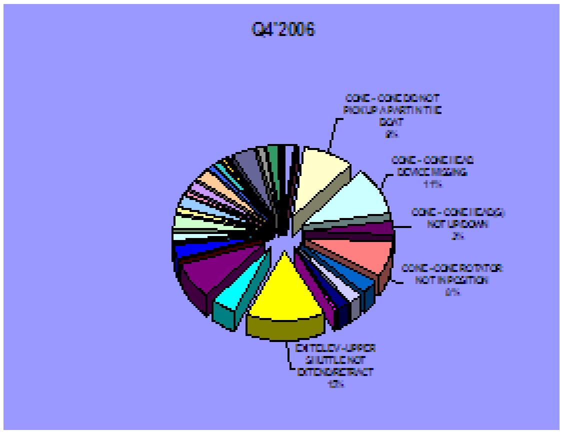

Figure 1 Q4'2006 Failure mode pareto

Understanding the RFS handler Cone Chuck

The RFS handler cone chuck is situated at the rear end of the handler (see Figure 2). At this area (Chamber) the temperature is controlled so that the uingnits can be preconditioned before testing at the desired temperature. The RFS handler is capable of test between -60°C to 160°C. The cone chuck is made up of 2 chucks perpendicular to each other with each chuck having 2 cone heads attached to it so it is able to test 2 units at a time in one single socketing. (See Figure 3)

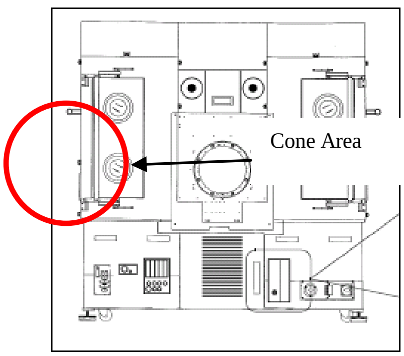

Figure 2: Rear view of the RFS handler

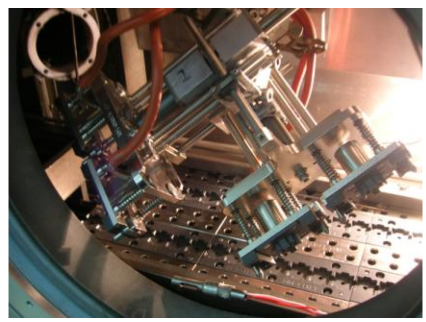

Figure 3: Photo of the Cone Chuck

The typical flow of the RFS handler starts with the units being transferred from the tray to the boats. The boats will ferry the units to the chamber area where a controlled environment is maintained for electrical testing. At the cone area, the units are being picked up by the chuck head where it will be rotated to the horizontal direction and socketted to the Tester Interface Unit (TIU) for electrical test to take place. After this has been completed, the units will now be placed back into the boats and will be transferred out of the chamber area to be sorted out on trays as "Pass" or "Fail" units.

Issues faced with the RFS

Due to the small form factor products being tested, it has been a great challenge to the handler to maintain high accuracy and at the same time consistency. This in particular is very hard to achieve as most of the controls inside the RFS are still governed by air (pneumatics). Besides this the design of the Cone chuck is such that there are many connectors (see Figure 4) from the vacuum generator right up to the suction cup. We cannot deny that in every connection point there is a small fraction of leakage that will occur and in this case, if you lump all that small leakage up you will have a significant amount of leakage that will certainly impact the suction strength. High assist is also a concern. For example, if suction strength is low, there will be units being dropped (see Figure 5) or, going one step further, missing units cases being reported out. This in turn leads us to low mean time between assist (MTBA). Finally the high maintenance cost is also a great concern as the high wear and tear especially of the Nest causes us to change it frequently. The cost of 1 nest is approx USD$170 and 1 RFS handler uses 4 Nests.

With the high assist and low suction strength, equipment downtime (DT) will be high as the technician will have to attend to the handler every time an issue is triggered. In other words the machine utilization will be low and the overall Total Utilization (TU) will be affected as well.

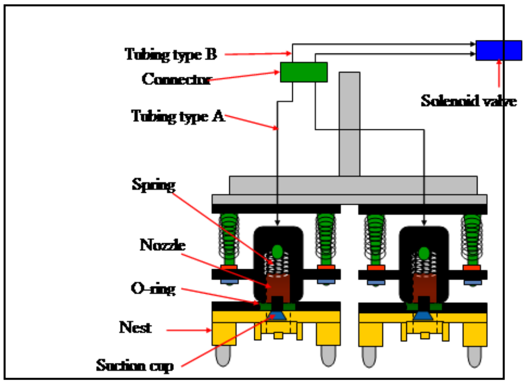

Figure 4: RFS Cone Chuck

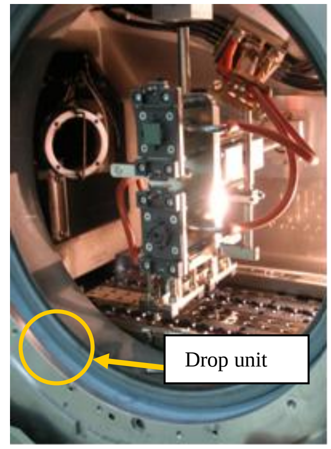

Figure 5: Dropped unit scenario

Methodology

As we now know, the Cone Area is the most important part in the handler as the testing is done in this area and also the most movement of the units. Unfortunately it is also the area where most jams/ breakdown happens (see Figure 1). With this particular section being an area of interest, we looked for that glimmer of hope to find a way to stop the menace of the Cone Area jams in places never ventured before. Never being used before and with only glimpses of its great ability being heard, we opted to the Theory of Inventive Problem Solving better know as TRIZ. Now TRIZ was a new approach for us since all previous attempts with the conventional way seem to be less than fruitful in solving this problem.

We plotted the Cause and Effects Chain (CEC) (see Figure 6) of the Cone Chuck in the TechOptimizer [3]. Step by step we included in the supersystems and components and mapped out the working order of the chuck and every part in it matching it to its own purpose and function. Engineering contradiction (EC) was introduced to ensure the new design that we came up with was not causing more harm then good. We had to ensure that every part that we changed was accounted for and that the original function was not changed or else the project would have been a disastrous outing.

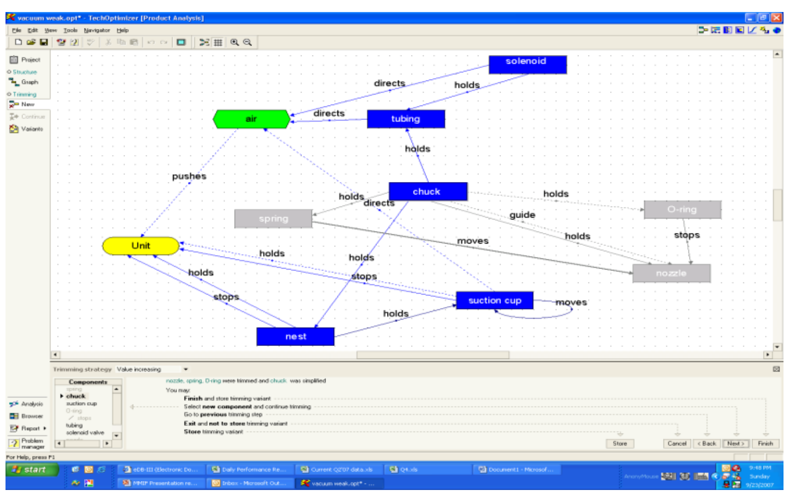

Figure 6: Example of the CEC

Principal #5: Merging [1]

In a conventional way of making an improvement, usually what is done is that a new sensor or even a tool or at least a device is added into the system for the change to be made complete. However in our case, less was more as when we came to the trimming exercise, we noticed that we could eliminate or merge a few parts together and yet not change the basic function or ability of the cone chuck. We found that the many connections from the vacuum generator right up to the suction cup were actually the main root cause of the low suction strength. We successfully managed to remove the compression spring and also the o-ring inside the chuck head and remodeled the nozzle to be without these two parts. Next since we had many connectors from the vacuum generator right up to the suction cup i.e. tubing A, tubing B and the many connectors, we removed the connectors and used only one single tubing to replace the two different tubing previously (see Figure 7).

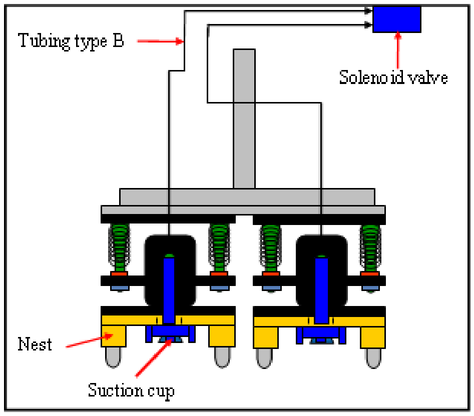

Figure 7: RFS Cone chuck after changes made

Principal #1: Segmentation [1]

TRIZ also helped us in saving cost as it narrowed down our spending root cause to the Nest during a periodic monthly Preventive Maintenance (PM). The four anvils at the centre of the Nest are used to orientate the units in position so that no unit gets stuck at the TIU. So if any of the anvils wear off, the Nest will have to be changed as there will be a lot of Cone jams triggering.

By segmenting the Nest into 3 smaller pieces, we are now able to change the part that is worn off only and not the whole Nest as was done previously (see Figure 8).

