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Institute of Environmental Technology

Mission report 11/2004

Report on Re-engineering at Export Mechanical Tool Stock company

6 – 19 November 2004

ENCLOSURE 4

University of Applied Sciences Basel
FHBB
Faculty
Industry
Institute of
Environmental Technology

Mission report 11/2004

Report on Re-engineering at Mechanical Tool Stock Company

6 – 19 November 2004

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Muttenz, November 2004

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Content

1 Summary

EXPORT MECHANICAL TOOL STOCK COMPANY is a fast growing enterprise that produces plated metal products. The financial situation allows the company to invest in completely new production facilities that will be launched in 2006. The overall investment will be about 2 Million US Dollars for the mechanical and plating area.

The current report reflects the data compiled during a mission to this company conducted by Mr. Robert Kistler (Kistler Engineering) and Mr. Jürg Walder in November 2004. The installed plating technology was analysed, a gap assessment performed and suggestions for new technologies and auxiliaries made.

The assessment of the existing plating line of the company used for articles to be plated with Nickel-Chrome and Zinc showed some important gaps between European standards and the existing situation concerning product quality, environmental protection and health and safety.

The analysis of the technology installed and calculations of yearly savings in water and chemicals by using adequate process- and rinse technologies showed huge cleaner production potential.

Total cost for the consumption of chemicals for the mentioned treatments is about US$ 160'000.00 yearly.

The total estimated possible annual savings in water and chemicals amount US$ 96'000.00. Savings of chemicals > 60% and water of > 95% are possible.

A reconstruction of the plating line with adequate technology based on an EST-transfer from Europe of a second-hand plating plant will be calculated based on the collected data listed in this report upon request of the VNCPC and Export mechanical tool stock company.

FHBB together with plating experts may assist the planned reconstruction of the plating shop at the new location outside Hanoi. Especially the plant layout and plating sequences shall be optimised according to the suggestions made in this report.

2 Introduction

2.1 Company

Company name: EXPORT MECHANICAL TOOL STOCK COMPANY

Address: 229 Tay Sơn Str., Dong Da District, Hanoi

Tel.: 563-6383/563-1633

Fax: 04-563-1633

Director of Company: Mr. HO VIET TAM, Bachelor of economy

Vice director of engineering: HO VAN MAN, Engineer

The actual workforce has 689 employees.

EXPORT MECHANICAL TOOL STOCK COMPANY was established in 1960 as Medical equipment Company No 1, which mainly produced medical tools.

From 1975 to 1990 the company produced and exported mechanical tools to Socialist countries (80% was for export).

Since 1990 the company has been specialised in producing mechanical tools and machine parts for motorbike manufacturers as well as in some traditional products like pliers for Western Europe.

The volume of sales is 160 Million of Vietnamese Dong (about 10 Million of US Dollars).

The yearly demand of production is heavily increasing. From last to present year there has been an increase of more than 80%. The production capacity can not cope with this demand.

The main production is for the domestic market and 10% is exported to customers like Honda, Yamaha, Ford, BMW etc.

2.1.1 Initial meeting

The initial meeting was attended by the following people:

- Mr. Ho Van Man (Vice director, Export mechanical tool stock company)
- Mr. Robert Kistler (plating expert, Kistler engineering)
- Mr. Do Trong Mui and Mr. Dinh Thang (VNCPC)
- Mr. Jürg Walder (FHBB)

The customer has two urgent focal points where he needs to optimise and invest; one of them is the plating section the other one the metal processing area.

During the initial meting on 11 November 2004 with the vice president of the company Mr. Ho Van Man the customer explained his priorities for optimisation as follows:

1. Quality improvement
2. Cost reduction
3. Environmental protection

With focussing on quality improvements the costs can be reduced simultaneously and lower environmental impact will be a result of a correct lay out and correct rinse technique as well.

The financial situation allows the company to invest in a completely new production site and to move in during 2006. About 2 Million US Dollars for the construction of the mechanical and plating area are available.

The start of the construction of the new building will be in 2005 and the investments will be done step by step according to the financial opportunities and the income.

The company is certified according to ISO 9'001 (2000). A re-certification is planned for 2006.

2.1.2 Surface treatment

During the company visit the product range was presented in display e.g. also domestic tools like barbeque forks and other bloat ware of steel. However the main production comprises of motorbike parts like nickel and chrome plated kick-starters of steel. There are also other steel articles with zinc coating and white, yellow and black passivation.

Most of the parts who are chrome plated and also some zinc plated parts are produced by blanking. Therefore these work pieces are mechanically treated by several kind of abrasive methods such as sandblasting, grinding and finally barrel finishing,

3 Methodology of re-engineering a plating plant

3.1 Possible proceeding

3.1.1 Step 1: Survey of basic data

To obtain an optimal result, there is a detailed assessment necessary. Based on checklists the data survey has to be undertaken by a plating expert.

The following detailed data is requested:

- General Company Data
- Personnel of the Company
- List of products of the plating company / department. Indicating the amounts produced in the last 12 months, as well as their sale prices
- Horizontal projection and a flow chart of the process sequences
- Pictures of the plant and infrastructure
- Description of the surface treatment processes and specification of the process variables (temperatures, pressures, pH, etc
- Description of the secondary treatments like waste water treatment, waste air treatment and specification of the process variables (Volumes, treatment sequences, chemicals, pH, etc).
- Amount of the materials that enter the process (input), such as raw material and energy, as well as chemical agents and water (not to forget to include rinsing and washing, and their cycles).
- Amount of materials that leave the process (output) (products, waste, waste water, waste air, sludge, hydroxides, remainders, etc.). Please indicate if some material is reused (e.g. cooling water, closed loop rinse water, heat).
- Water consumption of the whole surface treatment area
- Energy consumption
- Main loads (energy): Equipment that generates high energy consumptions: Compressing of compressed air, boilers, furnaces, etc.)
- A description of the calendar of the company, including an estimation of the total of days worked in the 12 last months, amount of turns per day, days per week and hours per day.
- Supplementary questions like local restrictions etc.

3.1.2 Step 2: Calculation of the water and chemical-balance

There should be given an overview for water and chemical flows in order to find weak points where the big amount of losses and bad rinsing occur.

3.1.3 Step 3: Check for technical and chemical CP opportunities

What are the customer's problems and needs?

- Quality
- Quantity
- Industrial health and safety
- costs
- Damage to the environment
- Etc.

Are the existing processes and sequences adequate for the production of the customers articles?

Could a process be substituted by a better and less toxic one?

Is there another adequate and sounder technology?

Etc.

3.1.4 Step 4: Calculation of the optimal process- and rinse technique

There are special calculation models to calculate the concentrations in rinsing tanks to obtain an optimal balance between valuable dragged out chemicals and their drag back or reuse or optimal recycling.

The priorities are always:

- Avoid waste
- Reduce waste
- Reuse

3.1.5 Step 5: Create a realizable lay out

This lay out is representing the optimal case for adequate and sound technology. It should contain the lay out of the tanks and the treatment sequences in an optimal way to avoid inadequate operations and dripping of chemicals in other processes and infrastructure.

3.1.6 Step 6: Search for very reasonable infrastructure

Not the most modern equipment is always the best solution for a specific case. In Europe (especially Germany and Switzerland) there are used plating plants and equipment available. Some of them are in really good shape and can be bought at a reasonable price.

Applicability is more important than having a high-tech solution.

3.1.7 Step 7: Technology Transfer

Used plants and equipment can be rebuilt to an adequate process- and rinse technique and to the needs of the e.g. Vietnamese customer.

The plant and other infrastructure can be shipped to Vietnam, overhauled an assembled by Vietnamese personnel under the direction of qualified European personnel.

The customer must be assisted during the calculation, planning, organization, assembly, make-up, start-up and operation by an experienced plating engineer.

4 Current situation

4.1 Product quality and customer requirements

The customer mentioned following amounts of surface treated products:

• Ni-Cr on racks	30	Mio dm2
• Zn barrel	5	Mio dm2
• Electro polishing	0.5	Mio dm2

Compared with European standards the product quality is pretty low.

Grinded parts still show their grooved surface after plating. There are also hollows and scratches in the surface stemming from the production processes. These hollows are not well platable and therefore corrosion will occur after a short time.

Since the last expert visit to the company the rejected parts decreased from about 18 to 2%. The problems were bad Nickel and Chrome quality on motorbike parts.

After the CP seminar on metal plating hold by FHBB/Kistler engineering in 2003 the customer has implemented a triple counter current rinse cascade in the pre-treatment of his Nickel line and he could save about 30% of water.

Now there are still several quality problems, such as low penetration of Zinc into tubular pieces like socket wrenches.

Black passivated Zinc pieces show white parts and corrosion at low current density positions and at positions where two pieces are jointed. There are capillaries where chemicals are flowing out during the drying process.

Black passivated parts show after some weeks a change of black into a lighter colour.

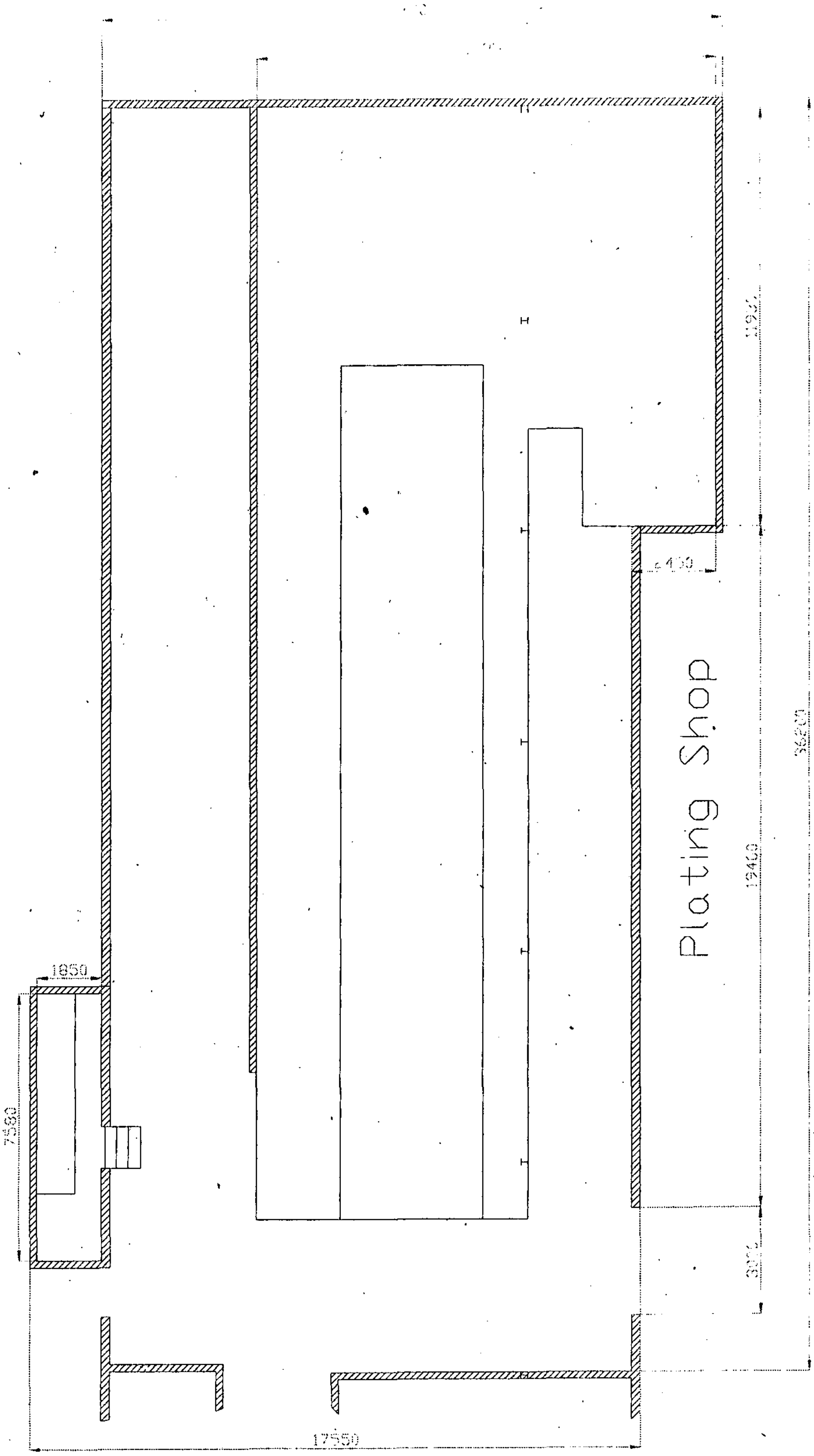
During the assessment different inexpedient activities and equipment were noticed and a need of correct information and know how was identified.

The employees are paid by piecework and not by quality. The consultant observed a low awareness of quality. E.g. the retention time for chrome plating is only about 10 seconds instead of 60 seconds or more.

4.2 Plating shop

The plating shop is a building constructed of steel, bricks and some wooden parts. All around there are places where air can circulate. Between the walls and the roof there are open spaces for ventilation. Only the pickling section is closed where only a small window is located. The floor is mostly paved with concrete. The condition of the building is low because of heavy corrosion of the steel girder. For the Ni-Cr plating line there is a steel crane runaway installed. This device is also heavily corroded.

Graph 1 Dimension of plating shop



4.2.1 Description of relevant processes

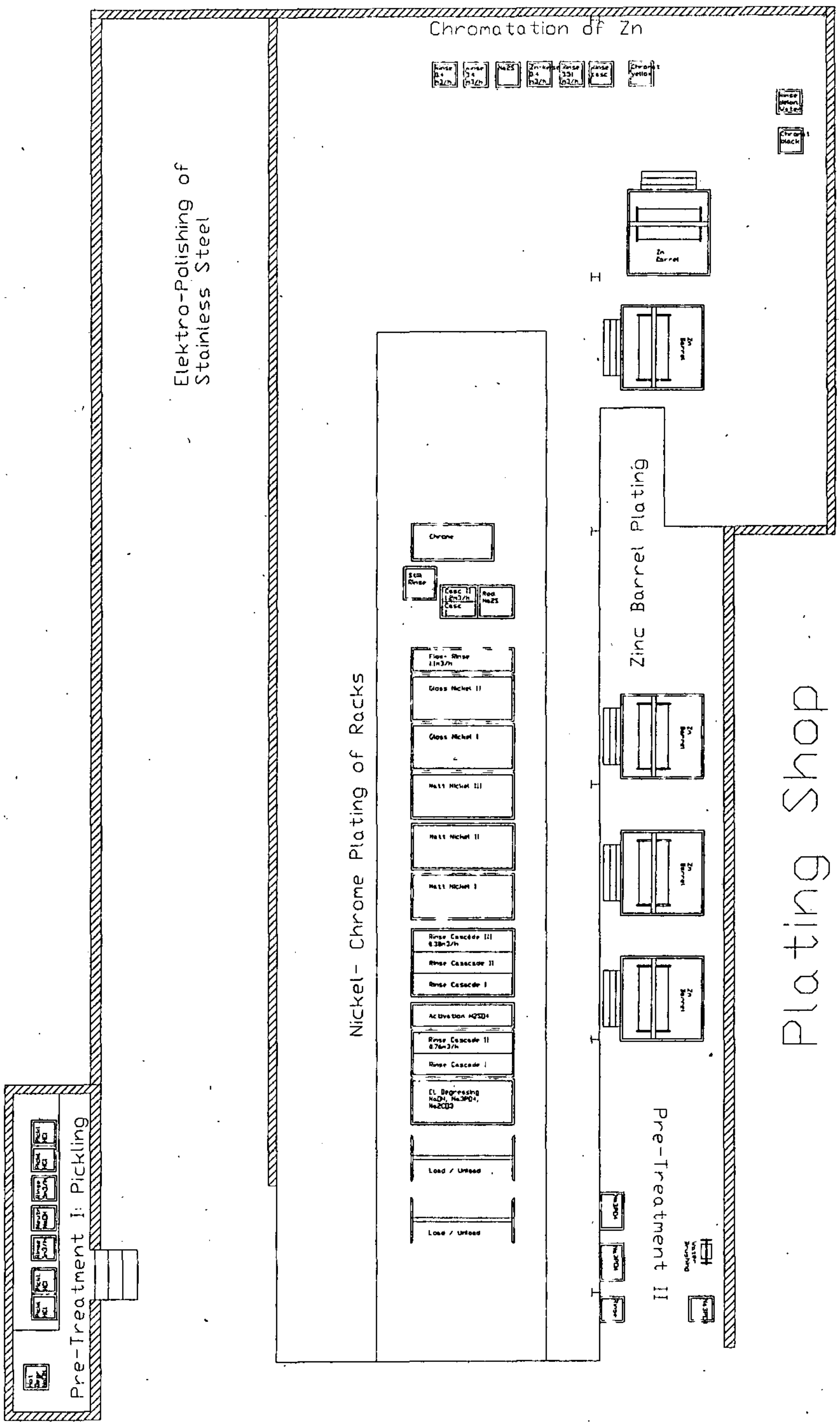
There are chemical and electrochemical surface treatments as follows:

- Acid Zinc Plating white (90%) yellow (5%) and black (5%) chromating of steel
- Nickel and Chrome plating (double Nickel layer: matt-Ni and gloss-Ni) of steel
- Electro polishing of stainless steel (Basket ware)

In this study the Ni-Cr- and the Zn-plating processes are considered.

