TAMK-UNIVERSITY OF APPLIED SCIENCES
Environmental Engineering

Final Thesis

Ma. Jovita Tortola

A STUDY ON LIFE CYCLE ASSESSMENT OF DENTAL PROSTHESIS

Supervisor Principal Lecturer Marjukka Dyer
Commissioned by JK Hammas, Mr. Kalervo Ingalsuo
Tampere 2008

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ABSTRACT

The purpose of this study is to assess and know whether the processes and its materials in making denture are safe to environment and as well as to assess whether it has significant impact to climate change. This report consists of the basic LCA steps, processes of making dentures, materials in making dentures, and analysis of the results of its production and materials composition.

Research and practical works are the main methods in making this study to give an idea about the work that has been applied on this paper. As a result, denture production has less impact to environment but have greatest impact to the worker's health in the long run. The production of denture produces less waste because it is very dependent on the number of patient's or customer that needed a new denture, maintenance and repair. Most of the materials used for making dentures especially the chemicals have been pass through the European Chemical Agency for assessment of chemicals depending on its hazardous effect into the environment as well as to human health.

As conclusion to this study, denture production has good processes and safer to environment. Waste management is very applicable because most of the materials are re-used and recycled for another process or application. It does help to minimize the environmental degradation and possess a clean and safe production method.

TAMPEREEN AMMAATTIKORKEAKOULU
Environmental Engineering

Tortola, Ma. Jovita

Selvitys hammasproteesien elinkaaren ympäristövaikutuksista

Tutkintotyö 34 sivua
Työn valvoja Yliopettaja Marjukka Dyer
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Avainsanat hammasproteesien LCA, komposiittimuovien elinkaariarviointi

TIIVISTELMÄ

Tämän tutkintotyön tavoitteena oli selvittää hammasproteesien elinkaareen liittyviä ympäristövaikutuksia tarkastelemalla niiden valmistusmateriaalien ja hammasproteesien valmistuksen yhteydessä syntyviä päästöjä sekä näiden vaikutuksia terveyteen ja ympäristöön. Kestävä kehitys edellyttää kaikkien tuotteiden elinkaaren arviointia ja materiaalien mahdollisimman tarkkaa tuntemusta ja hyötykäyttöä, joten on luonnollista, että myös hammasproteesien elinkaarivaikutusten tuntemus on tärkeätä. Selvityksessä luodaan katsaus elinkaariarvionnin (Life Cycle Assessment) perusteisiin, käydään läpi hammasproteesien valmistusvaiheet sekä niiden tällä hetkellä käytössä olevat valmistusmateriaalit ja näiden terveys- ja ympäristövaikutukset.

Selvitystä tehtäessä on seurattu käytännössä hammasproteesien valmistusta alusta loppuun ja työvaiheet kuvattu yksityiskohtaisesti. Suurimmat terveys- ja ympäristövaikutukset kohdistuvat itse valmistus- tai korjausprosessiin ja näissä työskentelevien terveyteen. Materiaalia voidaan myös kierrättää. Tutkintotyö on ainutlaatuinen ja antaa hyvän pohjan laaja-alaisemmallekin terveydenhuollon materiaalien elinkaariselvitykselle.

FOREWORD

I would like to thank Mr. Kalervo Ingalsuo to give me chance to do my practical work and my thesis in his company and help me to gain knowledge about his work and how a company work. It was been a big pleasure to learn and discover how to work and deal in making dental prosthesis.

I learned that it wasn't simple and easy to make a denture, it takes time and energy to make a single denture because you need to be careful and fast in mixing all the materials that will be used in the process. It you work slows the materials or the products will be ruined and useless because you won't able to apply or use it at all.

At the end the practical work does help a lot in making this thesis a success and the information that has given during the work. It was hard to make an assessment especially if you are missing an important data or you won't able to mange to do the run the analysis of the process in computer software that is designed for LCA.
Things have been working well and I would like to thanks my supervisor, Marjukka Dyer, who helped me to correct my thesis and guide my work.

For my sister, Merlita Ingalsuo, who helped and gave me an idea and translated my abstract into Finnish with the help of his husband and to my family for all the support and trust.

Thanks to all and Congratulation to Batch 2008 of Degree Programme in Environmental Engineering of TAMK- University of Applied Sciences.