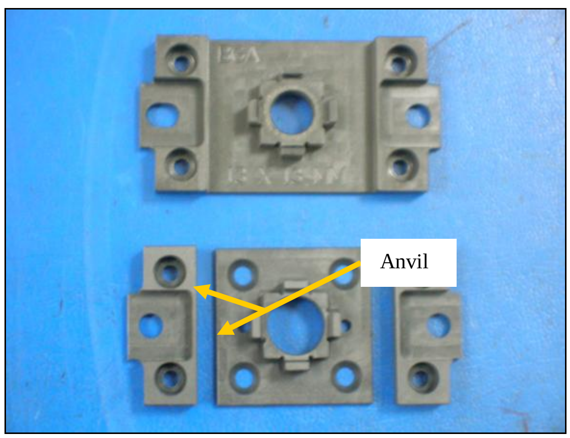

Figure 8: One piece Nest and the 3-piece Nest

Prototype of the Chuck

So as we successfully managed to simulate the changes and make the apparent assumptions for the chuck to be redesigned but it was not good enough as all we had done was to make it look good on paper. We now moved to the next stage of the project whereby we put into action all that was said before to see if we can get the same results as predicted through the simulations. The fabrication was carried out by a 3rd party supplier governed by a Corporate Non-Disclosure Agreement (CNDA) so that the design cannot be reproduced without Intel's approval.

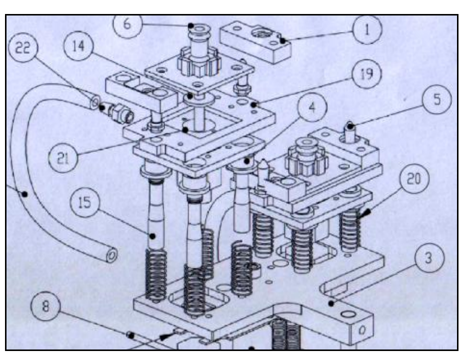

Figure 9: Technical drawing of the chuck

The chuck was designed without the compression spring and also the o-ring inside the chuck head. (See Figure 9) Then again this does not mean that the spring's effect on the chuck is not needed. The purpose of the spring inside the chuck head is to give the chuck the extra ability to absorb any excessive force that may be exerted onto the units. Therefore what we did was to change the rigid suction cup that was used previously to a bellows suction cup (see Figure 10). The spring effect is now transferred to the suction cup and the original function of the chuck is maintained but with minimal parts.

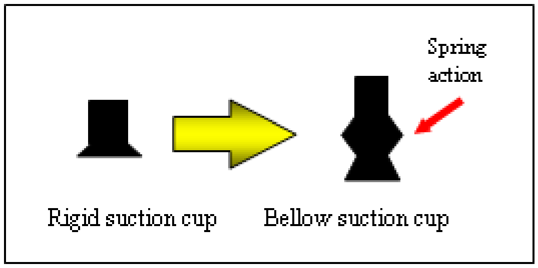

Figure 10: Changes in the suction cup

Results and Discussion

Now that we have brought the model from paper to life, let us put the new designed chuck to the test to see if what we predicted was right. With the intention to improve suction strength without changing the vacuum generator, we merged the many connections in the previous design and removed the compression spring and o-ring. We started off with the inspection of the suction strength based on the before and after that we measured using a digital gauge. Here we seem to have crossed the first hurdle as we recorded almost double the suction strength present in the new design compared to the original design (see Table 1). This was indeed very encouraging to the team.

Vacuum reading (Psi)	Before	After
Vacuum Reading 1	-0.36	-0.78
Vacuum Reading 2	-0.31	-0.74
Vacuum Reading 3	-0.39	-0.76
Vacuum Reading 4	-0.25	-0.79

Table 1: Vacuum reading

So now we seem to have solved our first issue, low suction strength. Next we moved to see if we could solve the high assist (low MTBA) coupled with the low downtime and high missing units cases. We installed the prototype design chuck on one system and the results we got were evident from the time of installation. (See Figure 11)

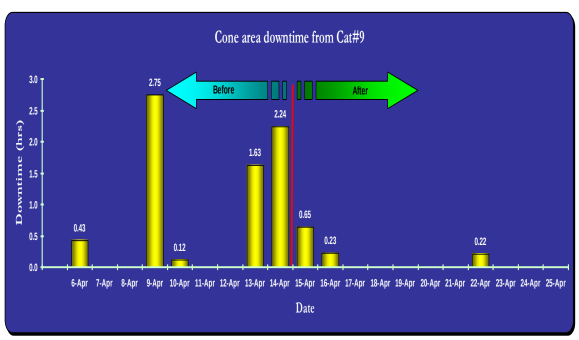

Figure 11: Installation of the prototype design chuck

Making comparisons to the other system running with the new designed chuck, we see a 25% reduction in Cone related jams and another 50% reduction in missing unit cases as seen in (see Figures 12 and 13). So this was good enough for us to actually proliferate the new design to all handlers. We managed to do that on April'07. Now with the new design in place for all RFS handlers in this particular module in the Malaysia site, we expected the similar outcome as to what we got during the trial run.

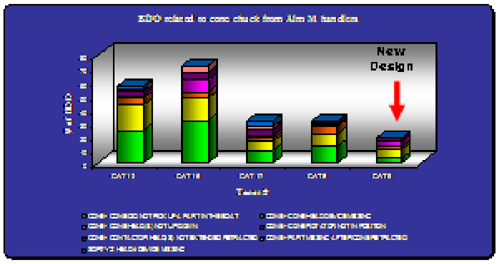

Figure 12: Reduction of Cone related jams

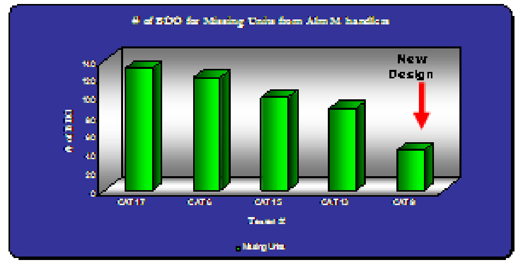

Figure 13: Reduction of missing units

Indeed we were not disappointed as the results we got back jived with the improvements that we got during the prototype chuck stage. We achieved 78 % reduction in cone area related jams and impressive 82% reduction in missing unit cases. So this will definitely lower the downtime caused by the 2 main Pareto factors. Besides this we managed to reduce our assist time by improving the MTBA by approximately 120 % from an average of 33 minutes/assist to now and average of 77 minutes/assist. (See Figure 14)

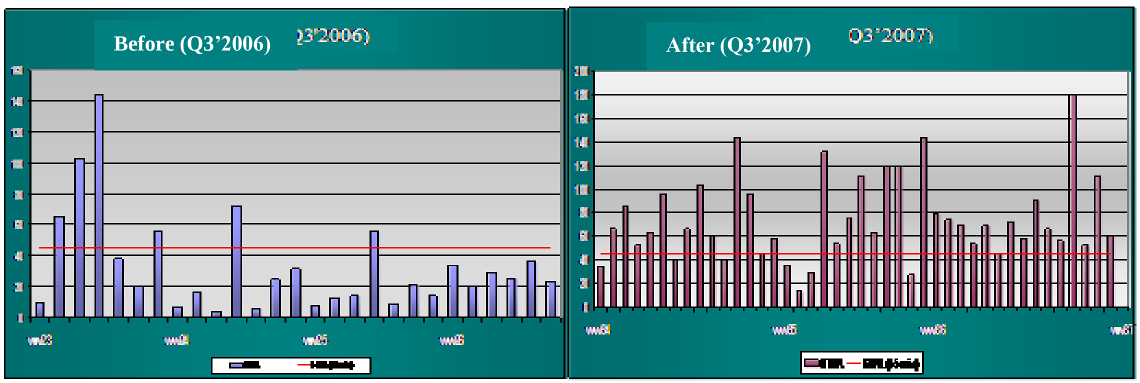

Figure 14: MTBA data before and after implementation

This is now very encouraging data that we are getting and when we proliferated this project to our counterpart in another site on May'2007, the data was also achieving the goals according to the predicted outcome.

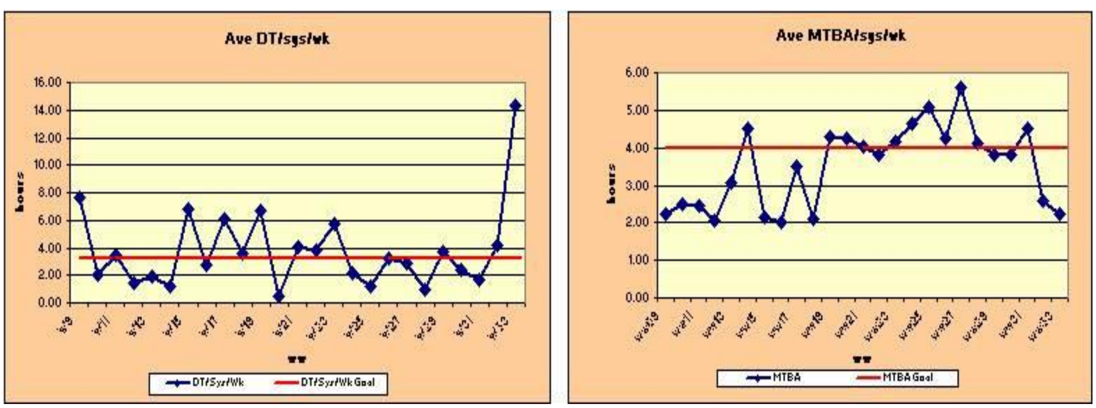

Figure 15: Downtime and MTBA Data from our counterpart

Our counterpart recorded a reduction of 13% in downtime and an improvement of 145% in the MTBA (see Figure 15). This data was based upon the 12 weeks before and after with regards to the installation date of May'2007.