Photo 1Main Ni-Cr plating line

4.2.1.1 Layout of plating shop



Pre-treatment I: Degreasing, Pickling

There is a separate pre-treatment room with NaOH hot soak cleaning and HCl-pickling.

All articles that will be plated is pre-treated in this room.

The dimension of the pre-treatment room is 7.5 x 18.5 m and has a small window.

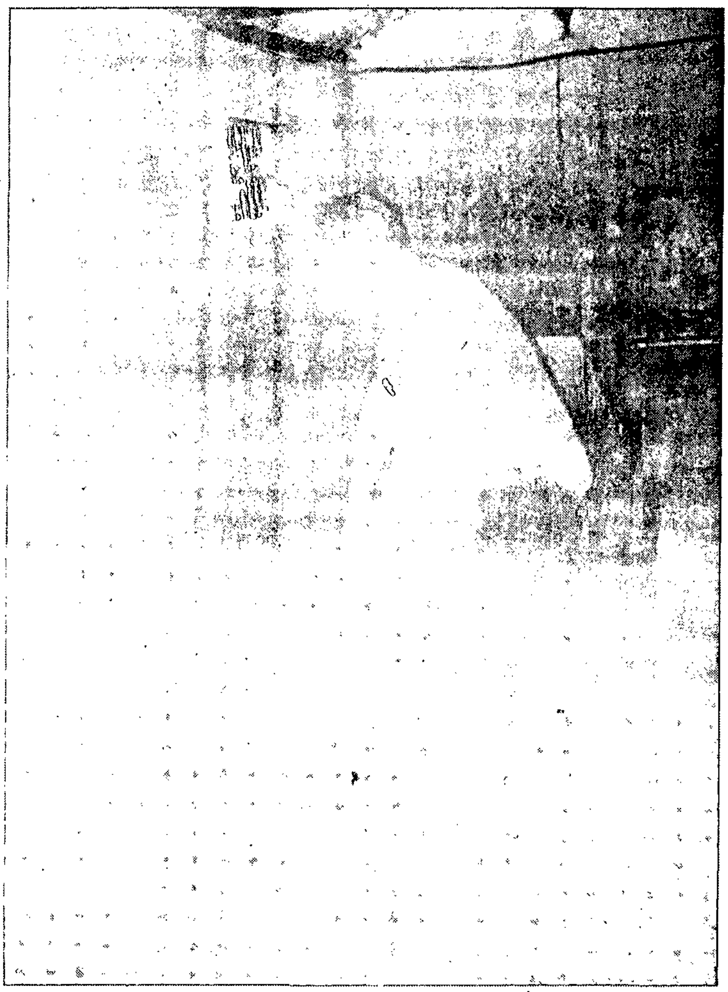
All the goods must be carried up 5 stairs to this room. In the longitudinal axis is a moat with about 70 cm depth where the tanks are put in. The upper part of the tanks are lower than the floor. The worker has to lift the heavy loads in self made plastic baskets down into the tanks and back out to the floor. The baskets are made of empty plastic containers of plating agents. Unfortunately there are only a few holes in the basket and therefore it takes a long time to drain correctly during lifting out. Thus there is a huge drag out. And each time a certain volume is also draining on the worker's feet who wears only sneakers and no protective cloths.

The tanks are placed below the floor and therefore there is a great danger to fall into the tanks.

Only the degreasing tank is located on his heater and the goods must be lifted in.

This room is full of vapours from the pickling acid and the worker doesn't wear goggles, gloves or aprons.

Photo 2 Degreasing and pickling



Pre-treatment II: Brushing with water, Na_3PO_4 intermediate storing

In this separate wet area beside of the rack loading of the Nickel plant there is a brushing device equipped with two rotating iron brushes and water feeding onto the pieces.

To avoid corrosion before plating, there are three Na_3PO_4 containing storage tanks and a rinse tank for pre-treated pieces.

The drained water is discharged into the domestic water channel outside of the building.

Photo 3 Brushing

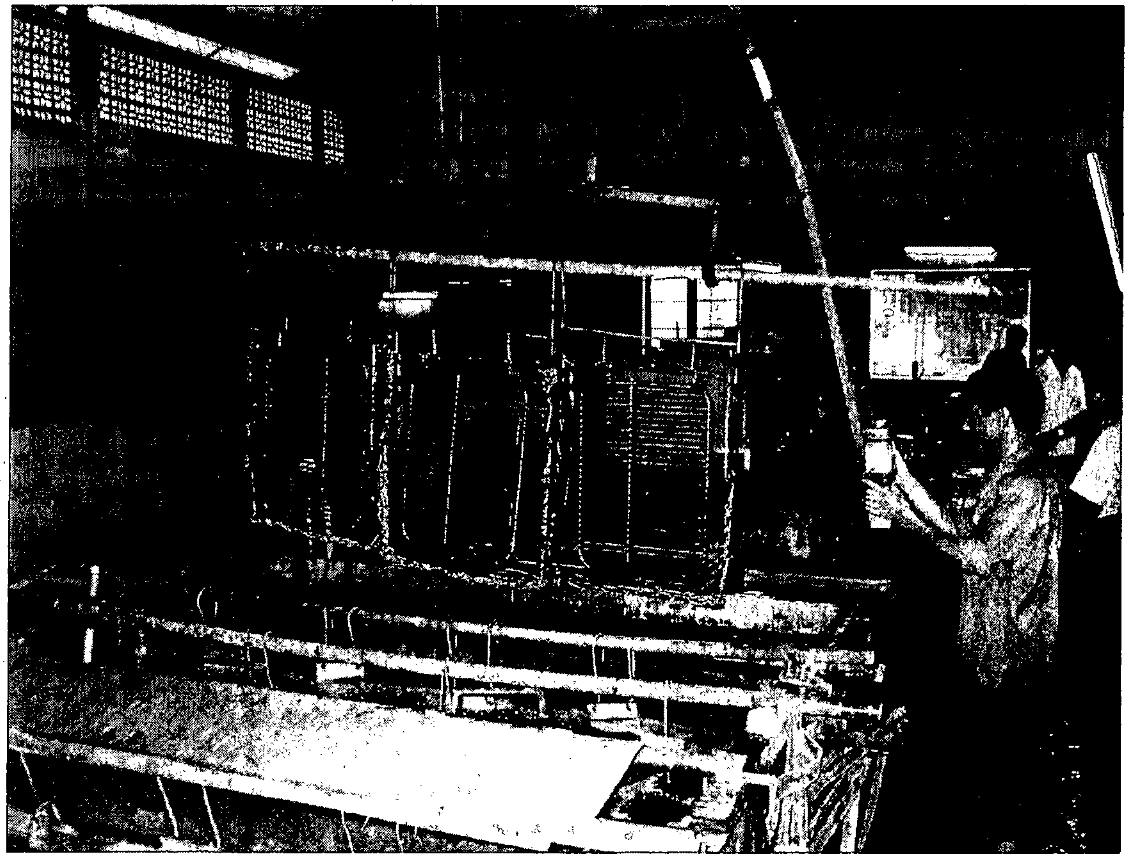
Nickel plating plant with subsequent hand loaded Chromium plating

There is a Nickel plating plant with hand controlled transportation device and subsequent Chrome bath, where most of the work pieces first are removed from the Nickel plating racks and being contacted by hand on Chrome plating racks.

This plating line is situated in a kind of dripping zone where liquids like rinse waters, dripping waters and process chemicals are collected and drained via collecting pipe out of the building. It's not certain if the whole amount of chemicals is discharged into the waste water treatment because there are several unknown pipes, directly leading into the water channel for domestic waters.

Around the tanks there are on several positions concentrated waste liquids that don't have a connection to the drain pipe. It is easily imaginable, that the ground is contaminated.

Photo 4 Nickel plating



Zinc plating area

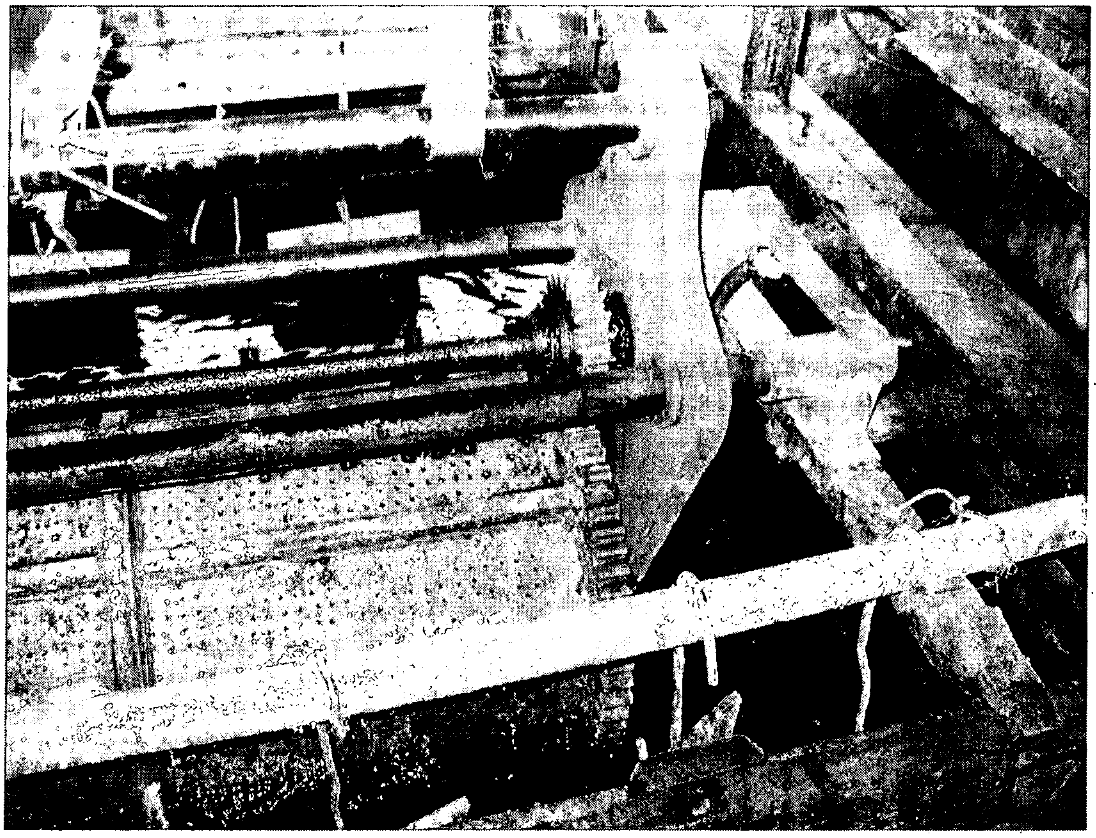
Alongside the Nickel plant are five Acid Zinc barrel plating tanks. These tanks are located on a higher level of approx. 1m than the Nickel line is.

There are no rinse tanks beside the plating tanks and all dragged out process chemicals are spilled on the way to the rinsing before chromating.

These waters are partially drained via Nickel area.

Between the plating tanks are the rectifiers for the Nickel, Chrome and Zinc allocated. three of them are air cooled.

Photo 5 Zinc plating barrel



Near the second last Zinc tank there is a rinse tank that is used as cooling device for two water cooled rectifiers. These rectifiers are equipped with pumps and water circuits. In this manner, the water always runs through the rectifiers and back to the rinse tank.

The amount of rinse water was varying during the visit. Estimated value: 500 l/h.

Chromatation area

At the back wall of the building and behind the Chrome bath are the Chromatation tanks located.

There are tanks for chromating and rinsing and beside there are a few smaller plastic cans containing black Chromatation liquids.

The Zinc plated pieces are brought by tumbrels and rinsed on this place.

The rinse waters a partly drained into the collecting pipe for Chromatation and into another pipe leading into the domestic water channel.

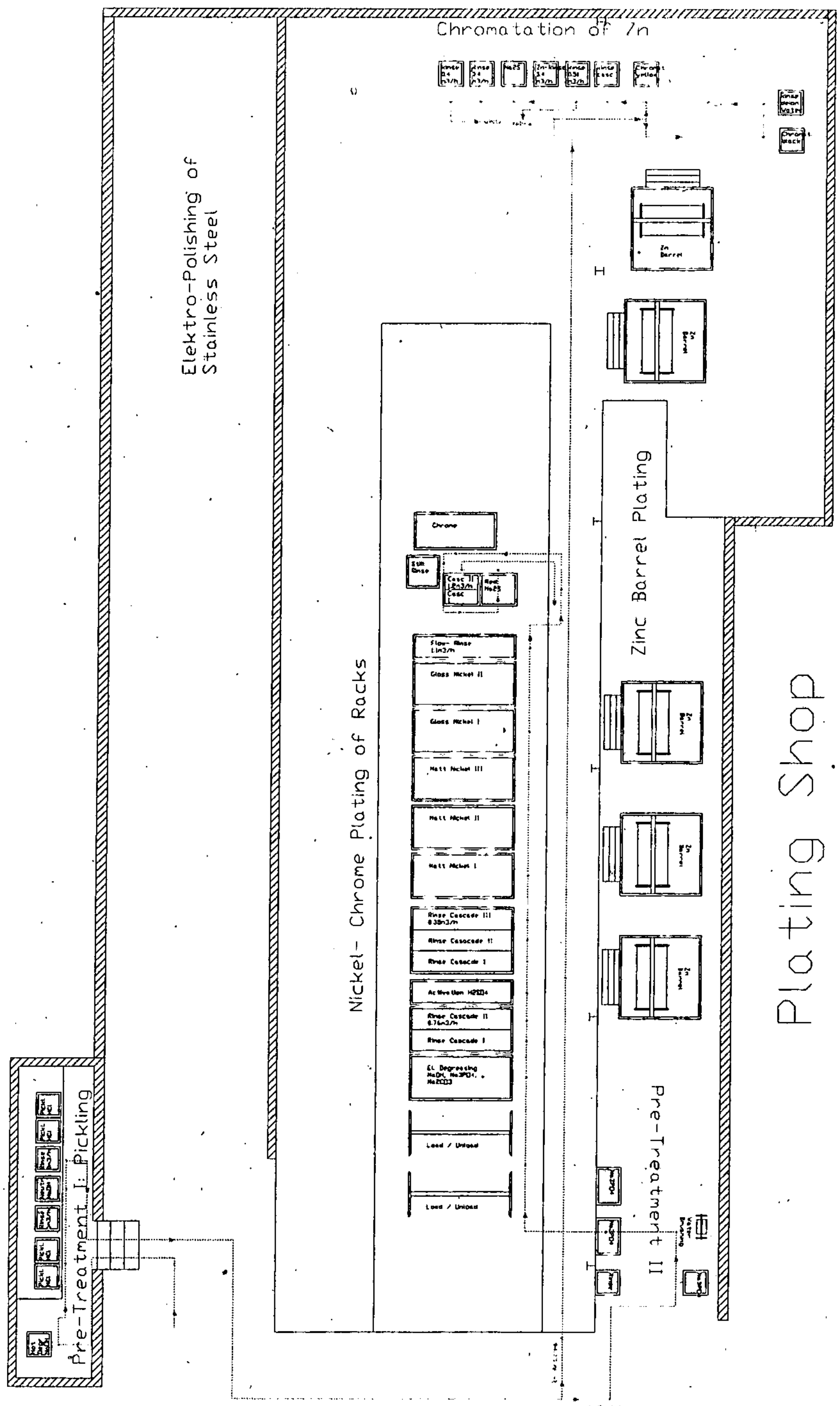
Photo 6 Chromatation

Electro-polishing area

The Electro-polishing 2500l 45°C (½ vol. H_2SO_4, ½ vol. H_3PO_4, 5g/l CrO_3) of stainless steel is located on the left side of the Nickel plant behind a wall. We will not specially consider this plating process in this project, because of low production and because it is a very different process that cannot be combined in the same plant as Nickel, Chromium, Zinc etc.