LIST OF ABBREVIATIONS

LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
LCI	Life Cycle Inventories
MMA	methylmethacrylate
PMMA	Polymethylmethacrylate
Pa	Pascal
EC	European Commission
ECHA	European Chemicals Agency
ppm	part per million
LC50	Lethal Concentration at 50 %
LD50	Lethal Dosage at 50%

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1. INTRODUCTION

LCA is a one of the tool in assessing a process of a product from its extraction of raw materials to its final disposal /3/. It helps to identify the possible impacts of certain process into environment and assess it whether the products or materials that is going to use are safe and has pass through the Environmental Legislation applied in each country.

Denture is medical practice that involves a practical work, chemistry and technical approach to complete the end-product. It has two types of denture: Complete and Anchored dentures. These dentures have different purposes and use that applies to particular person's typical shape of his or her mouth. For instance, anchored denture is use only for that person who has some teeth missing that it can be done either metal or fully acrylic resin depending on the patients' desire or wants. /1/

The materials and its processes are examined according from practical experience and its safety data sheet that is given from the products information in company's website or together with the products information data. The results of the assessment are basing on the safety data of each product and its content, mainly.

Finland has a strong legislation in environment that has been develop a waste management to separate the different types of wastes according to its level of hazardous or impacts that it may cause when it is disposed improperly. As for denture's production, it's mainly produce solid wastes that could be disposed as normal household wastes. /11/

2. BASICS OF LCA SYSTEM

According to the book of *Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards*, *"*LCA is defined as the compilation and evaluation of the inputs, outputs, and potential environmental impacts of a product system throughout its life cycle*"*. This means that LCA is one of the tools in defining the systems of products life cycle and its relation to its possible environmental and human impacts. It is an ideal practice to evaluate the utilization of resources and the discharge of waste relative to a standard industrial activity. /2,3/

Procedural Outline of LCA in ISO Standards /2,3/

- A full concept of development in LCA framework at present time has lately proposed in studies evidencing the key issues still under debate and the main field of practical application of LCA in its current state. A complete LCA is composed of four key elements in reporting such as:

1. Goal and Scope Definition
    - Objectives and initial choices are clearly defined and rational to the intended application. This involves assessment of typology, supposition, and limitation for inventory, distribution of operations and impacts to be considered.

2. Life Cycle Inventory (LCI)
    - Describing the systems of the product according to its unit processes, system boundaries, performance, and completion of the final products. The final result of the inventory is a table consisting all the data's of input and output from the product system. In other words, it is the collection and quantification of the inputs and outputs of the entire life cycle.

3. Life Cycle Impact Assessment (LCIA)
    - Consists of inventory data from the LCI that are interpret into potential environmental impacts by evaluating their range and implication.

- Common procedures consists of categorizing the inventory flows and differentiate them quantitatively in relation to different impact group referring to the ISO Standards that is drawn up by SETAC Working Group on Impact Assessment.

4. Interpretation / Evaluation
   - This is the final phase of LCA procedure, the outcome from the LCIA data are review in relative to the intended objectives in order to prepare concluding deliberations and commands for development.

3. GOAL AND SCOPE OF THE STUDY

The goal of this study is to find out whether dental prosthesis production has relevant impact to environment. By using LCA as technique of the study and Umberto software for the source of life cycle inventories, it will support to examine its impact to environment as well as to humans health. Materials and the process of prosthesis are the main focus of the study. The results of this study will be used to improve the product and process development of the item for consumption for the manufacturer, user, and supplier of the product.

The scope of the assessment is intended mainly on the materials, process of complete prosthesis and partially on its final disposal to the environment. Once, the product is ready and made for a certain person, it is then checked after 3 to 5 years of used. Some check-ups, repairs, and additional of resins are needed to monitor the condition of prosthesis.

The study is commissioned by JK Hammas, a small privately-owned company of dentures specialist. The functional unit of this assessment is based on the life cycle of one component of prosthesis that is complete type of dentures, made of acrylic resin.

The limitation of this study is that the quantity of the product or production is not elaborated very well but the quality it will produced and its future impact to

environment and also to human health will be discussed. The location of the production site is in Finland member of EU countries.