In terms of quality, the impact that we got from using the new chuck was evident on the cosmetic rejects failure. With respect to the Mark & Pack (M&P) Yield, the POR that is maintained for the cosmetic rejects is 50 DPM (Defects per million). But this change has brought a reduction of almost 90 %, as from the sample size of approximately 3.5M units we only saw 2 unit defects for this failure mode. Since then the M&P Yield goal has been improved by 200 DPM.

In terms of cost, we used to spend around USD$1.8K for a typical monthly PM (Preventive Maintenance) on one RFS handler. The bulk of the cost was going for the Nest. 1 RFS handler uses 4 Nests at one time.

The purpose of the Nest is to hold the unit in the right orientation so that there would be no units stuck at the TIU socket. Now if the Nest is showing signs of wear and tear especially at the 4 anvils, (see Figure 8) then the unit will not be seated perfectly horizontal on the anvil and the potential of the units dropping or even flying inside the handler will be very high. Previously we would change the whole Nest when there are signs of wear and tear but after going through the TRIZ methodology, we segmented the Nest into 3 small pieces whereby we now only change the part that is worn off and not the whole piece. The changes made on the suction cup from a rigid type to a bellows type have also resulted in cost savings. As a total, we saw a 35% savings in monthly PM due to the changes made and the overall ROI (Return Of Investment) across other sites that use the RFS handler was hovering around >USD$800K.

Conclusions

As was mentioned in the beginning on this paper, we see problems from the Cone Area of the RFS handler as the top Pareto (30% of the failure). Issues were happening due to high assist (high downtime and high missing unit cases) which was being caused by low suction strength. As a solution we merged the many connectors from the vacuum generator right up to the suction to one single connector and removed the spring and o-ring inside the chuck head. This resulted in higher suction strength without changing the vacuum generator and reduced the number of cone related and missing unit occurrence.

Besides that we also saw that the high maintenance cost was a concern due to the expensive parts being used and we solved this by breaking the Nest into a 3-piece part and now we only change the part that is worn off and not the whole Nest as was done previously.

In terms of the overall ROI, we are looking at a total of >USD$800K savings throughout other company sites. Therefore I am recommending that the changes made in this project can equally benefit other handlers with the use of segmentation and merging concepts as a simplification step.

Acknowledgments

I would like to thank the project members, Goh Cheng Teik and Azir bin Romli for the hard work and commitment put in to complete this project. Also to be commended is the factory management for their support and encouragement throughout the timeline of the project. A big thank you to our counterpart led by Nelson Lacerna who executed the flawless installation of the new design chuck there. Finally I want to especially thank the TRIZ instructors (TS Yeoh and EH Gan) for their sharing, which allowed us to get to this stage of the breakthrough.

References

[1] James Scanlan; School of Engineering Sciences, TRIZ 40 Design Principles, available online, www.soton.ac.uk/~jps7/Lecture%20notes/TRIZ%2040%20Principles.pdf

[2] ATM Tech Tribe website available at http://teamsites.ch.ith.intel.com/sites/ATMTOUS/PHINews/event/home.html

[3] Software used in the TRIZ approach

RFS Handler Cone Chuck Simplification for effective handling performance

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Malaysia

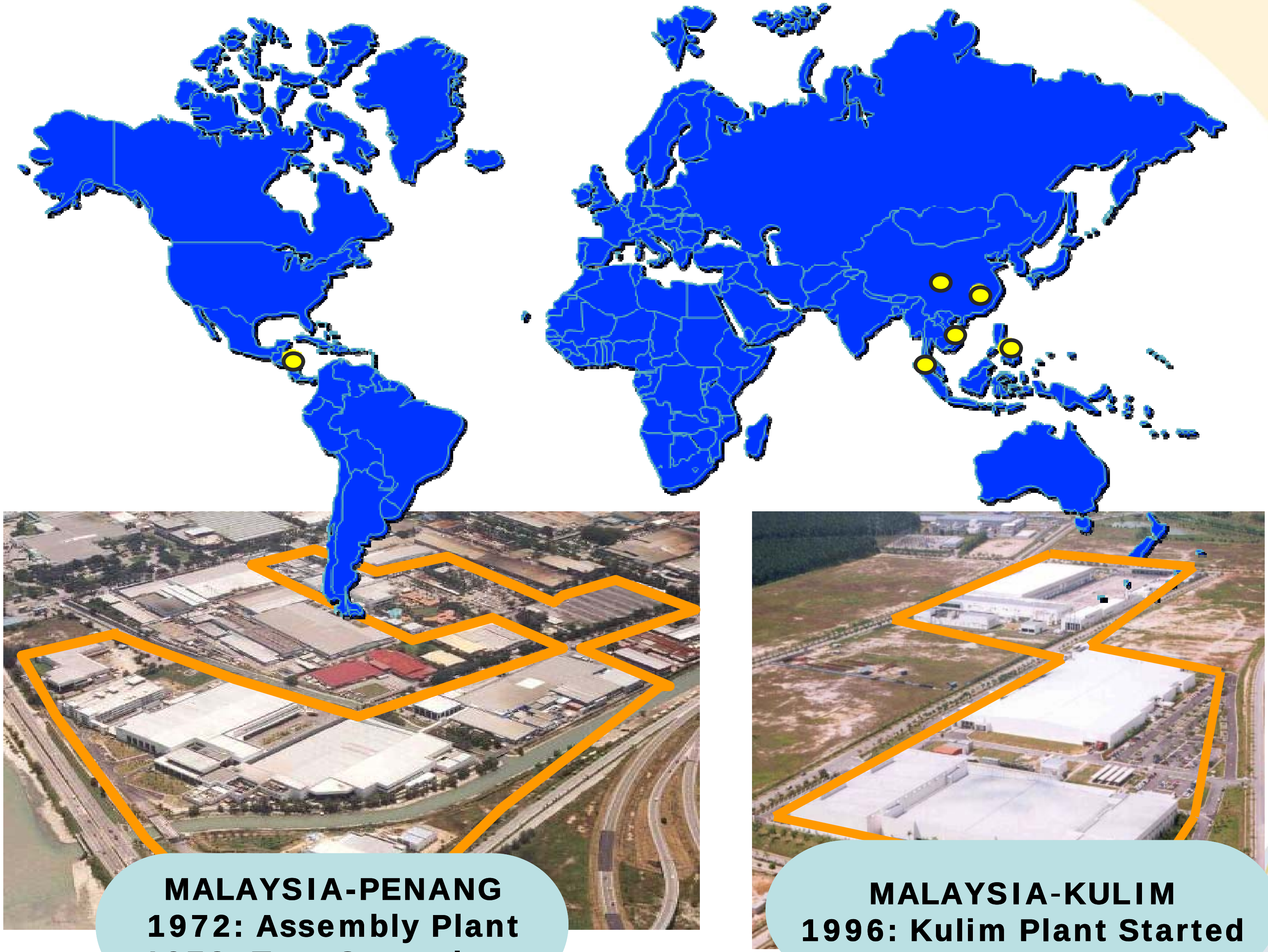
Outline of presentation

- Overview of Intel Malaysia
- Background
- Problem statement
- Changes made
- Concepts used
- Impact
- Summary
- Acknowledgement

Purpose of work being presented

- To demonstrate that Innovation can happen anywhere and everywhere irrespective of functional group, geography, etc.
- Old doesn't mean obsolete
- To demonstrate how Less can be More!!??

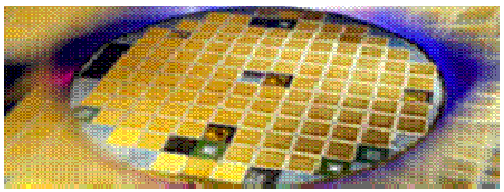
Overview of Intel Malaysia

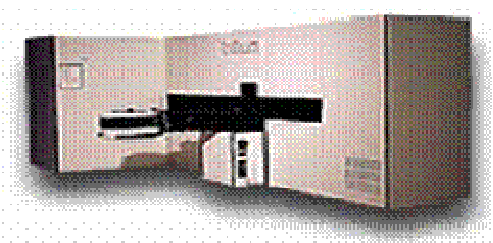


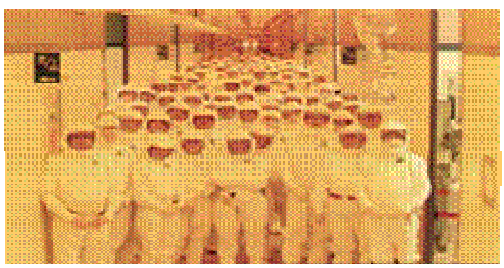
MALAYSIA-PENANG
1972: Assembly Plant
1978: Test Operations