The waste waters (rinse and discharged process liquids) are drained via several pipes on one hand into a water spillway beside of the building and on the other hand into separate collecting tanks. These tanks are located below the waste water treatment building that is located behind the plating shop.

4.2.1.2 Sequences



Pre-treatment I: Degreasing, Pickling

Step 1: Hot NaOH Degreasing

180 l NaOH coal heated hot degreasing in a simple iron tank, 80-100°C

The concentration is unknown and maintained by manual NaOH adding according to the feelings of the worker.

Photo 7 NaOH-Degreasing

There is no make up and the solution is kept over the entire degreasing time the same.

Remarks:

Hot degreasing should be done in a correct degreasing tank, containing oil overflow device, continuous oil absorber etc. There are several degreasing chemicals available for adequate effects.

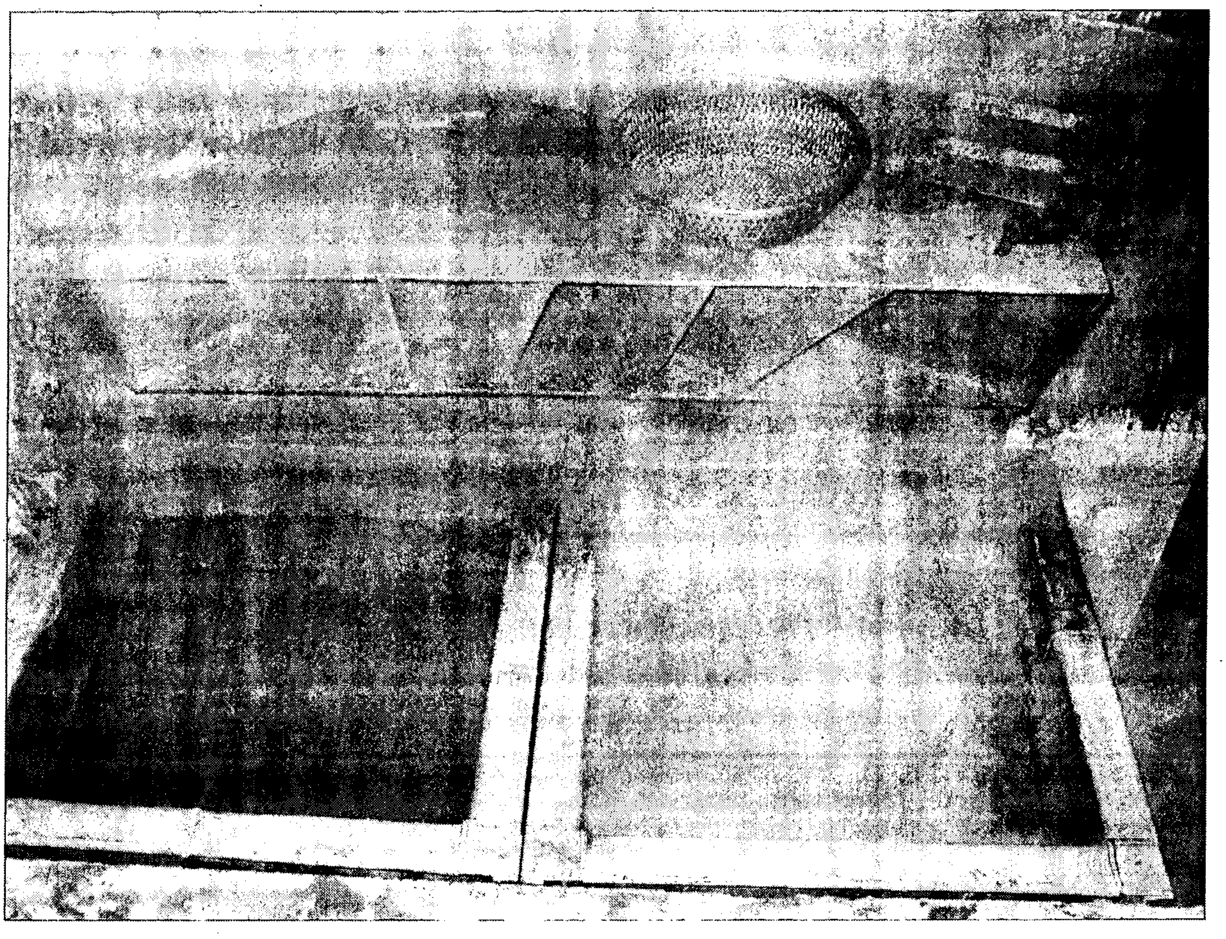
Otherwise, the oils will be dragged out by the work pieces into the following process steps where the product quality is minimized.

Step 2: HCl Pickling 2x 90 l, room temperature

Remarks:

Air suction device is out of order or inefficient working and there is a huge vapour that impacts environment and harms workers.

Photo 8 HCl-Pickling



Remarks:

HCl is a good pickling medium but very aggressive on metal (steel) constructions and devices and should be replaced by an adequate media like warm sulphuric acid or phosphoric acid etc. Inhibitors to avoid the attack of the bare metals are available.

Step 3: Flow- rinse 90 l

Flow rate: Approx. 1 m^3/h

Step 4: NaOH Neutralization 90 l, room temperature

Step 5: Flow- rinse 90 l

Flow rate: Valve closed at our visit

2nd HCl Pickling 2x 90l, room temperature

Air suction device, out of order or inefficiently working.

Pre-treatment II: Brushing with water, intermediate storing

This process is mainly used for pieces they are not clean enough for plating after pickling e.g. welded parts etc.

Pieces were brushed with water and then stored in the three tanks, containing a small concentration of Na_3PO_4.

Step 6: Flow-rinse 400 l

Flow rate: Valve open according to the need. Estimated amount of water: 800 l/h

Step 7: Brushing with water

Flow rate: Valve open according to the need. Estimated amount of water: 300 l/h.

Step 8: Na3PO4 intermediate storage

Room temperature, concentration unknown

Photo 9 Na3PO4 intermediate storage

After this step the pieces will not be rinsed. Now they will be contacted for Nickel- and Chrome plating:

Ni, Cr-plating

Step 9: El. Degreasing anodic, 2000 l, Pos. 1

Room temperature (29°C)

Exposition time: 5 minutes

El. current density: 5-7 A/dm^2 (value given from foreman. Practise showed, that no el. current is adjusted during the work)

Make up: (Information of the foreman)

NaOH	50 g/l
Na_3PO_4	40 g/l
Na_2CO_3	40 g/l

Remark:

The electrode-contacts and the wiring are heavily corroded and dirty. There are only cathodes in the middle of the tank. So there will be an insufficient current treatment.

Step 10: Flow-cascade rinse 2x500l, Pos. 2A, 2B

Flow rate: 760 l/h

Remark:

The used water is drained on the soil. No economic rinse used.

Step 11: Activation,1000 l, Pos. 3

Room temperature (29°C)

Exposition time: 30 sec. - 1 minute

Make up: (Information of the foreman)

H_2SO_4	5-10%

Remark:

The concentration is not controlled.

Step 12: Flow-cascade rinse 3x500 l, Pos. 4A, 4B, 4C

Flow rate: 380 l/h

Remark:

The used water is drained on the soil. This triple cascade could be very efficient after a process where a high amount of expensive chemicals are dragged out. The flow should be much less than now to allow a recovery of chemicals. This cascade is put after the process with the lowest and cheapest content of all processes. After the Nickel treatment it could be much more effective!

Step 13: 3x Matt Nickel, 2000 l, Pos. 5, 6, 7

Temperatures:

Suppliers' set point values (data-sheet on the wall): 45-50°C

Pos. 5: 37.3°C (measured by our team)

Pos. 6: 31.3°C (measured by our team)

Pos. 5: 37.4°C (measured by our team)

pH:

Suppliers' set point values (data-sheet on the wall): 4.2-4.8

Exposition time: 20 minutes (Information of the foreman)

El. Current density:

Suppliers' set point values (data-sheet on the wall): 4-5 A/dm^2

Make up: (Information of the foreman)

$NiCl_2*6H_2O$	40 g/l
H_3BO_3	50 g/l
$NiSO_4*7H_2O$	280 g/l
Tubor make up	10 ml/l
Tubor maintenance	30 ml/l

Remarks:

El. Current density, layer quality and thickness:

The El. Current density of 0.3-70.5A/dm^2 is usually much higher (e.g. 3-5 A/dm^2).
Example: Kick-starters on racks:

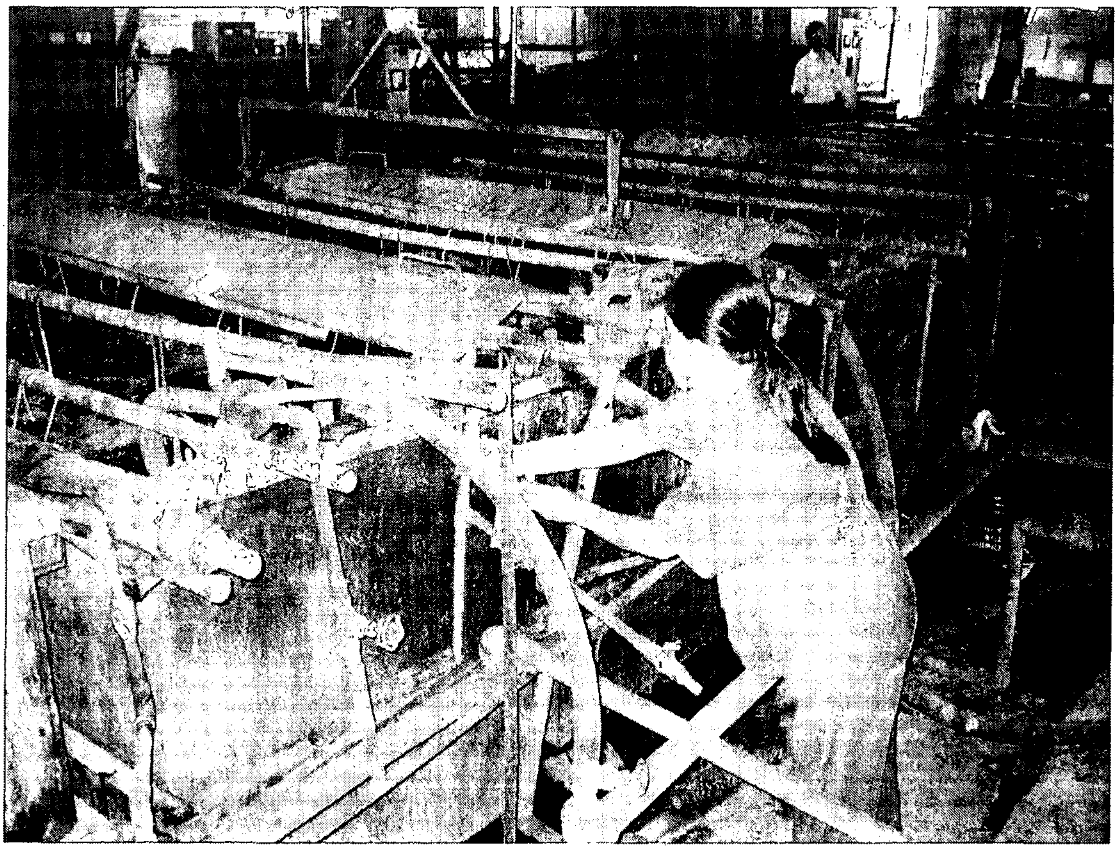
4 racks containing 18 pieces each = totally 72 pieces
Surface of 1 piece: 0.48 dm^2 → net 34.8 dm^2 / load
Surface of 4 non insulated racks = Approx. 30 dm^2 / load
Total surface = 65 dm^2 / load.
So the el. current should be in this case 200-320 A.

The assessment showed that the el. current was not adjusted or corrected for each load.

There was a Nickel load running by 18V, 800A and other currents were about 400A for different work pieces and areas.
So, the present current density is much higher than defined. It is evident to keep the el. current density in a very correct range to be able to produce a constant layer quality.

The electrode-contacts and the wiring are heavily corroded and dirty. The Nickel-anodes are contacted by very thin copper wires which is causing a high electrical resistance and therefore heating of the rods. These circumstances are rising the electricity costs. There should be much thicker electrical rods and wires to obtain a lower electrical resistance. The copper is continuously being dissolved in the nickel solution and will cause quality problems. The always changing electrical resistance is causing change of the electrical current and therefore different layer quality and layer thickness.

Photo 10 Matt Nickel plating



The anodes are not properly covered by anode-bags and therefore Nickel-grains will fall into the solution during the process. These metallic grains will be deposited on the surface of the work pieces and cause rough surfaces.

Filtration:

There should be a continuous and efficient filtration of the liquid, at least 6'000 l/h.

Temperature:

The process temperature of the three matt Nickel tanks is measured in a broad range from 31.3 - 37.3°C instead of 45-50°C. In Europe there are even higher temperatures of about

60°C used. The temperature is also one of the important factors for a correct and continuous layer quality and should be kept in a range of plus minus 1-2 °C.

Temperature-/Energy loss:

Heated tanks should be insulated to avoid loss of expensive energy and to save resources.

Surface-exchange of process liquid.

The load is hanging in the bath with practically no exchange of process liquid on the surface of the work pieces. Bad exchange causes low Nickel concentration in the liquid directly on the surface and therefore quality problems may appear. Possible solutions: cathode rod movement, stirrer, air injection, filtration etc.

Loss of process liquid:

There should be coverings between the Matt-Nickel-tanks to avoid dripping of liquid to the ground during transportation from tank to tank.