3.1 Background Information of Dentures /1/

A dental prosthesis or commonly known as dentures is a detachable alternative for missing teeth that is normally made of acrylic resin. It helps to sustain muscles in controlling the expressions of the face that needs support from the teeth in solving problems in pronunciation, face shape and chewing.

There are two types of dental prosthesis namely: Complete and Anchored or Partial dentures. A complete denture is used if there is no sign of teeth present in patient's mouth while anchored denture is used when there some teeth present in patient's mouth.

These two types of dentures have different forms but using the same base materials (acrylic resin). In anchored dentures, a metallic frame is usually joined together with acrylic resin to make it stronger, durable and better feeling. Sometimes it can be fully made of metal depending on the patients want and it is much denser than the one is made of fully acrylic.

4. PRODUCTION METHOD

There are several methods in making two types of dentures including the chemical reaction by polymerization and modelling of the denture by sedimentation. In this section, the materials and its application to the process, chemical composition, and procedure in making denture are discussed how it relates in making denture.

4.1 Materials and their Application /1/

There are several types of materials needed from the very beginning of making dentures to its finishing product. The following materials are listed below:

- Alginate
  - It is used for making new dentures to make a new preliminary impression of denture. Moulding the mouth of a patient by using

base paste that is mixed with hardener paste. It is elastic when it is mixed with water and lead free.

- Cement
  - It is applied to mould the final impression from the form of wax and to make stone cast impression.
- Wax
  - It is used for preliminary wax dentures to make stone cast impression.
- Plastic Wax Wafers
  - To make the wax rims stronger and withstand the recording of centric and eccentric positions.
- Wire
  - It is commonly used in anchored or partial dentures. It used to support or make stronger the construction of denture.
- Teeth
  - An important part in making dentures. It can be made by acrylic or porcelain.
- Adhesives
  - It is used for preliminary impressions of the dentures. Moulding the mouth of a patient by using base paste that is mixed with hardener paste.
- C- Silicone
  - It is used to prevent teeth from removing or scattering of wax and resins application into the stone cast impression. To prevent the teeth from being distorted from its position and damage.
- Separating fluid
  - It is used to smooth the surfaces of dentures materials and has excellent separating properties to segregate the base materials from each other. It is an aqueous alginate solvent.
- Polymer
  - It is a powder base substance that is made of PMMA together with other chemical substances.

- Monomer
  - A liquid base substance that is made of MMA that is highly flammable and irritant to skin.

Polymer and Monomer are the base material in making dental prosthesis that is mixed together to form a resin called acrylic resin.

4.2 Chemical Composition of each Material

The material that is used in making dentures is mixture of different compounds to produce a new substance. The lists of chemical mixtures are shown below:

Table 1. Products Chemical Information /4,7,8,9/

Name of the Product	Characterization	Hazardous Information
1. Lastic 90 fine (base paste)	Hydroxydimethylpolysiloxan Filling Material	No hazardous substance or hazardous compound
2. Zetalabor Hard 80 Shore A	Condensation Silicone(polysiloxane) Laboratory Use	None
3. Aesthetic Autopolymerisat Polymer, Powder	Powder of Polymethylmethacrylate, plasticiser, pigments and catalysts	0.5-1.5 % of Benzoylperoxide Irritant and risk of explosion
4. Aesthetic Autupolymerisat,Liquid	Mixture of Methyl methacrylate stabilizer, Dimethacrylate and catalyst	90-95% of Methylmethacrylate <5% of Butandiole dimethacrylate Highly Flammable and Irritant
5. Modelling Waxes	Blend of vegetable and mineral waxes	Skin burn if contacted to molten wax
6. Lastic Universal (Hardener Paste)	Organiton compound, mixture of silicic acid/ esters	Irritant to eyes
7. Separating Fluid	Mixture of water and sodium alginate, borax, glycerine and dye	None
8. Alginmax	Sodium Alginate Sodium, Phosphate, Magnesium Oxide, Magnesium Carbonate, Calcium Sulphate, Potassium Titanium Fluoride, Distomaceous Earth	Dust generation

4.3 Procedure in making Dentures

There are two types of dentures as mentioned earlier: the Complete and Partial Dentures. These dentures have almost the same process but in somehow have slight difference in material used. For instance, in complete dentures it can be fully made of acrylic resins or the lower impression will have a wire to make it stronger. On the other hand, a partial denture is can be made with fully metal and with a little resin or none at all applied on it.