MALAYSIA-KULIM
1996: Kulim Plant Started

Overview of Intel Malaysia







ASSEMBLY

↓

TEST

↓

BACK END

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DISTI

TEST

M

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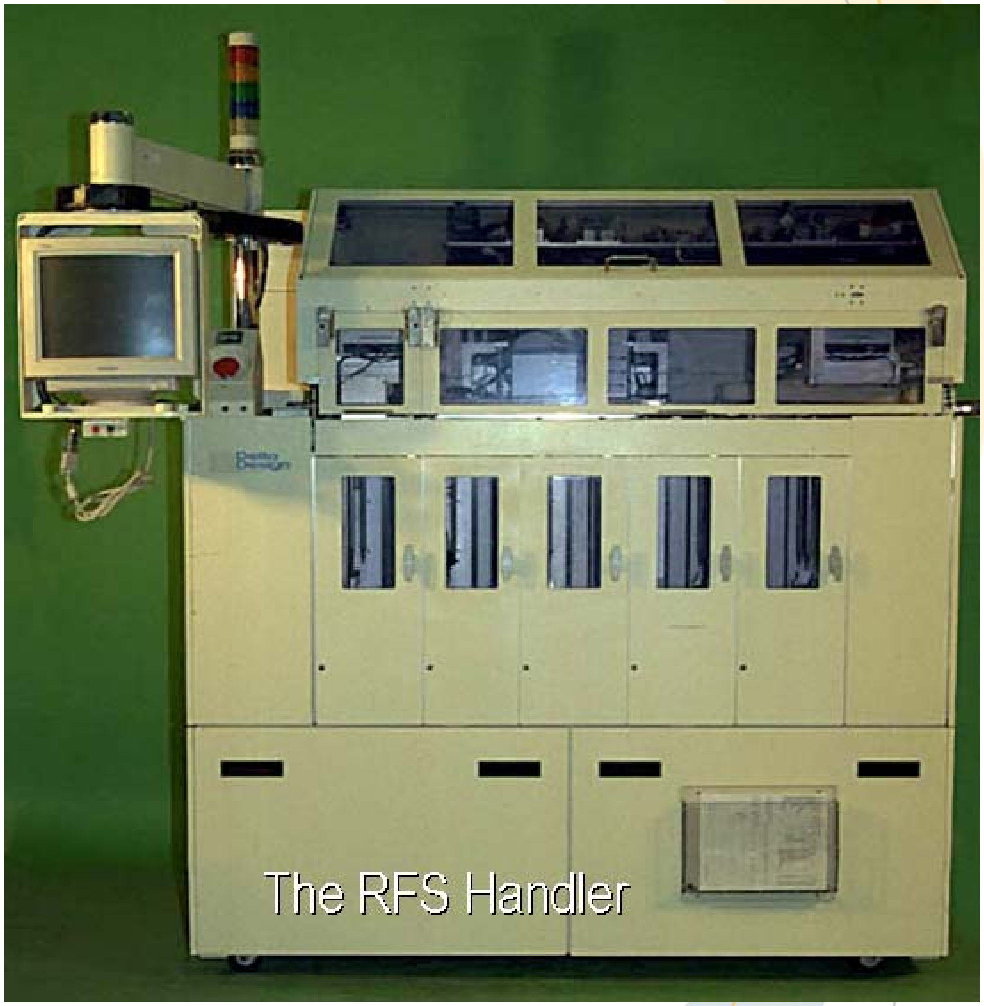
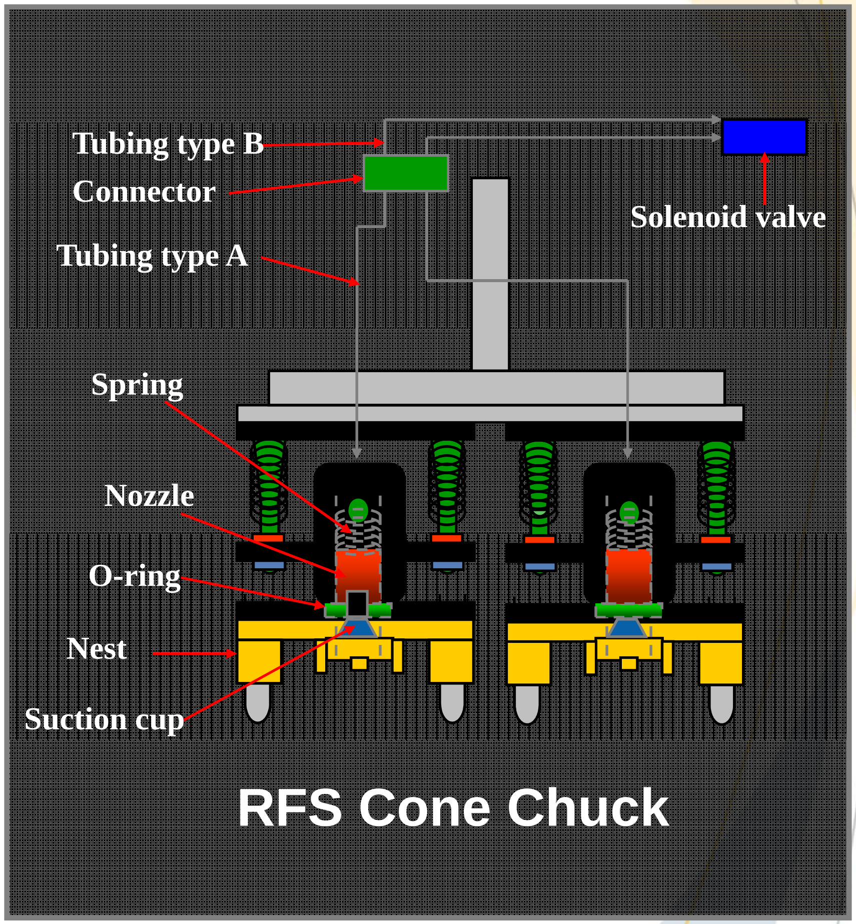
Background

- A Pick & Place Equipment that transports various **small form factor** products
- Have been used in Intel for **> 15 over years**
- Most movements inside the handler are still controlled by **air**
- **Fast Rotational Movement** of 2 perpendicular chuck heads (centrifugal force)



Problem Statement

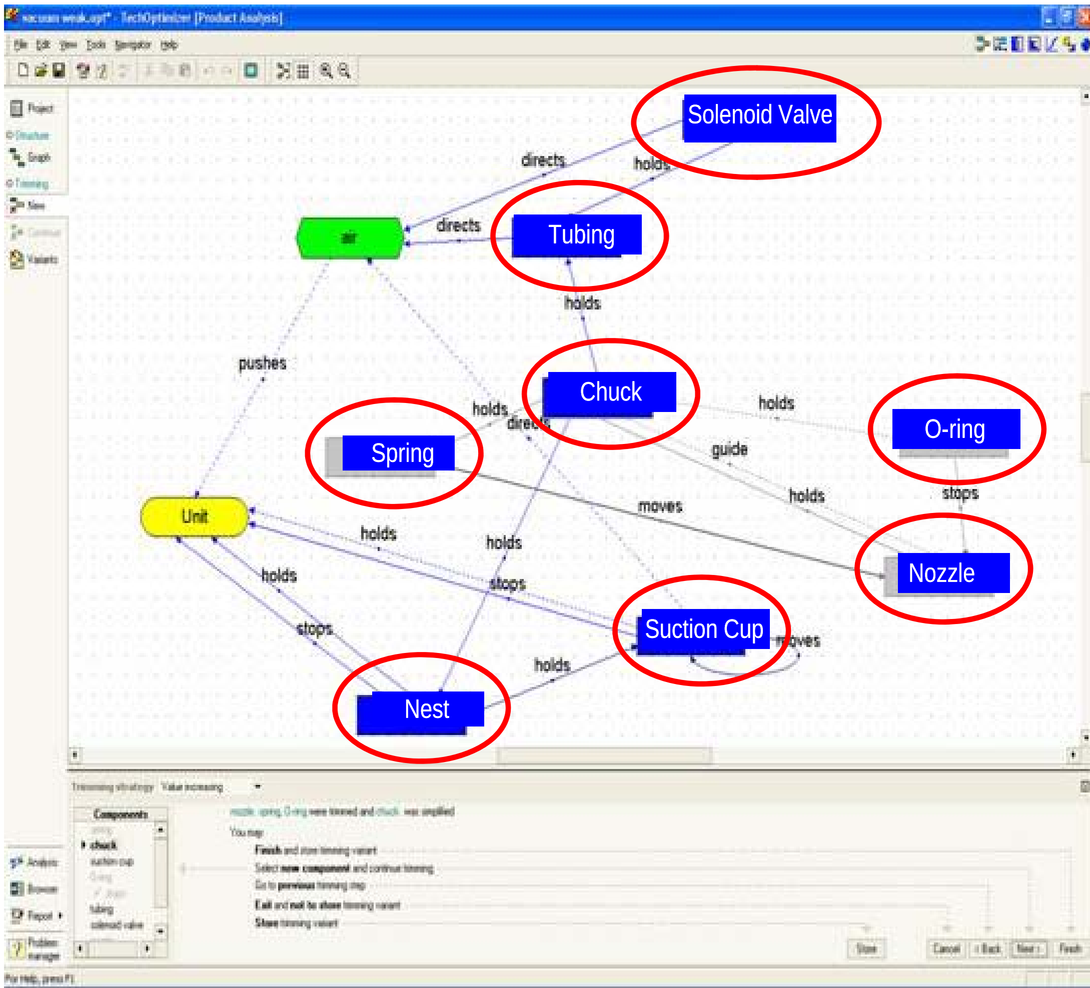
- **Vacuum leakage**
  - (too many connections)
    - Unit drop
    - Missing units
- **High assist**
  - e.g.: Cone Area jams
- **High maintenance cost**
  - Nest (>US$150 per piece)
    - Most expensive consumable part in the Monthly PM