Step 14: 2x Gloss Nickel, 2000 l, Pos. 8, 9

Temperatures:

Suppliers' set point values (data-sheet on the wall): 45-50°C

Pos. 8: 50°C (measured by our team)

Pos. 9: 57.7°C (measured by our team)

pH:

Suppliers set point values (data-sheet on the wall): 4.2-4.8

Exposition time: 10 minutes (Information of the foreman)

El. Current density:

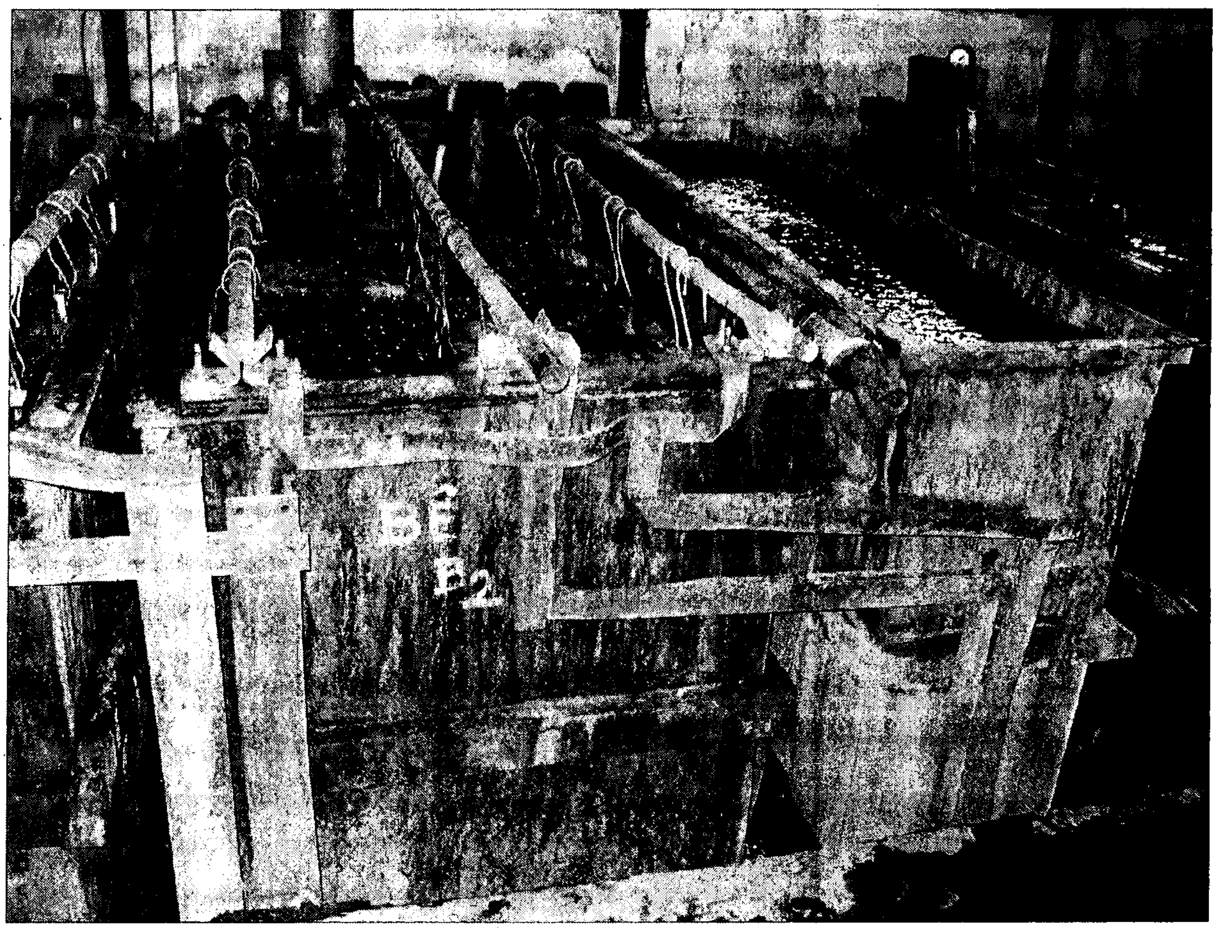
Suppliers set point values (data-sheet on the wall): 4-5 A/dm^2

Make up: (Information of the foreman)

$NiCl_2*6H_2O$	40 g/l
H_3BO_3	50 g/l
$NiSO_4*7H_2O$	280 g/l
Tubor make up	10 ml/l

Tubor maintenance 30 ml/l

Photo 11 Gloss Nickel plating



Remarks:

See Matt-Nickel plating.

Organic agents:

There were given the same values for the organic agents for Matt- and Gloss- Nickel. Usually Matt- Nickel has a much lower content than Gloss-Nickel. This should be checked.

Air injection vs. liquid injection:

In these tanks air injection is used for better exchange of liquid on the surface of the goods. Injected air into heated solutions is taking heat energy out. In Europe there are cheaper jet-injections by pumps instead of air injection used. It should be checked if this system could be used for this case.

Step 15: Flow rinse 1300l, Pos.10

Flow rate: 1100 l/h

Remark:

Lost Nickel chemicals:

The Nickel loads are directly rinsed in this water. There is no still- or cascade rinse. Therefore the whole dragged out valuable chemicals are lost.

Yearly amount for corrections of lost Nickel chemicals (Values from Company based on values from July- September 2004):

- $NiCl_2$, $NiSO_4$: US$ 30'000.00.
- Organic agents: US$ 17'000.00 (here there could be probably calculated a value of 50% that is lost, because a part of the consumption is used in the Nickel layer).

Thus there is an estimated yearly loss of US$ 38'000.00 on the Nickel rinsing.

All this valuable but toxic chemicals are drained into the waste water treatment or even into the river.

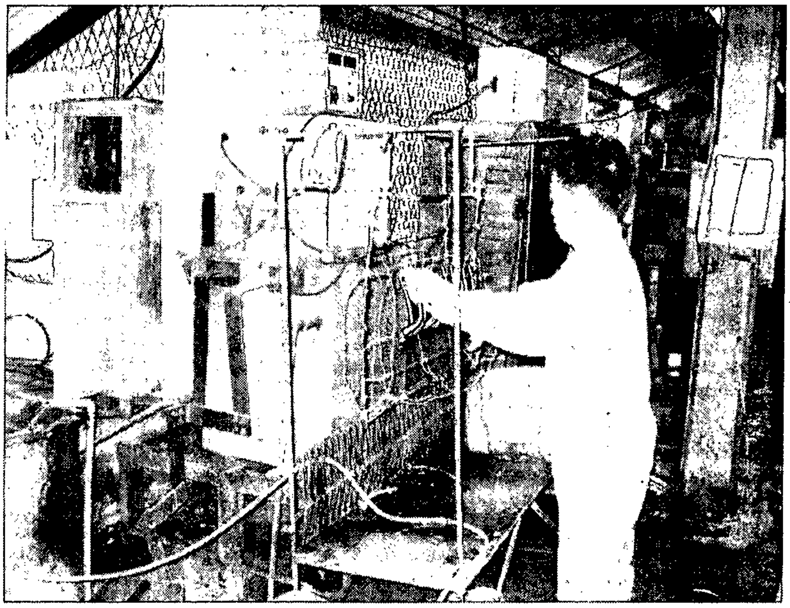
Between the Nickel tanks and this flow-rinse there should be at least a triple economic rinse cascade with an approx. flow rate of about 2-4 l/h. It is to be checked, if the concentrated rinse water can be used for the replenish of the Matt- Nickel tank because of accumulation of organic agents that will give the surface probably more gloss.

Step 16: Change to Chrome-Plating racks

Most of the Nickel plated pieces are removed from the Nickel racks and contacted to special Chrome plating racks.

This work is done be bare hands without any gloves that protect people and work pieces from contamination.

Photo 12 Chrome plating racks



Remark:

Low Chrome quality because of low plating rack quality:

The Nickel surface of the work pieces can become dirty, dry and passive so that the quality of the following chromium will be low.

Usually in such plating systems the work pieces are contacted on the same racks through the whole plating processes including Chrome plating.

The racks shall correctly be dimensioned so that the electric conductivity is fair (e.g. for copper there should be less than $1A/mm^2$). Otherwise the resistance in the rack is too high on different positions and the work pieces are not regularly plated.

The plating racks shall be insulated by an adequate plastic layer to avoid wasteful metal deposits on it. The contacts to the work pieces could be made of stainless steel in springing manner so that there is a flexible and strong contacting.

The racks can be demetallised in adequate strippers, one stripper for Chrome and the other stripper for Nickel.

Such constructed and treated racks are not cheap to construct but they will easily be used for a long time.

Step 17: Chrome plating, 1800 l, Pos. 10

Temperature:

Suppliers' set point value (data-sheet on the wall): 40°C

Pos. 10: 35.5°C (measured by our team)

Exposition time:

Suppliers set point value (data-sheet on the wall) and Information of the foreman: 1-2 minutes

Pos. 10: Approx. 10 seconds (measured by our team)

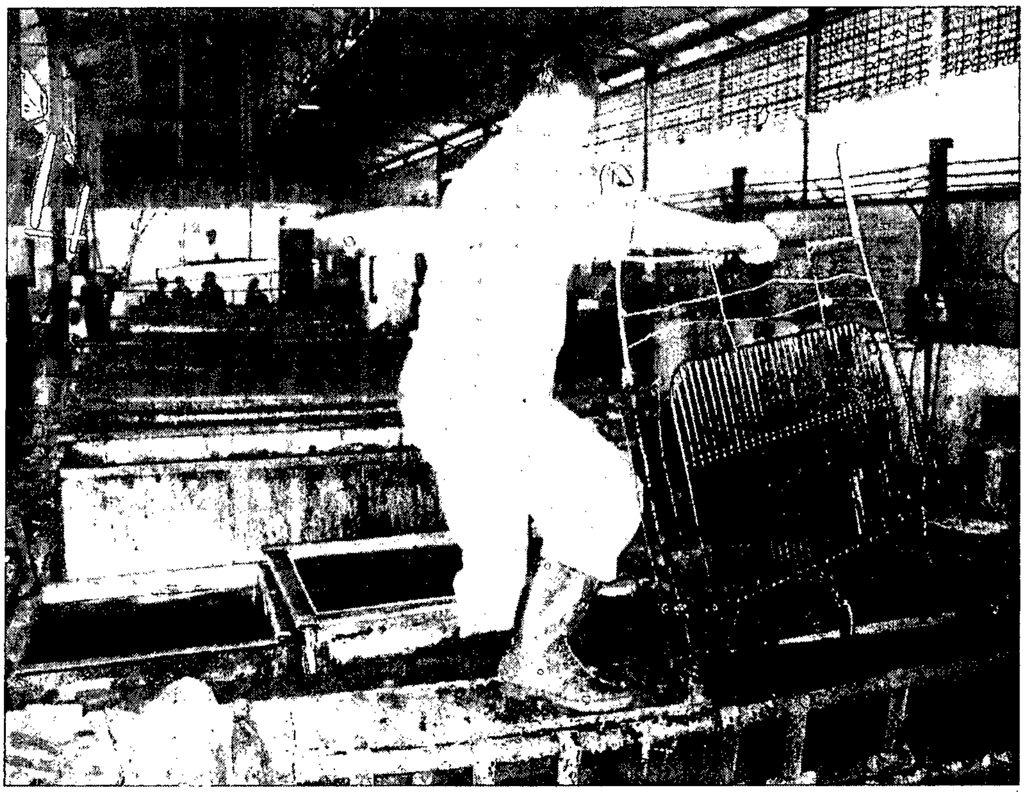
El. Current density:

Suppliers set point values (data-sheet on the wall): 15-20 A/dm^2

Make up: Suppliers set point value (data-sheet on the wall) and Information of the foreman

CrO_3	280 g/l
H_2SO_4	1%

Photo 13 Chrome plating



Remarks:

Too short process time:

There is a big difference between 10 seconds and 60-120 seconds of plating time in Chromium. With short time the layer thickness is very low and therefore the quality bad.

Chromium Plating: Variation of current density during process:

Usually decorative Chrome plating is being executed by a special proceeding of current densities in a sequence:

- There is a start time of several seconds by using the basis current density to activate the surface and to start the deposit.
- Then there is a high density time over some seconds by using about the double current density to activate the lower current density parts.
- And finally there is the remaining plating time by basis current.

In this manner the layer will cover a larger surface area and have a better quality.

Process temperature:

It's evident to keep the correct plating temperature to obtain the appropriate Chrome quality.

Step 18: Economic rinse 400 l

Flow rate: 0 l/h

Remark:

Low recovery

This tank is used for recovery of dragged out chemicals. The evaporation loss is replenished by this liquid. But the concentration is from experience quite low because the next rinse is already a flow rinse.

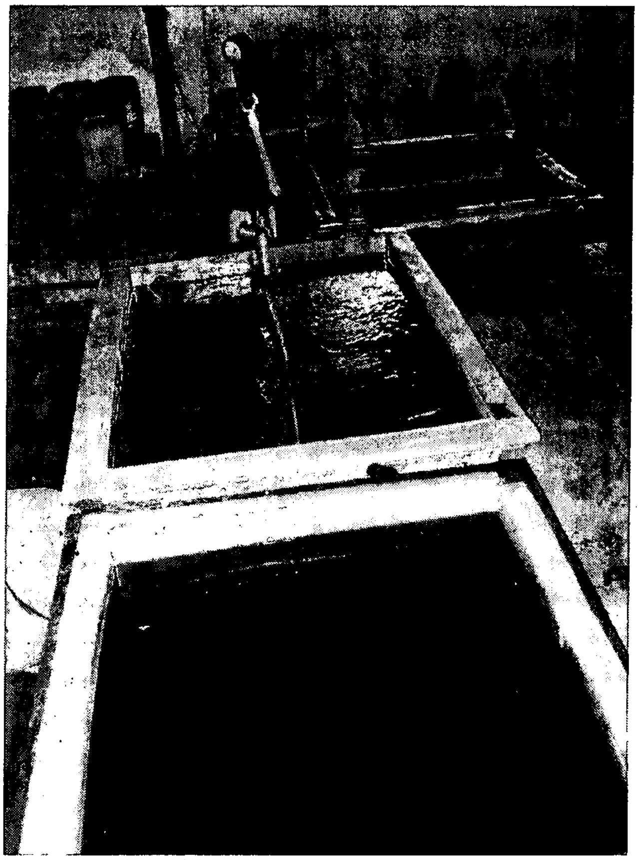
Ergonomic situation and danger

Between the three rinse tanks is a high wooden platform that has a level only about 10cm below the tank boards. The worker has to climb with the racks on this platform and has to put the racks very deep into the rinse tanks.

It's quite dangerous to fall into the tanks.

Upper boards of tanks should be 90-95 cm above the floor to get optimal ergonomic and safe working conditions.

Photo 14 Economic rinse



Step 19: Flow rinse cascade 2x400 l

Flow rate: 1'200 l/h

Remark:

The racks are rinsed only in the second, more concentrated position.

Step 20: Reduction rinse "Na_2S" 400 l

Make up:

Not known for the moment. But not important for this assessment.

Temperature:

Room temperature

Exposition time:

2-4 seconds

Remark:

In this position the contamination of Chromium VI+ ions on work pieces and racks is reduced into the much less toxic III+ form.

Step 21: Flow rinse cascade 2x400 l (same tank as on Step 19)

Remark:

The racks are rinsed only in the first, less concentrated position.

Step 22: Hot air dryer

Remark:

There is a new drying cabinet for racks. That seems to be the correct solution.

Zn-plating

The work pieces for Zink plating are also pre-treated as shown for the rack plating.

Step 1: Loading

The loads are assembled according to the weight.

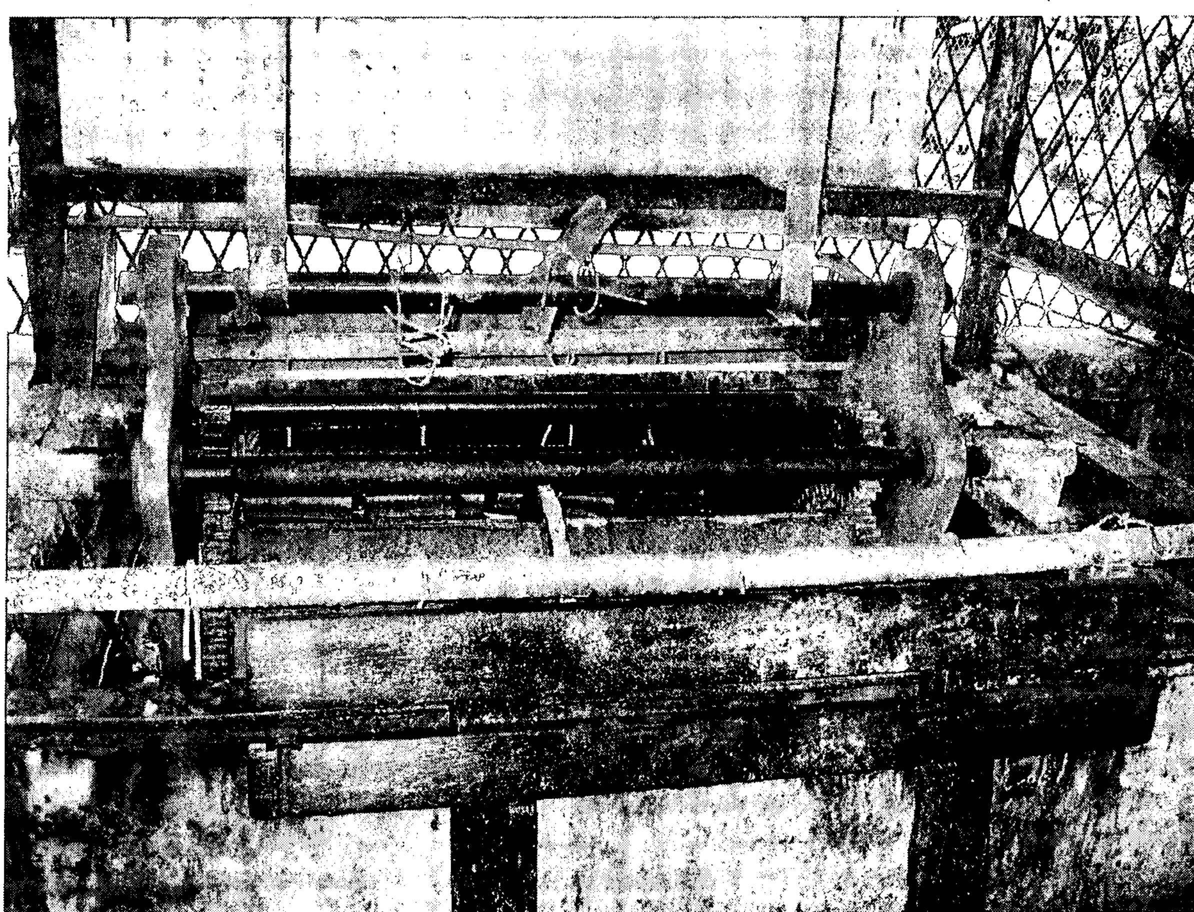
Remark:

The racks are rinsed only in the first, less concentrated position.