4.3.1 Steps in making Complete Dentures /1/

1. Preliminary Impressions

It is the first step in making dentures where the preliminary impression of denture is done to measure or take a model of a patient's mouth. Using a powder alginate that is mixed with water to make it glutinous and it is putted into the ACCU-tray kit almost full.
Then it is put inside the patient's mouth to get the formation of their mouth. After that, the alginate model of mouth is modified by using wet cement to transfer it to form a stone cast model. A small amount of alginate, water and cement is the waste product in this step.

2. Constructing Custom-Made Acrylic Impression Trays

When the stone cast model is ready, the next phase is making a custom acrylic tray in order to get a better impression. By mixing polymer (powder) to monomer (liquid) to dissolve the powder base and combining it polymerization process.

When the ready made acrylic resin is ready, it is then set into the stone cast model. When setting the acrylic resin to the stone cast has to be done quickly if it is getting dry more monomer is added to make soften and to wet the polymer longer. It is then laid in hot water and with air pressure for about 1 Pa in 5-10 minutes. The waste products in this step are hot water and acrylic resin.

3. Trimming Acrylic Tray

After 5-10 minutes the acrylic tray is ready and it is needed to be trimmed to desired size and shape that would fit in the patient's mouth. By using a manual trimming device to re-shape and take unnecessary acrylic resin on it. Particulates are the emission and waste produced in this step.

4. Second Impression

From the trimmed acrylic tray a new set of impression is taken from the patient's mouth by using base paste and medium paste together. It is then put in the acrylic tray and positioned inside the patient's mouth for a certain period of time until it is fully formed into the mouth's patient.

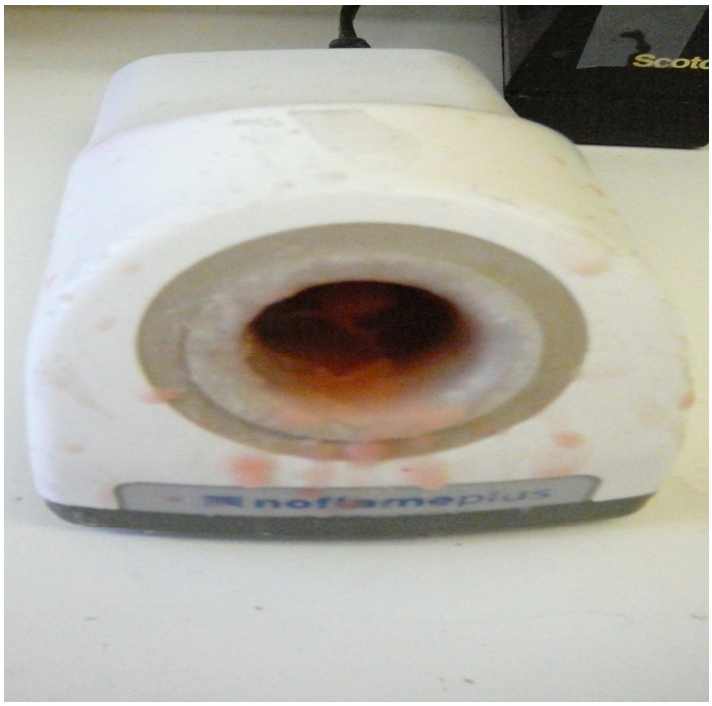
The next is making a stone cast model out from the hardened paste impression and setting it on the articulator for the next pace of the work. Mixed pastes and cement are the waste produced in this step.