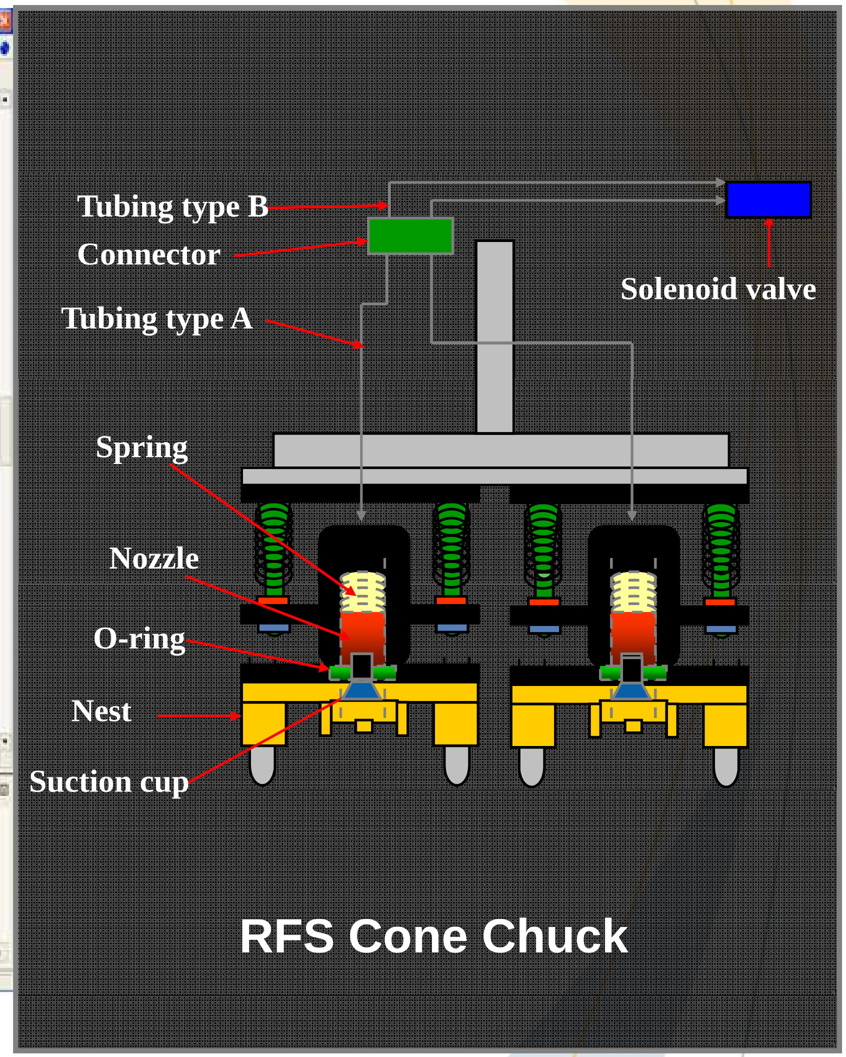


From Problem to Solution…

- Applied ***Theory of Inventive Problem Solving (TRIZ)*** to problem for a hope of a solution
  - **Built Functional Model**
  - Use the 40 Inventive principles
  - Perform Trimming
  - Make changes based upon recommendation
  - Evaluate the design performance

Built the Functional Model





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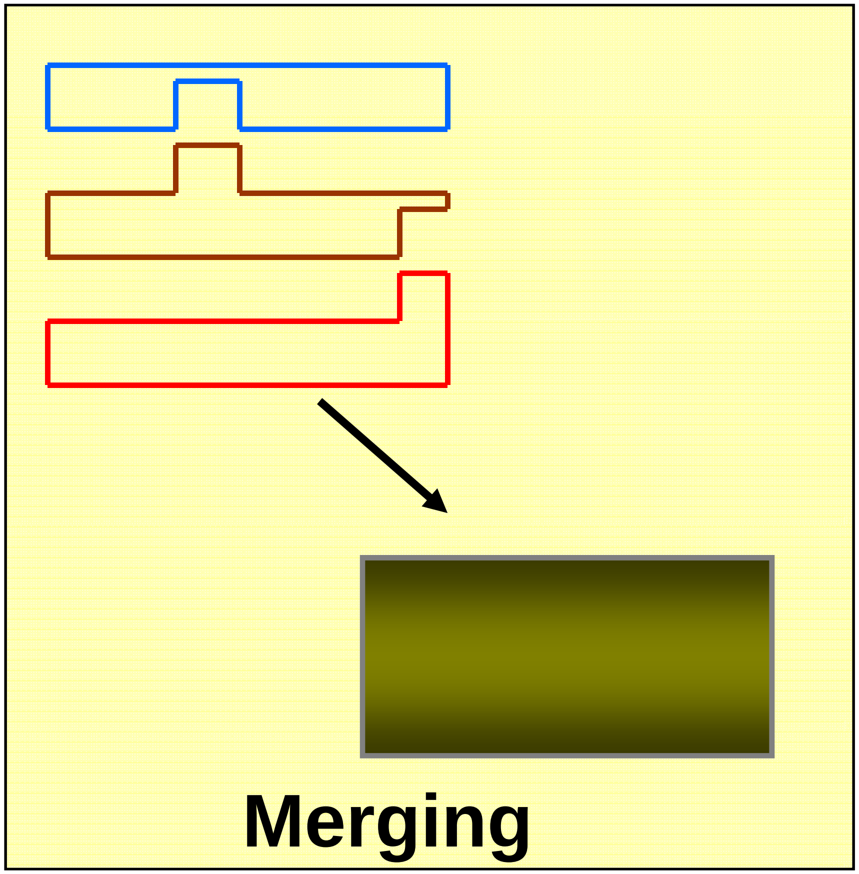
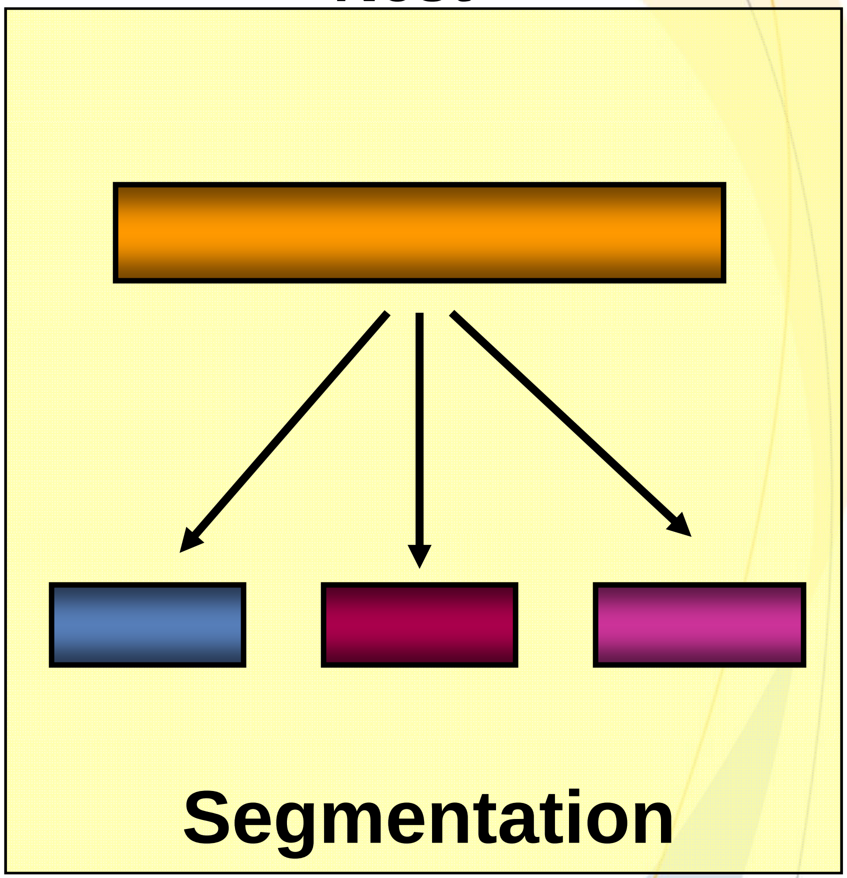
Concepts Used