Step 2: Zinc-plating, 1600l, (5 similar plating tanks)

These tanks are equipped with motorized turning barrels. The barrels can be lifted up for loading and unloading by a belt lifting device.

Photo 15 Zinc plating



Temperature:

Suppliers set point value (data-sheet on the wall): 30-45°C.

The optimal temperature will be at 30-35°C.

The temperature is not checked or controlled during production time.

Exposition time:

Supplier's set point value (data-sheet on the wall): 50-60 minutes

Information of the foreman:
Common pieces: 40-50 minutes (8 µm)
Long socket wrenches: 50-60 minutes (18 µm)
Remark: These values should be checked.

El. Current density:

Suppliers set point values (data-sheet on the wall): 0.8-1.5 A/dm^2
Information of the foreman: 0.2 A/dm^2
The electric current settings are made from experience and not calculated.

Remark: These values should be checked.

Make up:

Suppliers set point value (data-sheet on the wall) and Information of the foreman

NH_4Cl	280-300 g/l	
$ZnCl_2$	70 g/l	
H_3BO_3	30 g/l	
$C_6H_8O_7$	50-70 g/l	(Acid citric. Used since 1 month instead of Acid boric)
AZA	10 ml/l	
AZB	3 ml/l	

pH:

Suppliers set point values (data-sheet on the wall): Missing

Check daily twice before each working shift.

Analysis of content:

Once per week there is a titration analysis of $ZnCl_2$ done and the corrections are made according to the need.

Remarks:

Unusual weekly bath cleanings:

Each plating tank is weekly emptied into a separate tank and there the liquid is filtrated during cleaning the tank bottom, where a sludge deposit of 5-10 cm is found. This sludge is coming from different sources like lost pieces etc.
From experts experience a Zinc bath can be used at least ½ year until such a cleaning is necessary. A correct and careful handling during charging the barrels is evident. Lost pieces must be removed from the tank as soon as possible to avoid concentration of dissolved iron and other foreign substances.

Dosing of organic agents:

The dosing is effectuated according to the personnel's feeling. When the articles seem to be less shiny there is poured in about 10 litres of agents. There are no current counters and dosing devices. In this manner, the product quality has a huge range. The consumption of expensive agents is higher than with smaller dosing steps in shorter time. To be able to maintain a correct and most regular gloss, there has to be used a dosing manner according to the Zinc deposit which is represented by the amount of Ampere-hours.

Electric conduction and contacts:

As already mentioned on the other processes, correct dimensioned, equipped and clean contacts for anodes and cathodes are evident for an adequate result.

Temperature and quality:

The temperature is rising during the process because of the Ohm law. Different temperatures cause different layer quality. Cooling of processes is always expensive and should be substituted, if possible. In Europe there are warm operated processes available, where no cooling is needed.

Variation: Heated Zinc plating:

Heated processes have a big advantage: Evaporation allows a recovery of dragged out chemicals.

In this case there could be yearly saved: (values from company based on production period July- September 2004):

- $ZnCl_2$, NH_4Cl: US$ 2'600.00.
- Organic agents: US$ 65'000.00 (here an estimated value of 50% is lost, because one part of the consumption is used in the Zinc layer. Thus there is an estimated yearly loss of US$ 35'000.00 on the Zinc rinsing.

Ergonomics

The tanks are placed on the plain floor and the workers have to lift the loads up to the barrel over three steps. Usually higher plating tanks are placed at lower parts of the floor and there are gratings around the tanks to get a level of the upper tank parts of about 90-95cm above the grating. This size guarantees an optimal ergonomic and save handling.

Step 3: Unloading and carrying to passivation place

The plated loads are drained into wide metal sheet baskets and brought by tumbrels to the passivation place. There the whole load of work pieces is being poured onto the ground near to the Chromatation tanks.

Remark:

The whole drag out of Zinc chemicals is lost on the ground over the distance of 5 until 25m and finally drained via the existing discharging paipes into the environment. An economic rinse could help to drag back at least a part of the chemicals.

Step 4: Rinsing

The pieces are rinsed by spraying water from the nearest Chromatation rinse on the goods that are laying on the ground.

Remark:

The pieces are not moved during this process and the rinse effect is supposedly quite low. The used water is draining the same way as other chemicals from this place (without proper treatment). There will be a certain contamination of the Zinc layer of the work pieces and a quality problems are expected.

Rinsing should be done in a rinse tank by fair water quality and water exchange.

Step 5: Charging for Chromatation

The pieces are now put by shovels into smaller basket loads for Chromatation.

Remark:

This kind of treatment is scratching the surface of the pieces. It should be avoided and replaced by another manner.

Step 6: Yellow (pre-) Chromatation, 180 l

This step is also done for the white Chromatation. The difference is that the load is afterwards treated in a Na_2S solution to reduce the Cr VI+ content into a Cr III+.

Temperature:

Suppliers set point value (data-sheet on the wall): Room temperature.

Exposition time:

Suppliers' set point value (data-sheet on the wall): 5-10 seconds

Make up:

Supplier's set point value (data-sheet on the wall) and information of the foreman:

CrO_3	250 g/l
H_2SO_4	30 ml/l
H_3BO_3	30 g/l
HNO_3	40 ml/l

Analysis of content:

There is no analytical check.

Remark:

Corrosion protection and visual aspects are dependent on the chemical composition of the process liquid. We recommend analysing the values and maintaining the values in a certain range.

There are known methods available for correct analysis of such Chromatations..

Step 7: Flow rinse cascade 2x180 l

Flow rate: 510 l/h

Only for white Chromatation:

Step 8: Na_2S solution, 180 l

This step is only done for the white Chromatation. The load is treated in a Na2S solution to reduce the Cr +VI content into a Cr +III. The surface is changing from yellow into white.

Temperature:

Suppliers set point value (data-sheet on the wall): Room temperature.

Exposition time:

Supplier's set point value (data-sheet on the wall): 1-10 seconds

Make up:

Supplier's set point value (data-sheet on the wall) and Information of the foreman:

Na_2S	20 g/l

Analysis of content:

There is no analytical check.

Remark:

Corrosion protection and visual aspects are dependent on the chemical composition of the process liquid. We recommend analysing the values and maintaining the values in a certain range.

There are known methods available for correct analysis of such Chromatations.

Step 9: Flow rinse I 180 l

Flow rate: 400 l/h

Step 9: Flow rinse II 180 l

Flow rate: 400 l/h

Step 10: Hot air dryer I+II

There are two cubic dryers made of steel with a cover and wholes in the bottom. Air is blown by a ventilator through an electrical heated pipe into the dryer.

Remark:

Energy loss

The ventilators are quite strong and most of the heat energy is blown through the dryer cabinet unused.

Product quality

Fresh chromated layers are temperature sensitive. Applying a too high temperature will change colour and reduce the corrosion protection property. The correct maximal temperature should not exceed about 60°C.

We recommend the use of heated and heat regulated centrifuges. This equipment uses much less energy because the water is mechanically removed. The surface remains clean because possible impurities of the rinse waters are removed together with the water.

Only for Black Chromatation:

Step 5: Charging for Black Chromatation

The pieces are now put on small racks to be chromated.

Remark:

This kind of treatment is correct because freshly black passivated layers a very delicate and can easily bee scratched and damaged.

Step 6: Black Chromating, 20 l

This step is done in small blue containers with ready to use liquid. During the audit in an example the process was demonstrated as no workpieces were available.

Step 7: Clean water rinse

There is special deionised water used for rinsing.

Remark:

Black Chromatations are quite delicate to handle and to maintain.

The customer showed some problematic pieces and we already gave him some hints to probably reduce these problems.

In this case, there is a low amount of pieces to treat and one should consider getting first more information about the applied processes.

In any case, for black Chromatation there are very exact and clean pre-processes needed and we urgently recommend realizing first the above mentioned items.

4.2.1.3 Compliance with process parameters

Electrical contacting and wiring

Rectifiers should be connected by sufficient copper wiring or by copper rods until to the anodes and to the work pieces. Otherwise there will be too high electrical resistance and therefore an expensive heating of the circuit. The dimensioning is dependent on the wire length. All contacts must be free of contaminations and oxides to guarantee a correct result. See also comments at the mentioned processes.

Temperature

Process temperatures are a factor for the determination of the process quality and of the layer properties like crystal structure, hardness, ductility, corrosion resistance etc.

The temperature shall be maintained in a small range, dependent on the kind of the process (e.g. plus minus 2K).

Dwell time

Process time is the factor of the correct process efficiency or layer thickness and must be executed in a range of 1-5% according to the need of quality. As shown on Chrome plating there are broad differences.

Dripping off time

On several positions the load is lifted out from the bath and put immediately into the next step without any dripping phase. Correct dripping off causes a much lower drag out up to 50% including chemicals. The waste water treatment will therefore be cheaper.

Electric current density

Electric current density in plating processes is the main parameter for correct layer quality. It should be maintained correctly for each load. Therefore the correct plating current is to be carefully calculated and put according to the amount of the surface area of each load. Wrong current density is causing irregular layer quality and layer growth. By maintaining constant current density the layer thickness can easily be calculated in advance by determining the dwell time.

Composition of chemicals, auxiliaries and pH-adjustment

The compositions of chemicals and the auxiliaries are to be kept in a defined range. In most cases this range is given by the supplier of the process. To evaluate the existing value correct analysis has to be carried out.

Example: Zinc bath analysis. There are only one weekly $ZnCl_2$ analysis and two pH measurements daily.

The used process liquid is containing:

- Zinc
- Chlorides
- Ammonium
- Citric acid
- pH

For each of these values there are certain limits to be considered. Therefore, adequate analysis is necessary to be able to know and maintain the correct values. The supplier of the processes should be able to assist one in finding the adequate analytical process.

In general, for a correct treatment quality, the used parameter of each process step should be known and kept in correct limits, such as degreasing, pickling, el. degreasing etc.

Impurities

As shown in Nickel-plating the process liquids are to be kept very clean. Foreign metals may be part of the plated layer reducing the desired quality. Problems are: Too hard layer, low ductility, bad adhesion strength, wrong colour etc.

It should also be looked for an adequate quality of the used product for make up and replenishing, especially on plating processes.

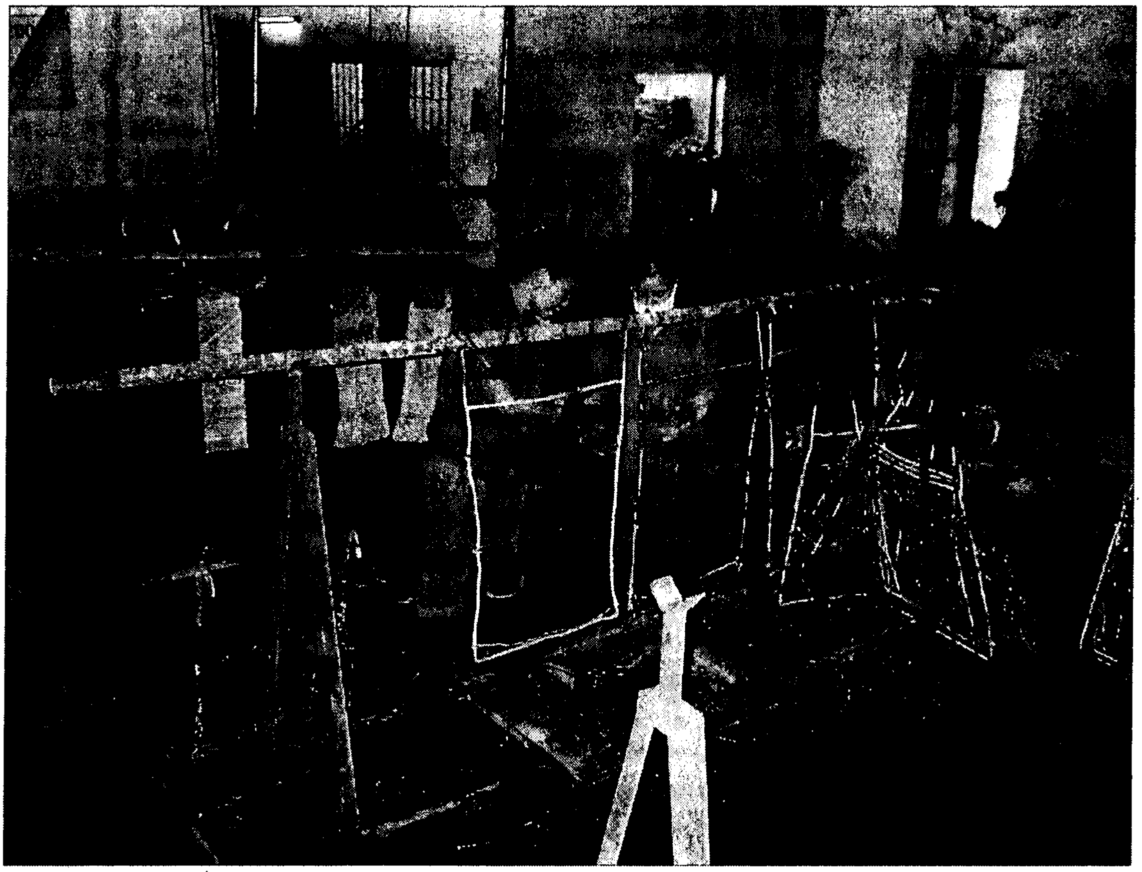
Construction of racks and arrangement of electrodes

As shown, racks should be constructed in a solid manner for having a correct electrical conductivity to allow a most regular layer thickness on the whole load.

Racks shell be insulated to avoid expensive loss of metals, energy etc.

A good electrical contact and a correct dimensioned cable or rod diameter on the whole electrical current circuit is evident for low energy consumption and correct layer quality.

Photo 16 Construction of racks



To obtain a most regular layer thickness over the whole load the work pieces on the racks should have very regular distances between each other. The load shall be placed over the whole tank length and height. There should only be about 10 cm distance between the last piece and the sidewall. The top of upper pieces shall be placed about 3-5 cm below the process liquid level and the lowest piece about 15 cm above the tank bottom.

The anodes must end about 15 cm above the lowest piece to avoid too high electrical current lines at the bottom. Also the anodes shall be well contacted by correct anode hooks or baskets of Titanium or stainless steel according to the used process.

4.2.1.4 Monitoring of process parameters

All checked parameters and their limits like temperature, analytical contents, pH and their corrections should be monitored in reasonable intervals and listed preferably on a computer. This is a pre-condition to be able to keep all parameters in adequate ranges. The tracing of the reason for bad quality would then be much easier.

The intervals of the analysis depend on how often the analysed value is above the limits. If values are in correct limits for a longer time there are fewer tests to do.

4.2.1.5 Working manner

Electroplating is done in a lot of different process steps according to the needed result. Each step has its own parameters and must be executed in the correct manner. Also rinsing is an important step and must be executed carefully.

Each step needs specific and clean working manner to obtain adequate quality. If a bad rinsed piece is getting in to a plating process like Nickel, the surface is not able to have a correct deposit with good adhesion strength. At the moment of dipping it into the process liquid on the surface of the piece there will be other chemical processes that reduce the desired quality.