Picture1. Stone Cast Impression

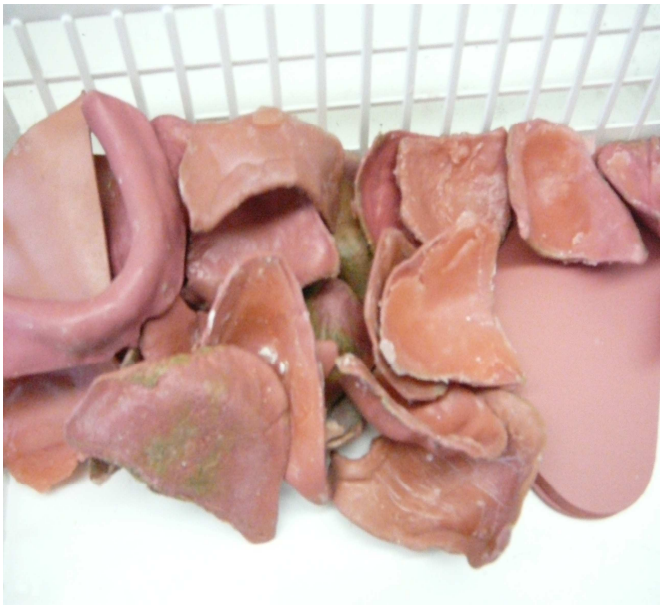
5. Making a Master Cast Model

Making a master cast model is by using a wax that is easily to be melted. A wax wafer base plate is used to support and reline denture accordingly and to endure the footage of eccentric and centric positions.

One piece of wax is not enough to make one impression it is melted by using a heating machine and a metal spatula to smoothen the wax and also remove excess wax in the wax impression. The stone cast model is followed accordingly and with the help of articulate to see whether the upper and lower impressions are in right position or places of biting blocks of the wax impression.



Picture2. Heating device for wax impress



Picture 3. Wax wafer base plate

Picture 4. Wax impression with teeth

6. Setting-up Teeth

When the wax model is ready the teeth are allocated accordingly to its places. Heat energy is used to melt the wax to soften it so that the teeth will be assembled easily. Excess wax on the teeth is removed to

prevent acrylic resin goes through the teeth when putting acrylic resin. The wastes produced are wax and dusts coming from the teeth when removing or re shaping the teeth for better set-up of teeth.

7. Setting-up Acrylic Dentures

When the final impression and master casting is done, making acrylic dentures is next. The first thing to do is to boil water in a kettle about 1.5 litres and using half flask metal for modelling of the acrylic dentures. C-silicone and hardener paste is mixed together for a short period of time and spread it all over the wax dentures.

For upper and lower dentures the total used of cement is about 200 grams and the amount of water is about 100 ml depending on how muddy the mixing of cement and water as you want.

Soap is used to separate the upper and lower half flask metal. It is spread around the cemented area on the lower flask metal and the upper flask is placed on top of the lower flask and filled with cement. Then it is placed on the presser to compressed the inside component of the half flask metal.

When the cement is fully hard enough, it is then placed in hot water for about 10-15 minutes to dissolve the wax inside the flask. It is then opened and the wax is removed by a hot water with soap on it. The stone cast impression should be free of wax. The wastes produced in this step are water, melted wax, soap, C-silicone with hardener paste and cement

Picture 5. Half flask metal

8. Acrylic Dentures

As the stone cast model is ready, mixing polymer and monomer to produce acrylic resin. 20 ml of monomer and 41 g of polymer is used for both upper and lower dental prosthesis. First, separating fluid is

spread around the cemented area so that it would be easy to open the half flask and the separating the cemented area from the acrylic resins. Then it is pressed into a bench press for a couple of minutes to compressed the inside acrylic resin in the half flask.

It is then put into a heating machine with water inside and stays for two and half hours in more than 100°C temperature that emitted water vapour during the process.