The numerous connectors



Nest



*40 Inventive Principles from TRIZ

From Problem to Solution…

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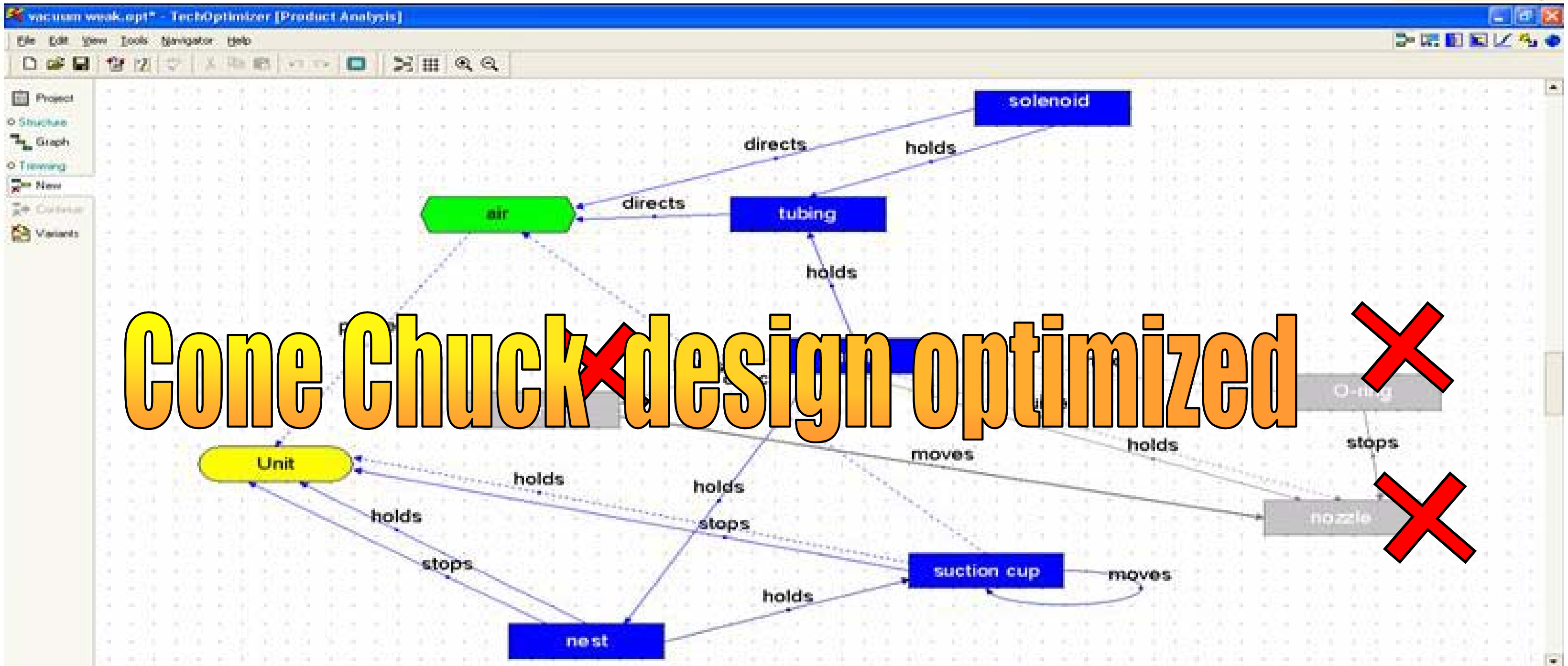
  - **Perform Trimming**
  - Make changes based upon recommendation
  - Evaluate the design performance

Functional Model & Trimming of Chuck



Trimming rules

Rule A: You don't need the function anymore

Rule B: The object performs the function itself

Rule C: Some other component does the function

Nozzle – remodeled as one with the chuck body

Compression spring and o-ring – removed as to minimize connectors

From Problem to Solution…

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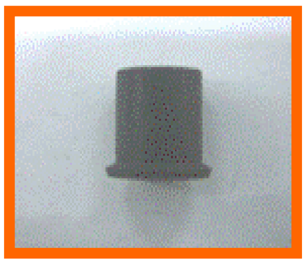
  - Built Functional Model
  - Use the 40 Inventive principles
  - Perform Trimming
  - **Make changes based upon recommendation**
  - Evaluate the design performance

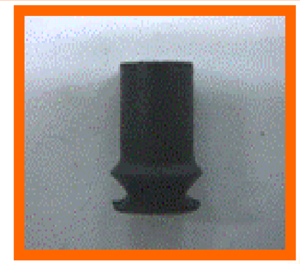
Changes Made

Before | **After**

Eliminated the Compression spring and o-ring by transferring the spring effect to the suction cup

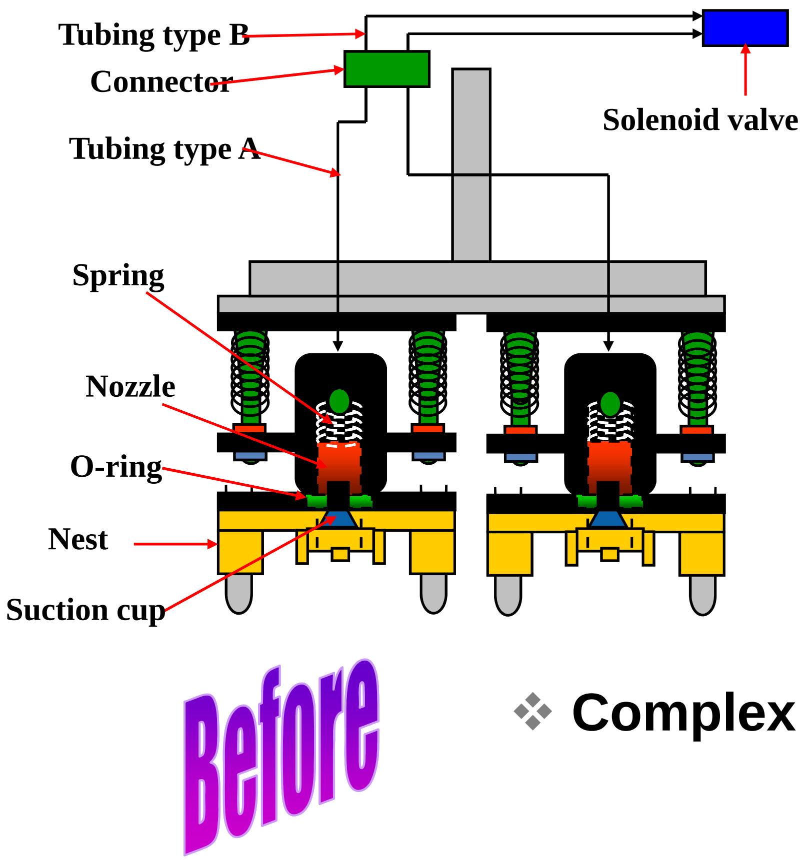


Changed the current rigid suction cup to a bellows suction cup

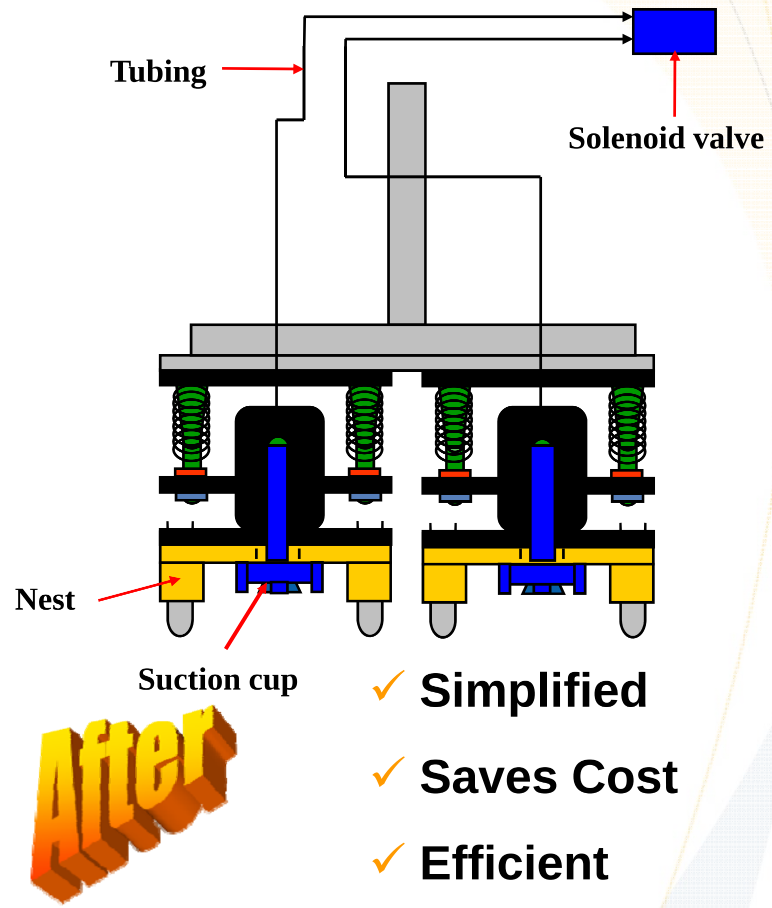


Segmented the Nest to a 3-piece part

Changes Made



❖ Complex



- ✓ Simplified
- ✓ Saves Cost
- ✓ Efficient

Less is More!!

The Final Design

Side View

Front View

Nest

From Problem to Solution…

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  - Built Functional Model
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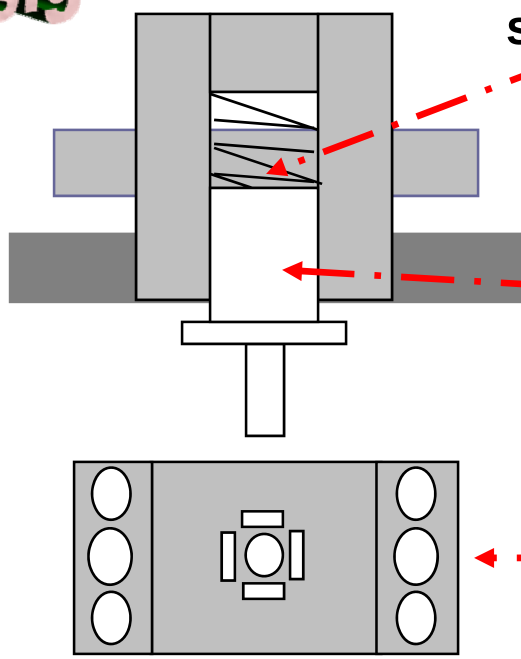
  - Perform Trimming
  - Make changes based upon recommendation
  - **Evaluate the design performance**