Workers are paid by pieces and therefore they want to produce as many as possible. Process times are shortened and there is bad rinsing and dripping off. We recommend finding other solutions to instruct and motivate the workers for an efficient correct working manner.

4.2.2 Detailed inventory of relevant chemicals and water

4.2.2.1 Inventory of chemicals

Following table was handed over by the company. Raw material consumption is listed for the period between July and September 2004:

No	Item	Costs VND/unit	Quantity July – September	Total VND/ 3 months	Total US$/ 3 months	Purpose
	Anodes					
1	Ni	250’000	1883	470’750’000	30’000	Ni
2	Zn	25’000	3011.6	75’290’000	4’800	Zn
3	Copper wires	61’000	41.45	2’528’500	161	Contacting
	Total			548’568’500	35’000	

No	Item	Costs VND/unit	Quantity July – September	Total VND/ 3 months	Total US$/ 3 months	Purpose
	Chemicals					
1	Nitric Acid, HNO3	5'640	245	1'382'500	88	Zn chromat
2	HCl	1'670	21'042	35'163'100	2'240	Pickling
3	H2SO4	2'500	1'560	3'900'000	248	El.-Pol. + Ni-Activ Pos. 3
4	H3BO3	14'000	50	700'000	45	Nickel Pos. 5-9
5	H3PO4	16'190	525	8'498'900	541	El.-Pol. Stainless Steel
6	H2CrO3	28'200	2'300	64'871'400	4'130	Chrome
7	H2O2	6'300	30	189'000	12	Ni
8	BaCO3	6'000	100	600'000	38	Zn- Chromat. + Chrome
9	ZnCl2	18'000	100	1'800'000	114	Zn
10	Na2CO3	3'600	120	432'000	28	El. Degreasing Pos. 1
11	NaNO2	5'740	150	860'300	55	Blackening of Steel
12	NaNO3	5'610	100	561'400	36	"
13	Na3PO4	6'000	150	899'900	57	El. Degreasing Pos. 1
14	Na2S	15'480	425	6'579'300	419	Cr- Rinse
15	NaOH	5'800	1'220	7'079'700	450	Hot Degreasing + El. Deg. Pos. 1
16	Na2SiO3	3'400	2'400	8'160'000	519	Polishing
17	NiCl2	60'250	725	43'681'300	2'780	Ni
18	NiSO4	57'240	1'200	68'686'900	4'370	Ni
19	NH4Cl2	5'320	1'500	7'980'000	508	Zn
25	Polishing	8'040	2'100	16'874'700	1'070	Polishing

No	Item	Costs VND/unit	Quantity July – September	Total VND/ 3 months	Total US$/ 3 months	Purpose
	sand					
26	Polishing gel	25'000	1'550	38'749'900	2'470	Polishing
27	Agent AZA Zinc	54'500	1'875	102'187'300	6'500	Zn
28	Agent AZB Zinc	68'600	2'100	144'060'100	9'180	Zn
29	Agent Tubsmaiter Ni	96'400	425	40'970'100	2'610	Ni
30	Agent TuborMakeup Ni	92'000	250	23'000'000	1'460	Ni
31	Methanol	9'460	1'630	15'419'800	982	Not defined
32	Agent 775 Ni	69'000	80	5'520'000	351	Gloss Ni
33	Agent 776 Ni	136'000	80	10'880'000	692	Gloss Ni
34	Acetylene C2H2	57'150	30	1'714'400	109	External
36	Udifin 990	106'900	150	16'034'400	1'021	Ni
37	Udifin 999	154'300	175	27'001'900	1'720	Ni
38	Citric Acid C6H5O7	16'310	350	5'709'900	364	Zn
39	NaHPO4	38'000	20	760'000	48	Zn
40	Na2S2O5	13'000	300	3'900'000	248	Waste water treatment
41	BaCl2	5'800	100	580'000	37	External use
42	NaCl (PA)	1'200	300	360'000	23	Matt Ni
	Sum 2			715'748'200	45'600	
	Surface dm2	Cr	Zn	El. Pol.		
	July 04	263'100	467'300	39'200	2'000	
	August 04	220'450	399'500	21'023	3'300	
	September 04	276'049	385'027	24'700	2'400	
	Total surface area	**759'599**	**1'251'827**	**84'923**	**7'700**	

No	Item	Costs VND/unit	Quantity July – September	Total VND/ 3 months	Total US$/ 3 months	Purpose
	kW Energy				**143'860**	
	July				48'000	
	August				46'700	
	September				49'160	
	Chromatation	White	Yellow	Black		
	Surface %	90	5	5		

Legend:

7: To remove organics from Ni- Solution

8: Cr→ $BaSO_4$

11: Not considered in this Assessment

36: Removal of organics from Nickel-Solution

37: Removal of iron from Nickel-Solution

39: Removal of iron from Zinc-Solution

4.2.2.2 Evaluation of current consumption figures

- *Lost Nickel chemicals (as mentioned):*

  yearly loss of US$ 38'000.00 on the Nickel rinsing.
- *Lost Zinc chemicals (as mentioned):*

  yearly loss of US$ 35'000.00 on the Zinc rinsing.

Other consumptions like chemicals for bath purifications can also be reduced by applying adequate working manner.

Example:

- *Udifin Agents: US$ 6'000.00 yearly*
- *Chrome: Estimated yearly loss of US$ 12'000.00 with Chrome rinsing.*
- *Pickling: Estimated yearly loss of US$ 5'000.00 with rinsing.*

Total estimated possible savings with application of adequate rinse technique and replacement of processes: US$ 96'000.00 yearly.

Total consumption cost of chemicals for the mentioned treatments is about US$ 160'000.00 yearly.

4.2.3 Stock keeping

4.2.3.1 Amount, location and type of stored chemicals

The plating chemicals are stored in wooden storage rooms together with other products for the production. Some chemicals, like sulphuric acid are stored outside of the storage room, where the workers pass. These containers are stored freely accessible.

There were woven plastic bags on wooden pallets and on boards and liquids in plastic containers. During the audit the room was quite full of different items.

Some identified items in the same storage area:

- Nickel sulphate bags
- Agent AZA in Containers
- $BaCO_3$ in bags
- Trisodium phosphate in bags
- Calcium chloride in bags
- Ammonium Chloride in bags
- Obtibor TG in bags
- HCl PA in bottles
- Chromium Acid in metallic containers
- Nitric acid in plastic containers
- NaOH in paper boxes
- Citric acid in plastic bags
- Zinc chloride in bags
- Etc.

Photo 17 Storage room for chemicals

4.2.4 Water consumption

4.2.4.1 Rinse water consumption on Friday November 12th

Following values were measured on Friday November 12th. As examined, workers change the input according to their need. So, following values are only representing this moment. Differences between these values and other production days are possible. Electro polishing of stainless steel was not considered because production was stopped.

Section		m^3/h
Pre-treatment I:	Flow rinse pickling	1.00
Pre-treatment II:	Flow rinse Brushing	0.80 0.30
Ni-Plant:	double cascade el. Deg. triple cascade activation Ni flow rinse Cr double cascade	0.76 0.38 1.10 1.20
Chromating:	1st flow rinse cascade 2nd flow rinse for Zinc	0.51 0.40

Section	m^3/h
3rd flow rinse	0.40
Rectifier cooling	0.50
Total rinse amount	**7.35**

For the location of the different sections please refer to Graph 2.

4.2.4.2 Relative water consumption per square metre treated surface

This is a rough calculation of some existing values:

From customer calculated surface for the month September 2004:
Cr: 2760 m^2
Zn: 3850 m^2 → Total monthly 6610 m^2

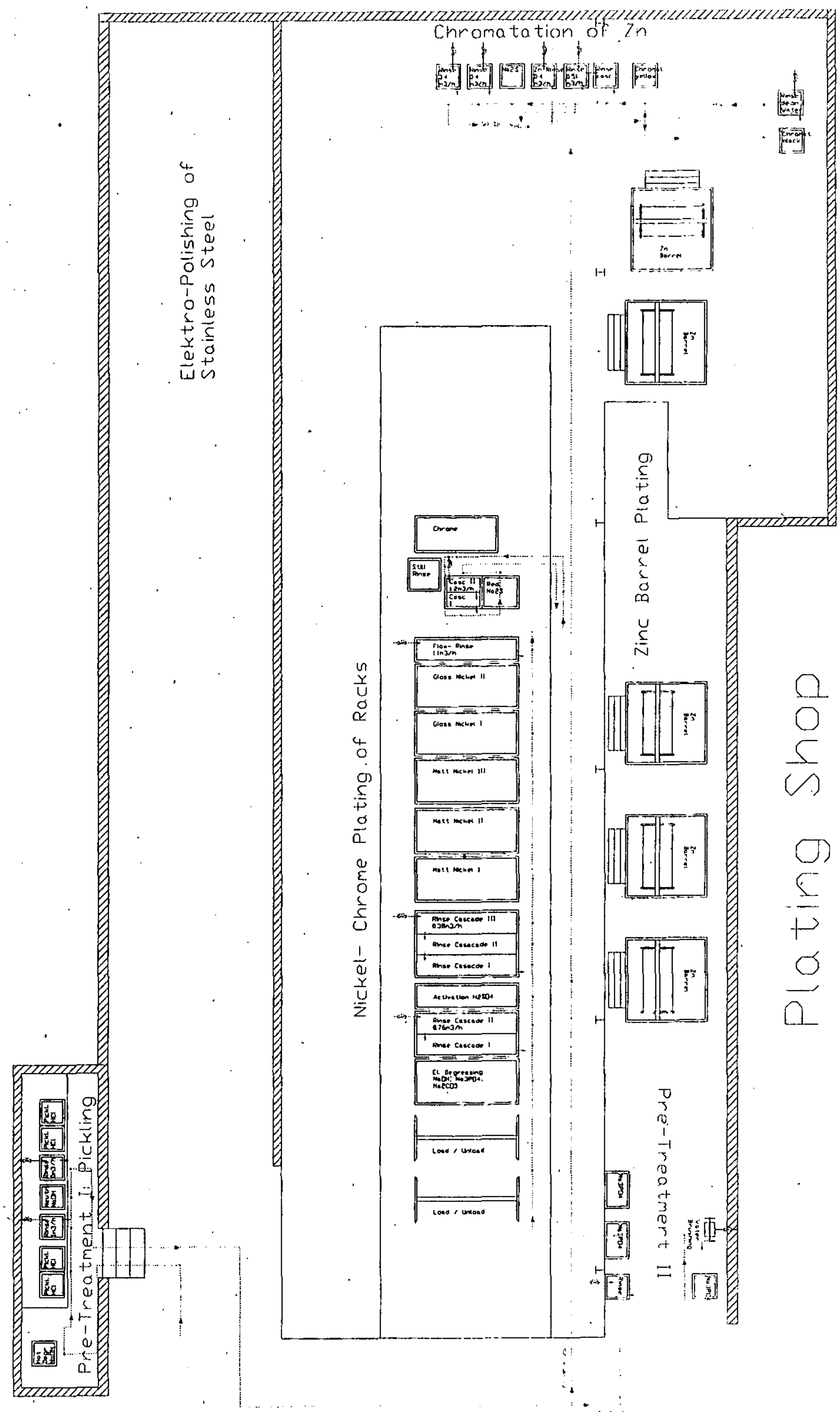
Measured consumption of water for the Cr- and Zn-plating:
above: 7.350 m^3/h

Monthly calculated 22 working days per 16 hours production:
22 x 16 x 7.350 m^3 = 2'587 m^3

Relative water consumption: Approx. 390 l/m^2 treated surface.

This value is heavily exceeding the benchmarks mentioned in chapter 5.1.1.

Graph 2 Plating sections and place of rinse water consumption



4.2.4.3 Analysis of rinse water use on Friday November 12th.

There is a water channel located outside and in parallel tot the longer side of the plating shop. This channel drains sanitary waste water from hand wash basins and the men toilet into the municipal channel.

On the side of the plating shop there were two water outlets identified from the Zinc- and Chromatation treatment.

At the backside of the plating shop there are several pipes and channels discharging different liquids and volumes into the sanitary channel and also into the waste water treatment plant. Some pipes were damaged and also the water channel seemed to be partly dug in the ground without proper sealing.

It was not possible within the short time of the audit to examine all of the discharge parameters. However, the main outflow of the plating shop was drained into the channel that is connected with a river without any treatment steps. First visual estimation resulted in a discharge of >70% of the entire waste water that is lead into this sanitary channel.

Two waste water samples were taken and analysed (Graph 3):

Sample I:

Relatively clear, no specific colour

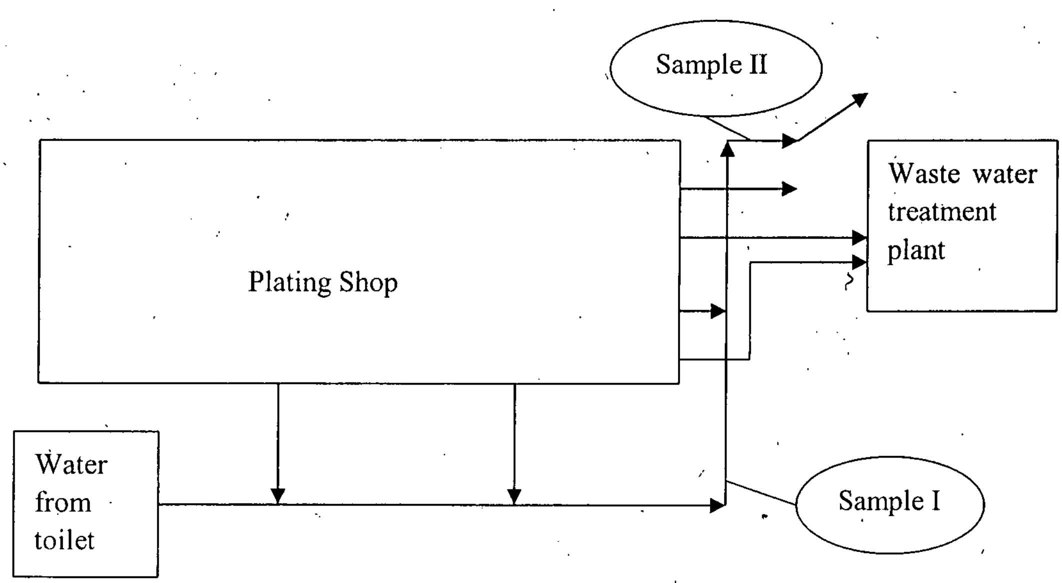
Content: Total Cr: 0.6 mg/l, Ni 14.5 mg/l

Sample II:

Relatively clear, showing yellow colour

Content: Total Cr: 29.3 mg/l, Ni 12.7 mg/l

Graph 3 Location of waste water sampling



Obviously there is a certain amount of toxic chemicals (heavy metals) being discharged untreated.

4.2.5 Energy efficiency

4.2.5.1 Tank heating (hot degreasing, Ni-tank)

As already mentioned, insulation of heated tanks above 45°C will reduce energy consumption and costs. It is recommended to consider this for the planned reconstruction of the plating shop.

4.2.5.2 Air dryers

There are closed air dryers available which are equipped with a heat exchange system. It is recommended to use them in the future project.

4.2.5.3 Lighting

The illumination of the working area is too weak for a correct examination of the produced surface. We recommend to increase the lighting in the load- and unload section and at the main treatment places. The use of natural light should be considered.

4.2.5.4 Air agitation of Ni-tank

As already mentioned air agitation has the advantage of fair exchange of liquid on the articles surface but the energy consumption of the compressors is rather high. It is recommended to substitute the existing system with injectors, cathode rod movement etc.

4.3 Waste water treatment plant

Export Mechanical Tool Stock company runs a waste water treatment plant exclusively for the plating shop. It was stated by the company that the entire amount of the main outlets of the plating shop (Cr, Zn, Ni, acids) is properly treated in this plant. However, it was observed that some outlets of the shop are connected to the sanitary waste water system (see above) without intermediate treatment. During the company visit the main flows of the treatment plant were taken up and the important parameters evaluated and listed in the following.