9. Trimming Dentures

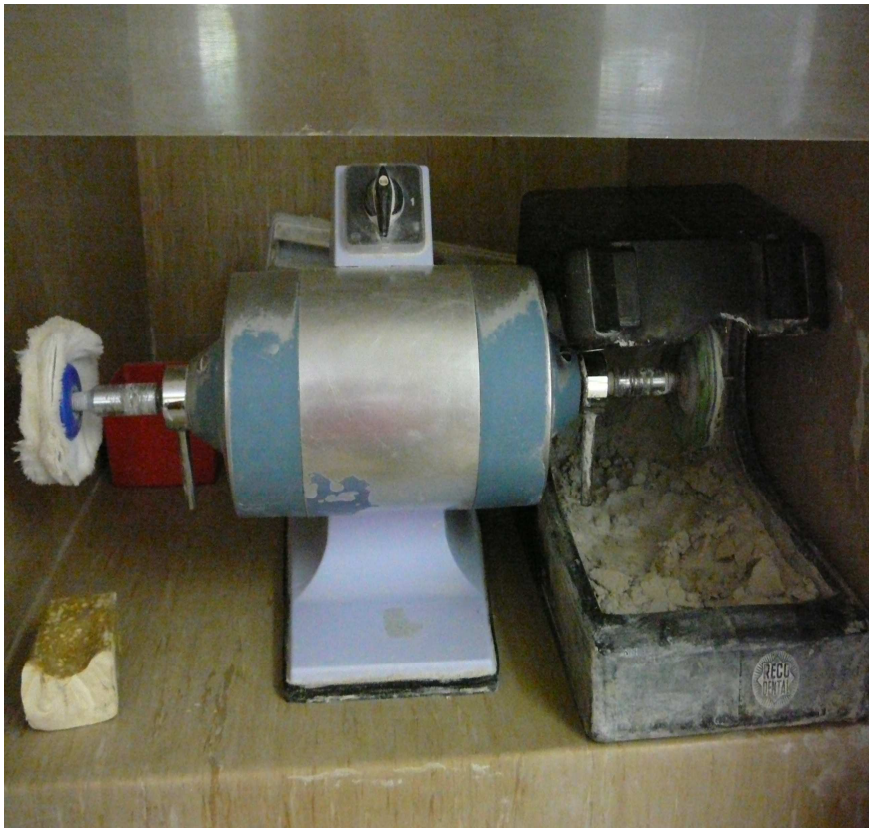
The half flask metal is taken out from the pressurized machine and it is opened to remove the fully made acrylic dentures. Excesses resin trimmed by using a trimming device for dental products. The outline of the dentures is followed accordingly and avoiding taking too much

resin in the dentures. The wastes in this step are dried cement and particles from the trimmed acrylic denture.

Picture 6. Trimming device

10. Polishing

The final step is making it shine and fine looking dentures. In this step, a fabric material, brush, bar wax and pumice are used to smoothen the surface to avoid the patient get wounded in using a rough surface of the dentures. Most of the materials in this step are been re-used for other dentures.



Picture 7. Polishing Equipment

Picture 8. Complete Acrylic Dentures(Upper and Lower)

5. INVENTORY ANALYSIS

In this section, the amount of materials and the wastes that is produced is showed in table 2 while in table 3 are its processes, inputs and wastes that will occur during its production . The amount that is used in this data is the total quantities applied in making a complete set of dental prosthesis from upper and lower dental prosthesis. The values of some materials are not applicable because it is used in a very small amount. In figure 3 it shows the cycle of making dentures. The chemical composition of these materials can be seen in table 1 section 4.2.

In table 2, the amount of materials that is inputted into the process is shown and as well as the output while the type of wastes explains what kind of waste it will be after its been used. Some data for the inputs and outputs are not available because the measurement hasn't done and the amount that is applied to the process is very small.

Table 2. Materials and its wastes.

	AMOUNT		
MATERIALS	**USED**	**WASTES**	**TYPES OF WASTES**
1. Alginate	100 g	100g	Dried alginate
2. Water	5-6L	5-6L	Hot water, some with melted wax, small amount of monomer and polymer, cement(white and blue)
3. Cement (Blue and White)	400-500 g	400-500 g	Dried Cement
4. Wax	5g	5g	solid waxes (small pieces)
5. Adhesives	n/a	n/a	Dried adhesives mixed with hardener paste
6. Hardener Paste	n/a	n/a	
7. C-silicone	n/a	n/a	Dried Silicone
8. Polymer	82 g	10 g	Acrylic resin
9. Monomer	60 ml		
10 Wafer Base Plate	3 g	n/a	Recycled
11. Teeth(acrylic made)	Varies on the sizes	n/a	Dusts
12. Separating fluid	n/a	n/a	

The process, inputs and outputs are shown in table 3 but the amount that is used during the process can be seen in table 2. In each process, it has almost the same inputs but having different quantity. The inputs are also the wastes in this case, dried waste is larger than the wet wastes so it mostly foes to the landfill sites for disposal. Water is used almost in every process because it is one of the major resources and needed in every process.

Table 3. Processes and its wastes.