Suction Strength Improvement

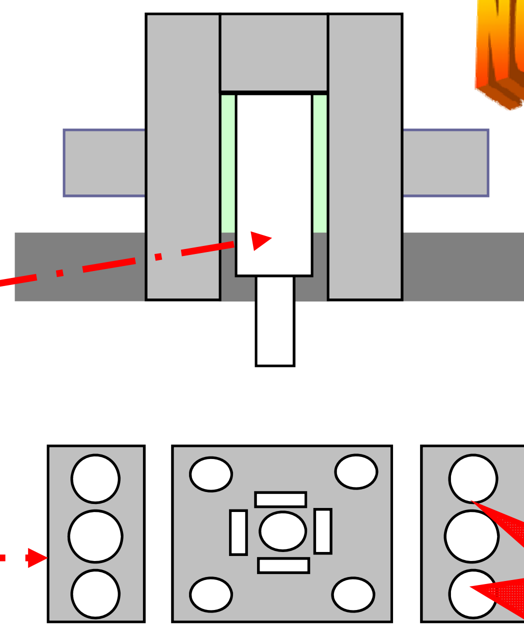
Old Design

Suction Cup



Vacuum reading direct contact to suction cup (Psi)	
Vacuum Reading	-0.36
Vacuum Reading	-0.31
Vacuum Reading	-0.39
Vacuum Reading	-0.25

New Design



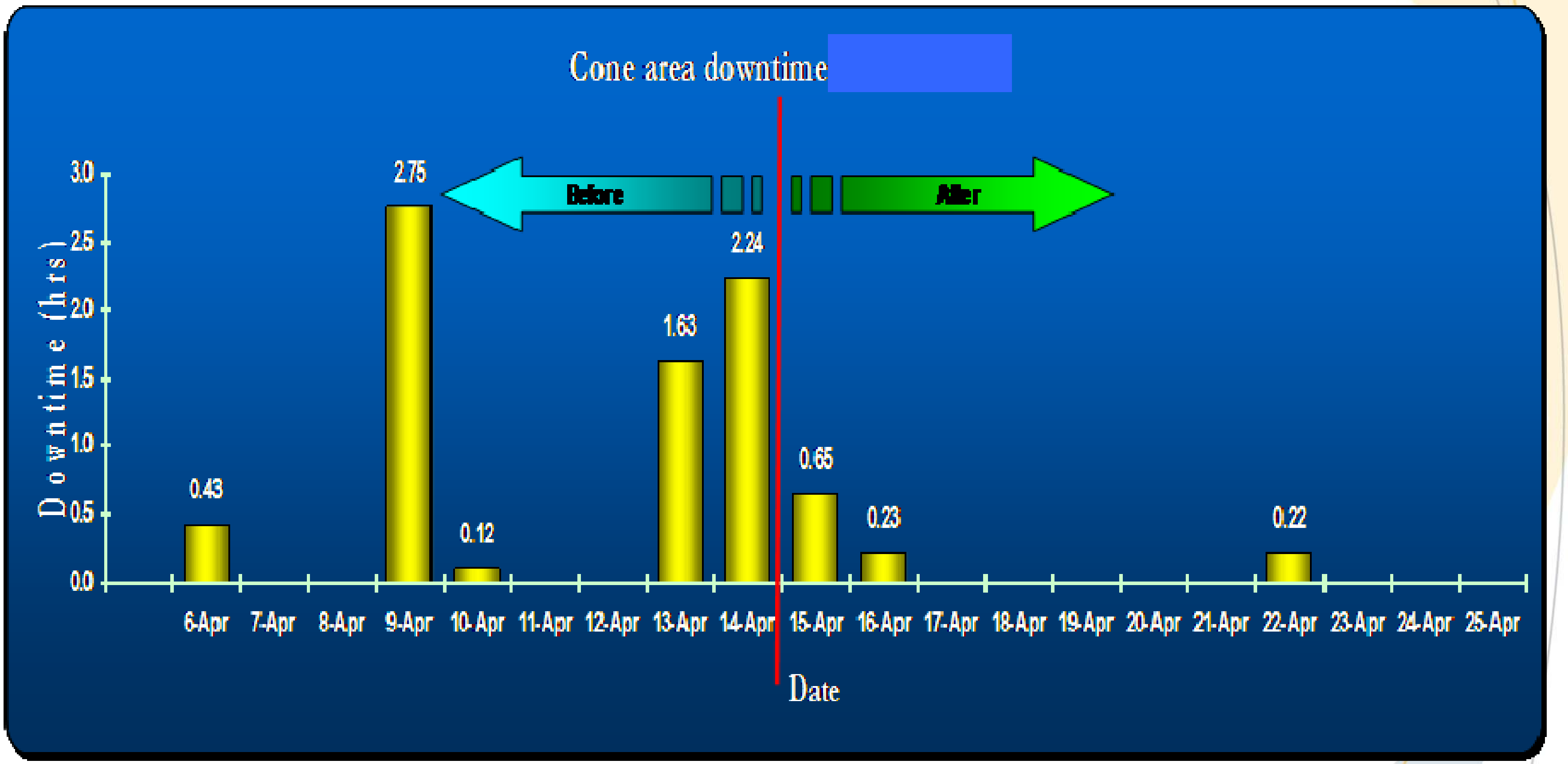
Bellows Suction Cup

Almost 2X increment

Vacuum reading direct contact to suction cup (Psi)	
Vacuum Reading	-0.78
Vacuum Reading	-0.74
Vacuum Reading	-0.76
Vacuum Reading	-0.79

Impact

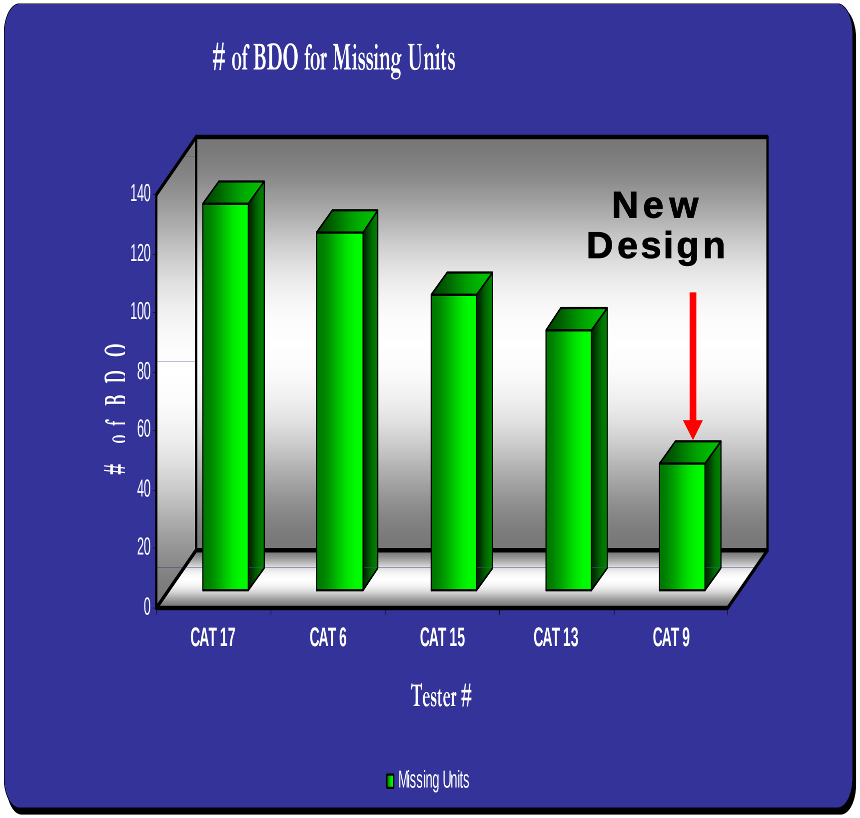
Upon installation of prototype

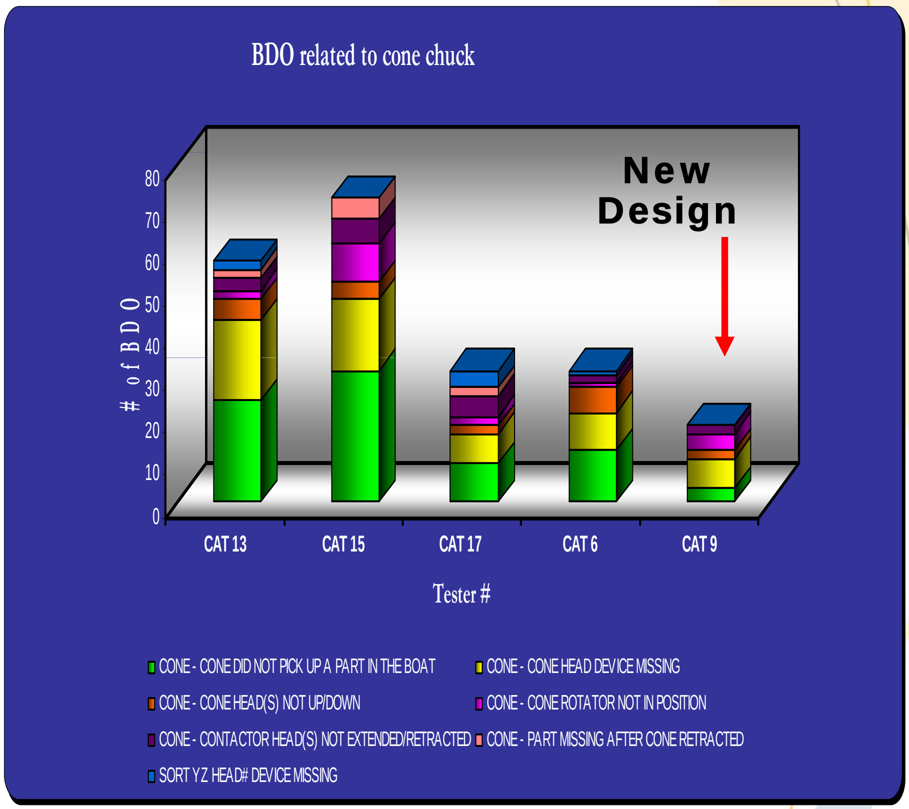


Number of **BDO** and **Downtime** reduced significantly after the implementation of the new chuck (Prototype)