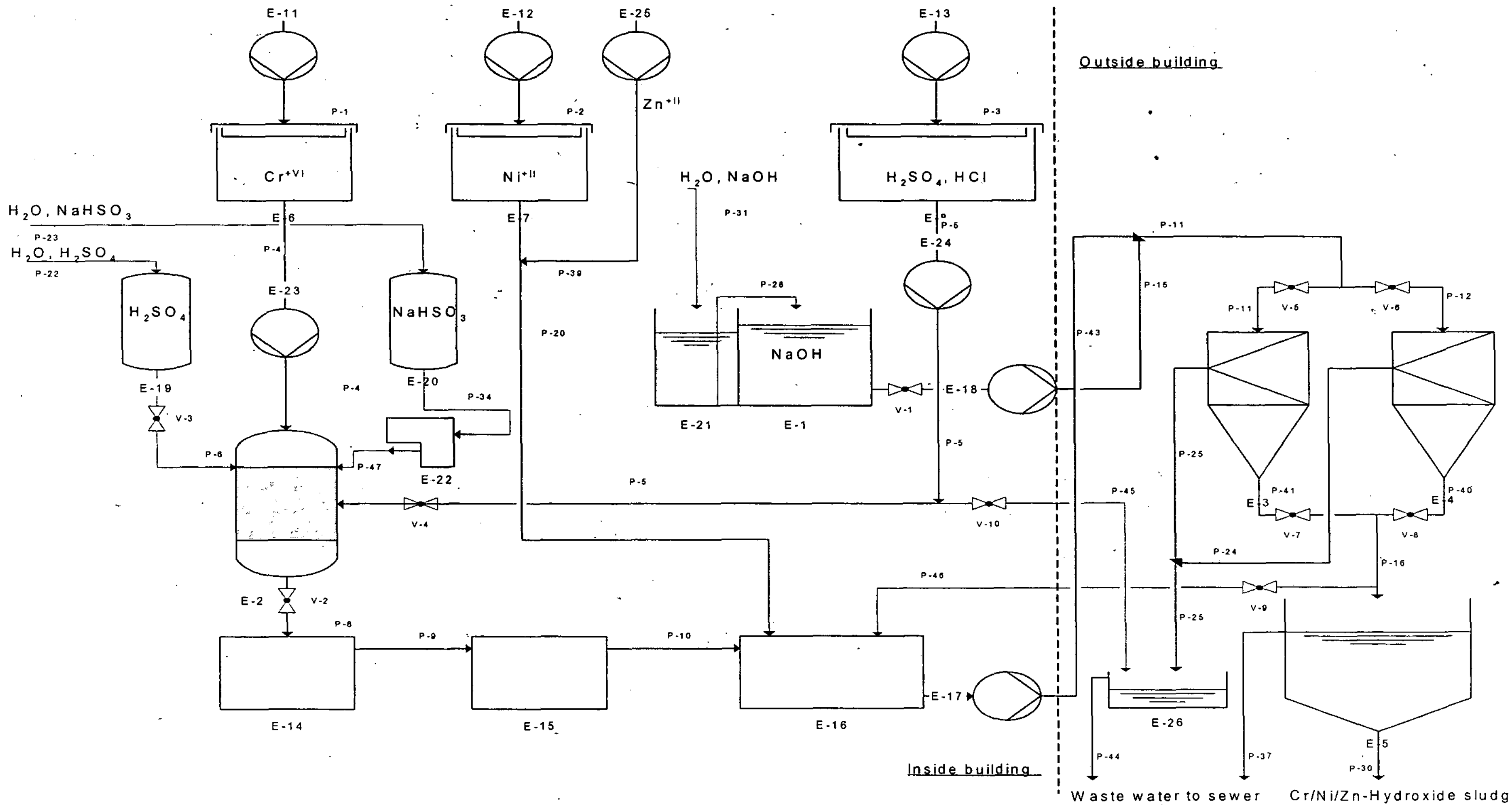
The plant consists mainly of three different treatment steps: batch reduction of hexavalent Chromium, precipitation of Nickel, Zinc, Chromium and other metals as well as sedimentation of the heavy metal sludge. The plant is divided into a covered part containing three rooms with the chromium-reduction reactor (room 1), the sodium hydroxide solution preparation (room 2), analysis and chemicals preparation (room 3) and storage of heavy metal as well as acid containing waste water (three tanks underneath the building). The part located outside the building consists of two precipitation cyclones (on upper level), sedimentation tank and overflow channels for the treated waste water that is discharged to the next river. For a more detailed layout of the plant refer to chapter 4.3.1.

The waste water inlet of the treatment plant is segregated into three different flows; however, all heavy metal containing flows are unified before final precipitation and discharge.

During the visit it became obvious that the treatment steps have been designed for a specific inlet flow and concentration of contaminants. All data received from the company regarding flows, concentration of heavy metals and pH-values were measured by the company itself and not by the auditing team. For an overview of details refer to chapter 4.3.1.1 and 4.3.1.2 of this report.

The waste water treatment plant is operated by one technician who takes care of the reduction process, the precipitation and the discharge of water. The measuring is all done manually at present. In specific the company measures the concentration of hexavalent chromium by visual testing during reaction to trivalent chromium with sodium bi sulphite. In addition pH-values are measured manually at the points stated in chapter 4.3.1.1. The quality of the final waste water flow to be discharged is checked by pH-measurement only. In irregular intervals the authority controls the required parameters of the discharged waste water and informs the company in case of non-compliance with the legislation.

4.3.1 Layout waste water treatment plant



4.3.1.1 Legend to waste water treatment plant (equipment)

Code	Installation	Purpose	Volume
E1	Storage tank	NaOH-storage	2'000 l
E2	Reaction vessel Cr^{+VI}	Reduction Cr^{+VI} to Cr^{+III}	500 l
E3	Cyclon	Precipitation and sedimentation 1	2'500 l
E4	Cyclon	Precipitation and sedimentation 1	2'500 l
E5	Sedimentation tank	Final sedimentation	1'338 l
E6	Cr^{+VI}-receiving tank	Initial storage of Cr^{+VI}-solution	---
E7	Ni^{+II}-receiving tank	Initial storage of Ni^{+II}-solution	---
E8	Acid receiving tank	Initial storage of waste acids	60'000 l
E11-13	Inlet-pumps	Transport of waste water from plating section to treatment plant	---
E14	Cr^{+III}-storage tank	Intermediate storage of Cr^{+III} solution	10'000 l
E15	Spill tank Cr^{+III}	Intermediate storage of Cr^{+III} solution	10'000 l
E16	Heavy metal storage tank	Intermediate storage of Cr^{+III}, Ni^{+II}, Zn^{+II} solution	40'000 l
E17-18	Feed pumps	Feed of NaOH- and heavy metal solutions	---
E19	H_2SO_4 storage	Acid storage for Cr^{+VI} reduction	---
E20	Storage tank	$NaHSO_3$-run-down tank	375 l
E21	Preparation tank	NaOH-solution make-up	1'000 l
E22	Dosing pump	$NaHSO_3$-dosing for Cr^{+VI}-reduction	---
E23-25	Feed pumps	Feed of Cr^{+VI}, Zn^{+II}, Acid	---

Measuring points:

P1, P2, P3	Flow measurement
E2	Cr^{+VI} (visual test), pH-value manually (automatic device out of order)
E3, E4	pH-value measurement
P28, P32	Chemical flow measurement
P25, P37	pH-value measurement

4.3.1.2 Legend to waste water treatment plant (materials)

Code	Measured flow	Properties	Requirements
P1	2'200 l/h, approx. 4.4 g/h Cr^{+VI}	Approx. 2 mg/l Cr^{+VI}	Initial layout data: 0.2-0.6 mg/l Cr^{+VI}, COD 800 mg/l, pH 5-7, 60 m^3/24h (2'500 l/h)
P2	1'700 l/h	Ni not measured	Initial layout data: 7-9 mg/l Ni, COD 600 mg/l, pH 5-7, 60 m^3/24h (2'500 l/h)
P3	2'000 l/h	Acids and Fe not measured	Initial layout data: 30-40 mg/l Fe, COD 1200-1500 mg/l, pH 2-3, 60 m^3/24h (2'500 l/h)
P32	70-80 l/d = 7-8 kg/d $NaHSO_3$ 100%	100 g/l $NaHSO_3$	According to reaction control
E2	---	pH 2.5	<0.09 mg/l Cr^{+VI} after1 day reaction time
P28	31-33 l/d = 14-15 kg/d NaOH 100%	NaOH 45%	According to reaction control
P11	See P1	---	pH 11, 3h reaction time
P25, P37	Not measured	pH 6-9, **no further measurements**	Legal requirements: pH 5-9, COD =100 mg/l, Ni=1 mg/l, Cr^{+III} =0.1 mg/l, Cr^{+VI} =0.1 mg/l, Q=120-160 m^3/24h
P22	Not measured, partly substituted by P3	Concentration H_2SO_4 unknown	According to reaction control
P39	Not measured	Zn not measured	No initial layout data available

4.3.2 Building, placement of equipment and piping

The waste water treatment plant building is located right behind the plating shop and therefore easy to be connected with the respective waste water storage tanks. The waste water inlets have PVC-piping that is connected to sediment bowls for Chromium-, Nickel- and acid-containing flows. Zinc-waste water is directly discharged into Nickel-waste water.

The building has a solid construction made by bricks and attached precipitation cyclones/overflows on the second level. This level can be reached by a ladder.

During the audit it was noticed that the continuous inlet flows stated by the company do not correspond with the real inlet flows controlled at the sediment bowls which are small or even not existing. Two separate sanitary waste water channels made of cement were analysed that are located right between the plating shop and the waste water treatment plant. It was recognized that a substantial part of the plating waste water is discharged to one of these channels that are directly connected to the sewer/river. Only some remaining plating waste water is directed to the treatment plant.

Photo 18 Ineffective sediment bowls

Photo 19 Open NaOH preparation tanks

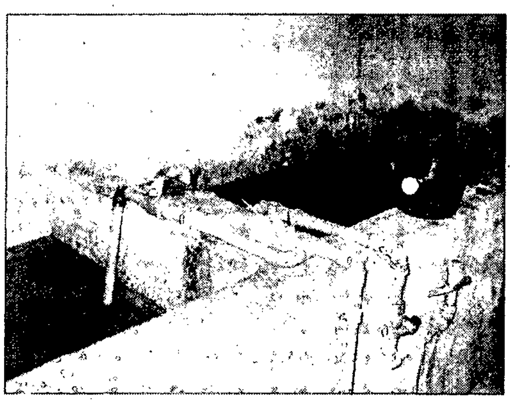


Photo 20 Precipitation cyclones causing sedimentation problems

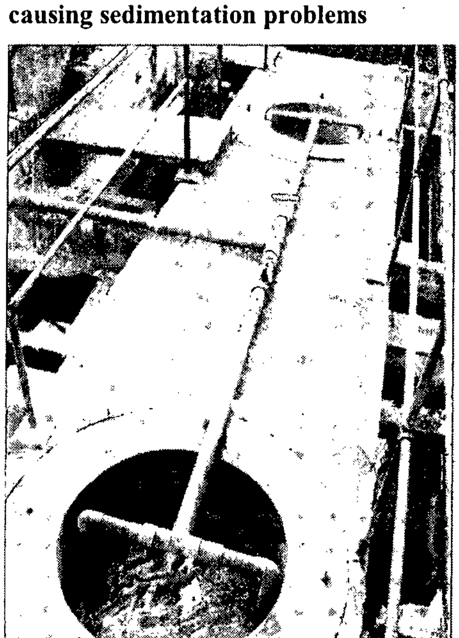


Photo 21 Lose electrical wiring

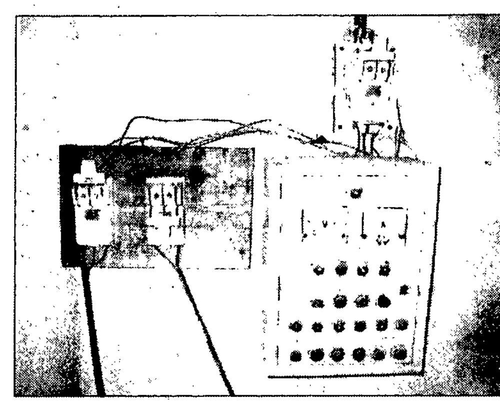


Photo 22 Open sedimentation tank with organic contaminants

Photo 23 Neutralisation and waste water discharge

4.4 Operational safety, occupational health

4.4.1 Impact of fumes, chemicals, heat and noise

As already mentioned, there are HCl fumes in the pickling section and the workers are contaminated on skin with toxic chemicals like Chrome-, Nickel-, Pickling- and other aggressive liquids.

It was observed that workers do not wear protective cloths like aprons, ear protection, gloves, goggles etc. only open shoes and jump suits. Long-term sickness will be the consequence.

In warmer seasons there is unwanted production heat caused by open heated devices like driers, not insulated tanks etc. This situation results in work stress for the employees and reduce their job performance.

In the plating area there are also two devices for vibration grinding of mass articles. During the audit these devices produced heavy noise that will cause ear problems. Such devices shell be placed in a closed and noise insulated area.

4.4.2 Ergonomics

People often work on the bare ground instead of using more ergonomic devices like tables and comfortable seats. Uncomfortable work is tiring and less effective.

Furthermore workers at the polishing machines do not have adequate chairs for this kind of activity causing backache or even health problems.

4.4.3 Illumination

Illumination of the working area is not appropriate for correct examination of the produced surface. It is recommended to increase the lighting at the load- and unload section and at the main treatment places.

4.4.4 Handling of heavy goods

Lifting of heavy weights in wrong body position was observed throughout the factory. Especially in the pickling section and at the chrome-rinsing tank this situation is a serious stress for the workers.

4.5 Environmental impact

4.5.1 Contamination of soil

Much of the soil of the wet areas in the plating shop is covered by a concentrated mixture of chemicals. These chemicals are trickling into the soil and contaminate ground water if not removed. At the time of the audit a severe contamination of the soil was already observed. Only small parts of the floor are sealed with concrete.

Only sealed and dry soils are appropriate foundations of such a plating line. Therefore there should be a correct lay out of the wet area e.g. incorporating collecting half pipes or channels.

4.5.2 Acidic fumes exhaust

Hydrochloric acid is heavily corroding iron and steel parts of building and machines. Even well working exhaust systems can't avoid these problems at the moment.

The vapours are also affecting infrastructure outside of the plating shop.

If possible, HCl should be replaced by another pickling acid.

4.5.3 Waste water discharge

There are two kind of discharged waste water:

- Treated in the waste water treatment plant
- Directly discharged untreated water.

It was noticed and measured that a certain amount of untreated heavy metal containing waste water is drained directly to the sanitary waste water system and the river:

Concentration of contaminants (see Graph 3): Total Cr: 29.3 mg/l, Ni 12.7 mg/l

These values are exceeding the threshold limits mentioned in chapter 5.1.2 by about 300 times.

5 Gap analysis

5.1 Benchmarking

In the following some typical benchmarks of modern and best available technology are listed like those which are commonly used e.g. in Europe. However, the following figures are by no means complete and only serve for comparison in the most important plating areas.

5.1.1 Raw-material and water consumption

More than 90% of plating chemicals are normally used by e.g. reuse, drag back, recycling etc. in a modern plating plant.

Water consumption can be reduced to 0.5-10 l/m^2 treated surface dependent on the plating process.

5.1.2 Waste water: Concentration limits of hazardous components

In Switzerland and Vietnam the limits (legal requirements) of discharged waste waters are:

Item	Switzerland	Vietnam
pH	6.5-9.0	5.5-9.0
Ni [mg/l]	1.0	1.0
Cr VI+ [mg/l]	0.1	0.1

5.1.3 Energy consumption

As a rule of thumb by optimal thermal insulation, heat recovery and more efficient processes the overall energy consumption of an obsolete plant can be reduced by 70%.

5.1.4 Product quality

Products imported in Europe should have an appropriate product quality considering uniform layer thickness, adhesion strength, corrosion protection, ductility and visual aspects. Standards of customers have to be checked in order to provide long lasting products.

5.1.5 Safety and Health

In Europe companies are rated according to the number of accidents occurred during a defined period of time. The insurance rates are calculated according to this rating. The fewer accidents a company suffers the smaller is the burden of cost.