	Inputs		Outputs	
Process	**Products**	**Energy**	**Emission**	**Wastes**
1. First Impression	Alginate, water, cement			alginate, water, cement
2. Acrylic Custom Tray	water, polymer, monomer	Air pressure~1Pa		acrylic resin, water
3. Trimming Acrylic Tray	Acrylic tray	Electricity	dusts/ particles	acrylic resin, water
4. Second Impression	Adhesives			adhesives, acrylic trays
5. Master Cast Model	Cement, water, wax, wax wafer plate	Electricity		cement, water, wax
6. Assembling teeth	teeth	Electricity	dusts from teeth	small waxes
7. Setting-up Acrylic Dentures	C-silicone, adhesives, soap, water, cement	Electricity		C-silicone, soap, water, cement
8. Acrylic Dentures	Polymer, monomer, water	Electricity	water vapour	acrylic resin, water
9. Trimming Dentures	Acrylic denture	Electricity	particulates	acrylic resin
10. Polishing	Denture, pumice, water, bar wax	Electricity	dusts	pumice

The amount of waste is not calculated and measured for a single denture. The most commonly wastes that is produced in this production that is risky to health and environment is the dusts or particulates. Some materials are recycled accordingly if it is still can be use for new application.

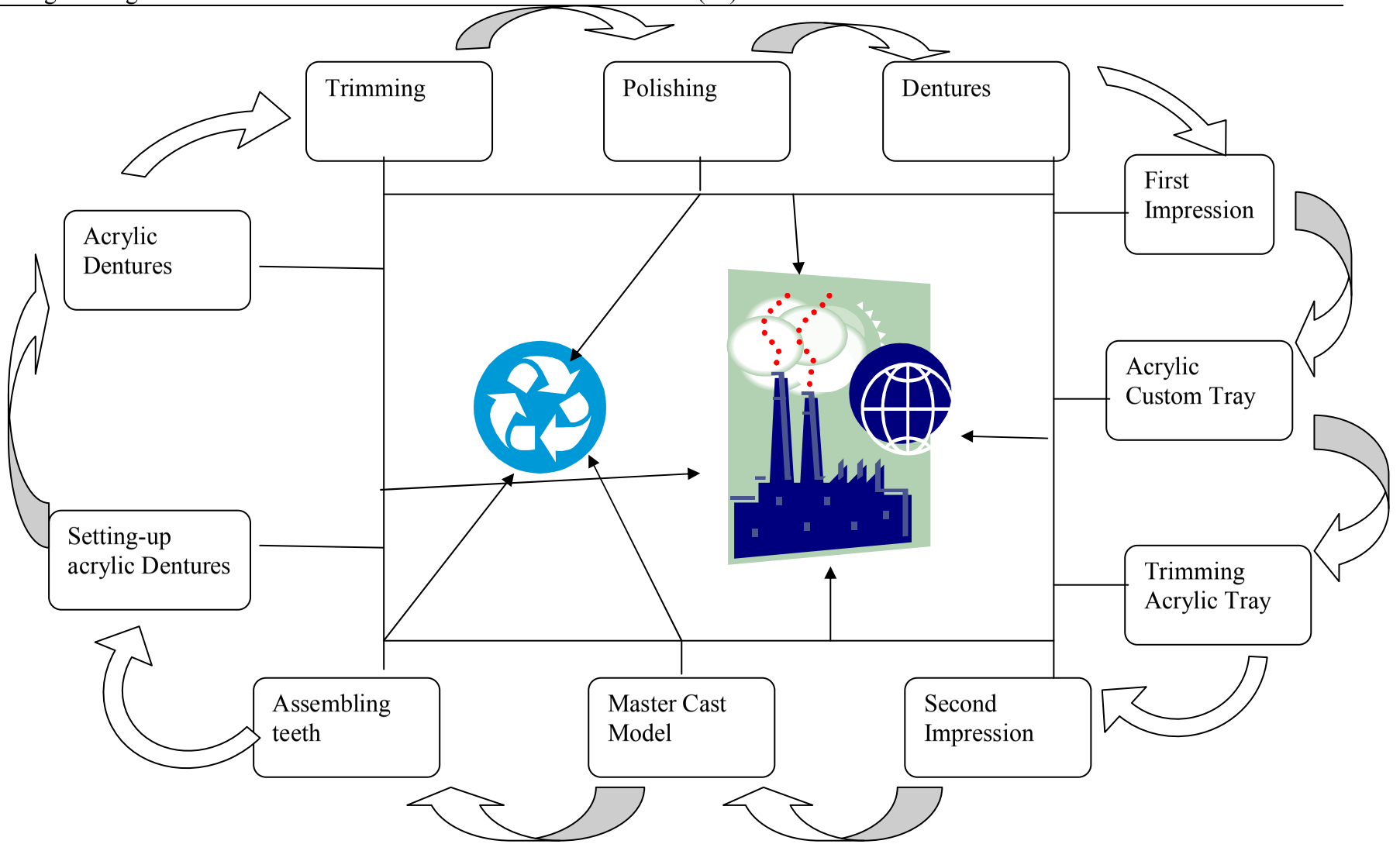


Figure 1. Life Cycle of Denture Production

6. IMPACT ASSESSMENT AND EVALUATION OF RESULTS

According to the inventory analysis of a single production of acrylic resin denture shows that it has a very small percentage of affecting the environment. It doesn't produce too many wastes and European countries have strict legislation towards waste management and chemical usage. The data in the inventories are obtained during the laboratory process of making dentures. Assuming that the process in making dentures for a single unit of prosthesis is producing about 5 kg of solid wastes depending on

Referring to the Handbook of Life Cycle Assessment, the lists of chemicals and the amount that is allowed to produce that may have an effect on the climate change, depletion of abiotic and biotic resources, human toxicity, ecotoxicity and others are given in the book. /3/

As the main materials in making dentures are polymer and monomer which are mainly produced by chemically and it has low amount of hazardous chemicals. According to the data sheet of the polymer and monomer products, it is not allowed to be disposed into the water system and soil directly because it may contaminate the marine and land ecosystem with the hazardous components present in the monomer product.