Improvements

Prototype System



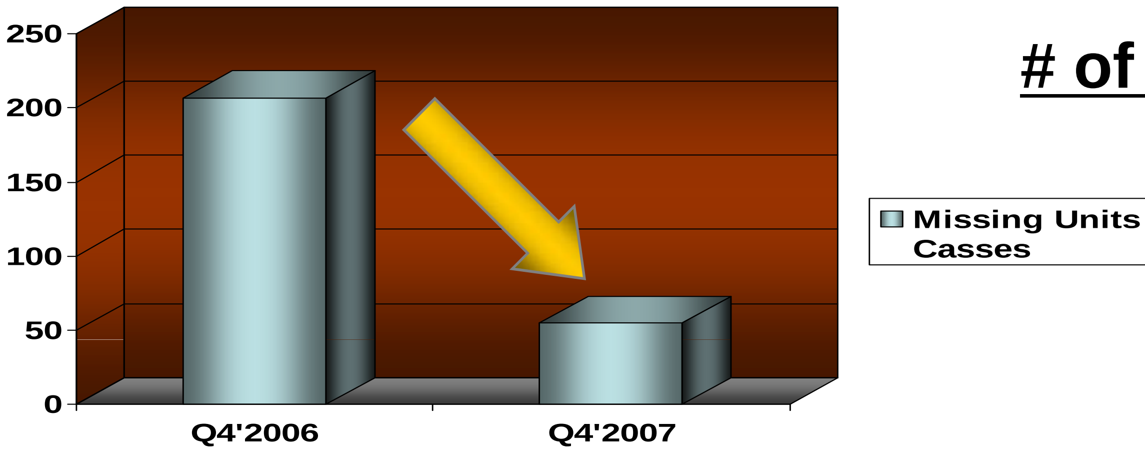


<u>**Reduction**</u> of almost **50 %** of missing units BDO (10 weeks Data)

<u>**Reduction**</u> of almost **25 %** of cone related breakdown (10 weeks Data)

Proliferation Results

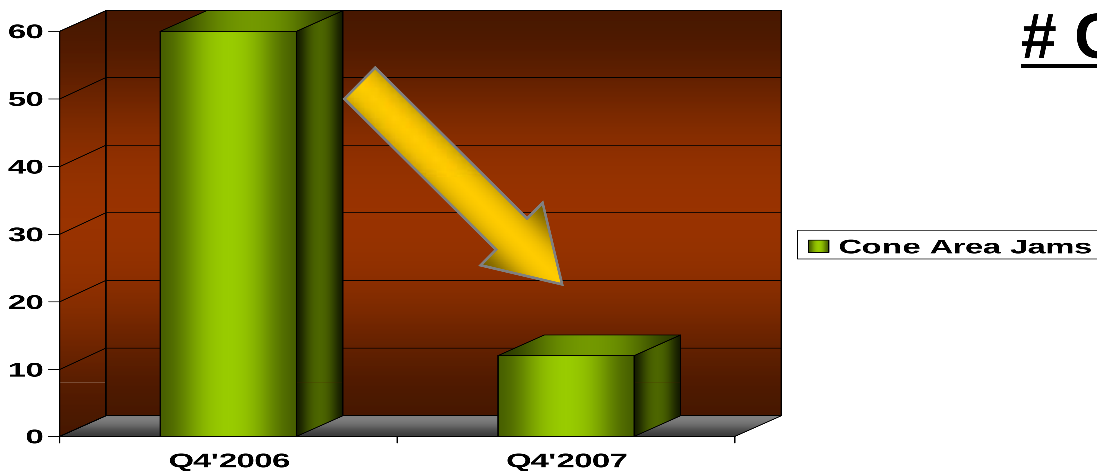
of Missing Units Cases



Before After

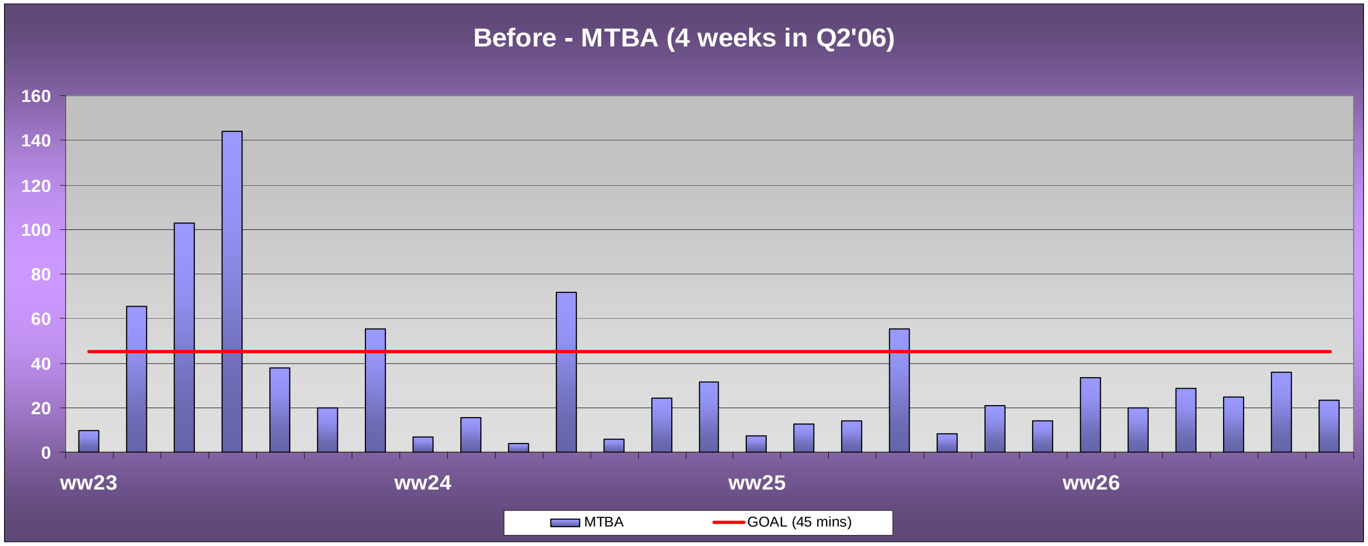
Reduction ~ 74 %

Cone Area Jam Cases



Reduction ~ 80 %

MTBA Improvement



Before (Q2'2006)

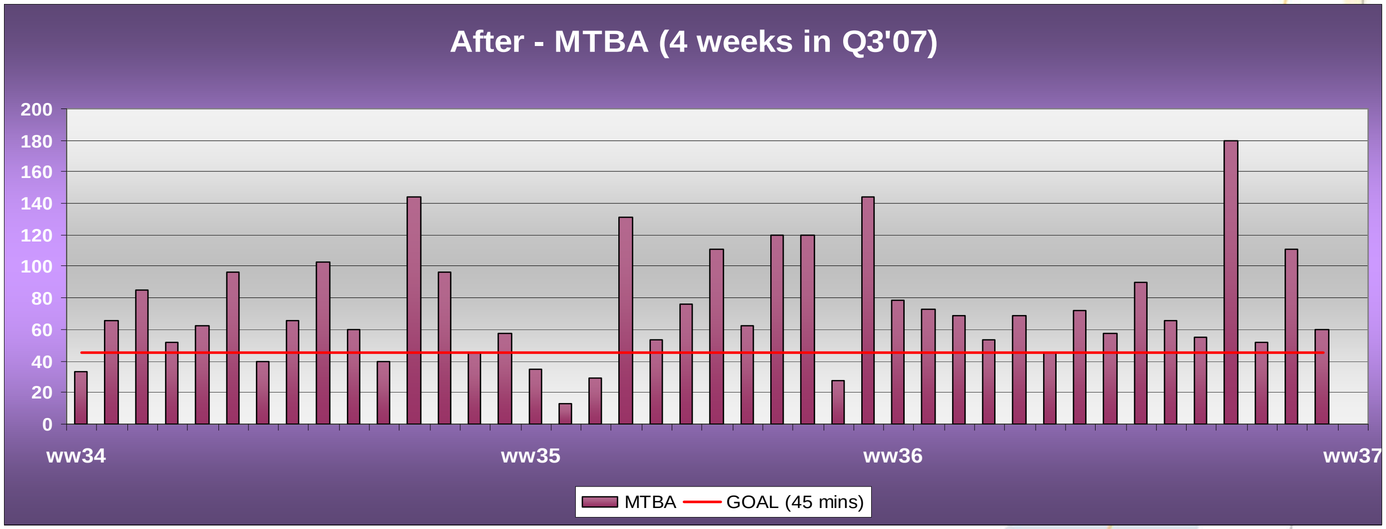
Average MTBA

= **35 min/assist**

After (Q3'2007)

Average MTBA =
70 min/assist

100 %



Cost Savings

Before

USD$1.80K / PM

After

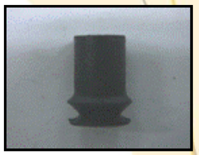
USD$1.16K / PM

Savings approx 35 %

An overall ROI estimate savings of approx USD$800K in the next 4 years

Summary

- **Vacuum leakage (too many connections)**



  - Removed the **spring, o-ring** and the **many connectors** and changed to the **bellows suction cup**

- **High assist**
  - With higher suction strength, better MTBA and lesser downtime is achieved

- **High maintenance cost**
  - Cost cut down by **35%** / handler during monthly PM

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Thank you!