Machines must have protection devices to prevent serious accidents with dangerous operations e.g. bruising of fingers with blanking, hurts caused by drives (pullies, transmitters) etc.

Handling of toxic and corrosive chemicals has to be done only with protective cloths (apron, goggles, gloves and rubber boots) and sufficient ventilation if carried out in closed rooms. The personnel has to be instructed on the properties of the chemicals handled.

Workers have to be trained in first aid and emergency devices like fire extinguishers have to be placed easily accessible in the plating shop.

5.2 Description of target situation

5.2.1 Applicable processes in Vietnam vs. Switzerland

Due to the different historical background the industrial situation in Vietnam regarding availability, profitability, functionality, requirements of customers, handling, education and skills differs from that of Switzerland.

However, there are technologies available to reduce the environmental and economic impact of an obsolete plant. In Europe second hand technology can be purchased for reasonable prices that enhance a lot production efficiency. However, this improvement has to be undertaken in parallel with capacity building.

5.2.2 Raw-material and water consumption

Raw-material: Chemical products

The overall cost of chemicals for the mentioned treatments is about US$ 160’000.00 yearly.

Total estimated possible savings with the application of adequate rinse technique and replacement of obsolete/unneeded processes amount US$ 96’000.00 yearly.

Savings of more than 60% of chemical cost might be possible.

Water consumption:

The measured consumption can easily be reduced by using rinse cascades:

Section		m3/h existing	m3/h optimized
Pre-treatment I:	Flow rinse pickling	1.00	<0.05
Pre-treatment II:	Flow rinse Brushing	0.80 0.30	<0.02 <0.05
Ni-Plant:	double cascade el. Deg. triple cascade activation Ni flow rinse Cr double cascade	0.76 0.38 1.10 1.20	New rinse technique Totally <0.10
Chromating:	1st flow rinse cascade 2nd flow rinse for Zinc 3rd flow rinse	0.51 0.40 0.40	New rinse technique Total <0.10
Rectifier cooling		0.50	<0.01
Total minimal rinse amount		**7.35**	**<<0.33**

As a result water savings of > 95% are possible. A relative consumption of much less than 17 l/m² treated surface can be achieved. The benchmarks listed in chapter 5.1.1 will be approached.

5.2.3 Energy consumption

Heated devices like dryers, tanks, pipes etc. should be insulated and only be heated during use. Proper covering of the surface of plating tanks (e.g. with plastic balls) can reduce the energy loss and evaporation of water as well.

The detailed calculation of the energy savings that could be achieved with these measures would go beyond the scope of this assessment. However, based on the experience in Europe the realization of these low-cost measures is recommended.

5.2.4 Product quality

Significant quality problems like low throwing power into lower current density parts or low adhesion strength of black Chromatation on zinc plated articles were mentioned by the customer.

During the assessment many processes could be identified where the parameters are out of the range of production tolerance. The only solution to improve product quality in order to fulfil the requirements (standards) is to keep all processes and their parameters within the necessary ranges defined by the technology/chemical suppliers or listed in this report.

5.2.5 Safety and Health

Safety precautions at machinery and personal protection equipment as mentioned in chapter 5.1.5 combined with sufficient training of workforce will result fewer accidents and less non-productive time.

The target should be continuous improvement and reduction of potential danger and accidents. Therefore efforts for the improvement of safety and health are ongoing activities with the involvement of the entire workforce.

5.2.6 Environmental protection

The entire environmental impact of the plating shop has to be reduced with state-of-the-art techniques that are applicable and economically acceptable. However, this has to be combined with employee capacity building. The overall target of a company reducing cost and increasing efficiency will automatically result in a lower environmental burden if carried out with indulgence. The reduction of chemical consumption or water use by proper rinse technique is a good example for this approach.

Another important factor for reducing the environmental impact is legal compliance. Vietnamese companies have to cope with limits listed in Vietnamese legislation that are partly already enforced – otherwise shutdown of the establishment could result.

5.2.6.1 Waste water treatment

The waste water treatment plant has been designed and constructed for a different amount of waste water as noticed at present. The hydraulic load apparently overtaxes the capacity of the plant, therefore a by-pass between the plating shop and the sewer was established. By using this by-pass a lot of toxic waste water is discharged causing severe environmental impact. Therefore, with cleaner production means the amount of generated waste water from the plating shop has to be reduced to a minimum.

Although the relevant equipment for the reduction of hexavalent chromium to trivalent chromium is installed and all the heavy metals are precipitated and separated the layout of the plant is rather inappropriate and based on the historical growth of the company. It is e.g. rather unusual to use separate storage tanks for the heavy metal containing waste water although all of the different flows are eventually unified. The production and possible sale of monometal-sludge ($Cr(OH)_3$, $Ni(OH)_2$, $Zn(OH)_2$) has to be evaluated. Furthermore a change from hexavalent chromium to trivalent chromium in plating (chromiting) would reduce the bisulphite process significantly.

The only measurement of the pH-value of the waste water discharge is not enough. The overflow has to be measured according to the legal requirements thus Cr^{+VI}, Cr^{+III}, Ni^{+II}, Zn^{+II} and COD has to be analysed in defined intervals. The company shall not be dependent on the irregular measurements of the authorities only. The online control of pH-values during the bisulphite reaction has to be measured appropriately and therefore automatically. The broken pH-measuring device as well as all the inappropriate electrical wiring has to be repaired immediately.

For the new production site of export mechanical tool stock company outside Hanoi the new expected waste water flows and the reduced contaminants have to be considered for the design of the new plant. As the re-engineering of the waste water treatment plant is not subject of the present analysis it is not described in this report in detail. However, following general points have to be considered:

- Design and layout according to expected waste water flows after re-engineering of the plating shop. The possible use of ion-exchange technology has to be evaluated. The treatment plant shall easily be extended according to the increase in production output.
- If ever possible safe construction of the plant with respective railings and lids for the pits.
- Closed vessels for the preparation of lye shall be used as causticization of operators might take place.
- Combined flocculation and precipitation will increase the precipitation rate and reduce the amount of heavy metals discharged to the environment.
- Sophisticated sedimentation tanks reduce the amount of discharged heavy metals.
- Closed sludge sedimentation tanks prevent people from falling into the containment and avoid further contamination with e.g. leaves.
- The filtering with chamber filter-press will reduce the amount of sludge and will result in a tradable product.
- All electric wiring and connectors have to be installed in a proper, moisture-proof manner.
- All piping has to be resistant against the respective waste water, properly fixed and labelled. A topical layout plan has to be established and displayed.
- The waste water samples have to be stored in order to reproduce the results.

5.3 Means for target attainment

Most of the means for target achievement have already been explained in the chapters above. The seminars on electroplating offered by the Vietnamese Cleaner Production Centre in the year 2003 and 2004 have shown several significant techniques to reduce cost and negative impacts. The present factory Export mechanical tool stock company can improve a lot the situation in the plating shop by the proper application of rinse technology and recovery of chemicals.

5.3.1 Technology modification

No high-tech is necessary for the improvement of the situation in the plating shop. However, obsolete, damaged or dangerous installations have to be substituted by proper ones as indicated in chapter 4. The main improvement has to be done with the following changes:

- Implementation of correct plating sequences
- Adjustment of correct process parameters

5.3.1.1 Optimisation of treatment sequences

Optimal treatment sequences are based on tests or on international experience. In this specific situation it is recommended to treat the articles in one complete process starting with degreasing and ending with chrome plating

Possible sequence for Ni-Cr plating of steel parts:

- Charging on racks
- Hot degreasing
- Cascade rinsing (approx.3 tanks)
- Pickling
- Cascade rinsing (approx.3 tanks)
- El. Degreasing
- Cascade rinsing (approx.2 tanks)
- Activating
- Flow rinsing (1 tank)
- Ni matt
- Ni gloss
- Cascade rinsing (approx.3 tanks)
- Flow rinsing (1 tank)
- Chrome plating
- Cascade rinsing (approx.3 tanks)
- Bisulphite rinsing (1 tank)
- Flow rinsing (1 tank)
- Clean rinsing deionised warm water (1 tank)
- Air drier
- Unloading from racks

Possible sequence for Zn barrel plating of steel parts:

- Charging on barrels
- Hot degreasing
- Cascade rinsing (approx.3 tanks)
- Pickling
- Cascade rinsing (approx.3 tanks)
- El. Degreasing
- Cascade rinsing (approx.2 tanks)
- Activating
- Flow rinsing (1 tank)
- Zn plating
- Cascade rinsing (approx.3 tanks)
- Zn cleaning (1 tank)
- Flow rinsing (1 tank)
- Chromating yellow, white etc. (separate tanks)
- Flow rinsing (approx.3 tanks, separate for each chromating colour)
- Air drier or centrifuge, unloading

5.3.1.2 Substitution and optimisation of inappropriate processes

According to the treatment sequences the treatment processes are to be considered. As already mentioned, some processes should be replaced or completed in their manner or technology to achieve a higher product quality.

Examples:

Hot degreasing

This process contains at the moment only NaOH that is never replaced. There is no detergent to get a correct degreasing effect and there is an accumulation and drag out of oils into the subsequent processes. All incoming oils are finally affecting the plating processes in the plant and causing serious quality problems.

Modern degreasing processes are handled as degreasing systems comprising of adequate degreasing solution, functional equipped degreasing tank and oil absorbing device.

Pickling

To protect infrastructure HCl has to be substituted by another acid that has lower volatility like sulphuric or phosphoric acid. Tests have to be undertaken to prove their effectiveness.

Zinc plating

There are newly developed acid Zinc plating processes available that work at elevated temperature. Advantage: forced evaporation loss enables a big amount of recovery of dragged out substances if correct cascade rinses are realized.

Chromitation versus Chromatation

Chrome hexavalent is a good corrosion protection layer. The applied Chromatation processes contain the harmful hexavalent Chrome substance and shall not get in contact with human skin.

In the last years there have also been Cr VI+ free passivations (Chromitations) available. European car manufacturers set these as a standard for their plating shops.

Disadvantage of Chromitation: The processes are more difficult to apply. Thus there should be a serious evaluation for the most suitable solution for the enterprise and the customers' needs.

5.3.2 Quality management

To maintain a certain constant quality of the processes there must be an adequate quality management of the processes. All quality influencing parameters are to be checked and corrected periodically. All these values should be documented and stored in an adequate place like a computer worksheet, containing name of the responsible person, date, values etc. as it is required by ISO 9'001 standard (the company is certified).

The plated layer on the products shall be checked and analysed according to the purpose, like corrosion protection, layer thickness, adhesion strength, ductility etc. There are several analytical instruments and testing methods on the world market available.

If there are quality problems occurring later on like blistering, changing of colour, corrosion etc. there is the possibility to find the reason with proper measurement instruments. Subsequently the faulty parameters might be adjusted and future errors of the same kind be eliminated.

The responsibility of each quality influencing activity shall be assigned to a person and documented. With respect to quality it is important to allocate responsibility to workers.

5.3.3 Training of personnel

Quality products can only be produced when the personnel is appropriately trained. The characteristics and property of each process should be well-known by the operator.

Following data should be known and communicated:

- Chemical components and their toxicity
- Use of chemicals and effects
- Main parameters of these processes like temperature, pH, current density, dwell time, concentration etc. Influences on the layer quality.

- Advantages of correct rinsing

Training on quality management and safety&health should be conducted in reasonable frequencies as mentioned in chapters 5.3.2 and 5.3.5.

5.3.4 Recycling

With correct technology application and practices there will be most probably no recycling necessary. During reconstruction of the plating shop of "Export mechanical tool stock company" the possible accumulation of waste has to be considered and calculated in order to choose the correct recovery or disposal.

Recycling can only be executed in an economical way if the rinse technique is realized in an adequate way. Correct rinse cascades must be installed where the drag back of chemicals is reasonable. Only such cascades enable the direct recovery of metals as they will be concentrated in the plating tank.

Any recycling is imaginable for Nickel like mono-sludge precipitation (combined with ion-exchange) or membrane electrolysis.

5.3.5 Safety and Health

As already mentioned there are several serious dangers of workers accident and sickness throughout the plating shop:

- Falling into (pickling) tanks
- Heavy weight lifting without any aids
- Contamination with harmful chemicals on skin and eyes
- Non-ergonomic work places
- Noise
- Corrosive acid vapours
- Insufficient illumination

All these factors influence quality and costs and should also be eliminated considering social aspects and company image.

In many cases there are easy means to improve the situation in the plant. As already mentioned all involved personnel should obtain personal protective cloths. Furthermore the company has to provide ergonomic working aids like comfortable chairs, desks, containments, fork lifts etc. Room climate and air quality has to be checked and where necessary ventilation hoods installed. Non-chemical influences like noise has to be reduced at the source by replacement of machines or appropriate insulation. Machinery has also to be checked regarding danger of physical accidents. It is recommended to carry out a safety&health audit together with involved workers. That way the risks can easily be identified and immediate action done.

5.3.6 Working conditions and motivation

The working conditions and resulting motivation are an important means to reduce costs, constant high product quality and low rejects respectively.

Good working conditions are the basis for motivation of the personnel. Good team work in a plating shop is a pre-condition for proper plating along the entire plating line. Each operator at his process step has to think about all next sequences as his/her work influences the work done by the colleagues.

Therefore it is recommended to evaluate the existing piece-work as workers are exclusively interested in the amount of output of their own working step. It would be a better approach to assess the resulf of a plating team with indicators like product quality, raw material/water consumption, number of accidents etc. To improve these factors incentives like free working days, financial benefits etc might be means to motivate operators.

6 Conclusions

An exclusive improvement of one part of inadequacies in the "Export mechanical tool stock company" will not result in the expected overall improvement of the company's performance. All aspects have to be considered during optimisation of a certain plant. Technology improvement is one part and should go along with capacity building at the workforce and improvement of organisational aspects.

The reconstruction of the plating shop outside Hanoi is a great opportunity to reconsider the entire plating line in order to choose the correct plating sequences according to the customers' requirements. The company has enough financial possibilities to build a state-of-the-art factory and should invest into a more sustainable future. It is foreseeable that the Vietnamese environmental legislation will soon be enforced due to the industrial impact that is an important factor mainly in urban areas.

The working situation for the people employed at the moment is in some cases harmful to health. Operators are more motivated and efficiently working if basic conditions do not affect their health. Furthermore as the company also exports to foreign markets in Europe and Australia the working situation should be optimised. For customers the social and environmental standards of a company will soon become an important criterion for selecting a certain supplier.

7 Recommendations

7.1 Immediate optimisations

Considering the planned new construction of a plating shop outside Hanoi and the probable technology transfer, immediate optimisations should only be implemented where dangers for workforce and severe problems with product quality exist. The principal investment should be done at the new site.

In this report, there are many areas listed where immediate optimisation is recommended, namely:

- Construction of adequate plating racks
- Start of analytical measurement, monitoring and replenish
- If possible: install triple cascade instead of the single Nickel rinsing tank and use the recovery effect. A significant cost reduction will result.
- Start to calculate correct parameters like defined surface areas, el. current density, process time, temperature etc. according to supplier information and suggestions in this report and implement/control these parameters.
- Improve the working situation for the staff where immediate danger occurs

7.2 Medium-term changes

It is recommended to correctly lay-out the new plating shop with the assistance of an experienced plating expert. An appropriate lay out of the entire future plaiting system will avoid expensive modifications. Subsequently the necessary new technology has to be selected and a respective technology transfer project undertaken. The Vietnamese Cleaner Production Centre with the assistance of FHBB/experts might support these activities.

Evaluations should be done regarding adequate substitution processes like warm-Zinc, Chromitation, rinse techniques, waste water treatment and the required infrastructure.

With regard to the selection of new or second-hand technology VNCPC/FHBB might carry out a survey on applicable technical solutions for "Export mechanical tool stock company" upon request. There is technology available in Europe for a reasonable price.

Going this way the future building for the plating shop will optimally be constructed according to the requirements of the plating system including material-, work- and chemical-flow. Furthermore the ergonomic situation, waste water and air treatment can be addressed in a cost-effective way resulting in higher productivity and better product quality.

8 Technology Transfer

This chapter will be finalized with the technology selection, transfer scenario, partners and financial engineering after the agreement with the Vietnamese Cleaner Production Centre and "Export mechanical tool stock company" on the continuation of the expert assistance.

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