The materials used in making dentures varies from the patients condition whether he or she has an allergic reaction towards the materials that was been used. If a patient has an allergy reaction another materials were used that is basically made for a person that has an allergy. The longest life span of the denture is for 5 years after that the denture will be repaired or added acrylic resin for better fit in patient's mouth. In between that year, there might be some damages will occur like missing tooth or it is broken then it is fixed accordingly were the problems occur.

Repairing of denture is almost the same as making a new denture but skipping some process such us preliminary impressions, master cast model, etc. Repairing dentures can be done in less than 2 hours depending on the types of damage on dentures and also the use of materials is less than new denture.

The materials used in this process are accepted in EC directives especially the liquid ones that contains hazardous chemical components. The quality of material that was used in this process has a good quality and safe to environment. /5/

10	**Stability and reactivity**	
10.1	Thermal decomposition	> 250 °C
10.2	Hazardous decomposition products	Product may decompose at elevated temperatures generating vapours which could be irritating (Methylmethacrylate). None, if used in accordance to instructions.
10.3	Hazardous reactions	none known
10.4	Further information	None.
11	**Toxicological information**	
11.1	Acute toxicity	Polymethylmethacrylate: The oral LD50 for rats is > 10'000 mg/kg. Benzoylperoxide: The oral LD50 for rats is > 7'710 mg/kg.
11.2	Subacute / Chronic toxicity	In rare cases can cause an allergic reaction. No adverse effects anticipated by this route of exposure incidental to proper industrial handling.
11.3	Further information	Dust can irritate eyes and respiratory passages.
12	**Ecological information**	Non soluble in water. German 'Wassergefaehrdungs Klasse (WGK): not dangerous to water No ecological problems to be anticipated if properly handled and used.

Figure 2. Toxicological information of Powder Polymer
Source: Safety Data Sheet. CANDULOR Company. 12 March 2008 /4/

10	**Stability and reactivity**	
10.1	Thermal decomposition	None, if used in accordance to instructions.
10.2	Hazardous decomposition products	None under normal conditions of storage and use.
10.3	Hazardous reactions	Polymerises in the presence of radical initiators (e.g. peroxides). Polymerisation with heat build-up may occur.
10.4	Further information	The product is highly flammable. Avoid ignition sources such as flames or spark producing equipment.
11	**Toxicological information**	
11.1	Acute toxicity	LC50/Rat: 3'750 ppm Oral LD50 for rats: 7'900 mg/kg
11.2	Subacute / Chronic toxicity	Prolonged or frequently repeated skin contact may cause allergic skin reactions in some individuals.
12	**Ecological information**	The product must not enter effluent, ground water, surface water or the soil.

Figure 3. Toxicological Information for Liquid Monomer
Source: Safety Data Sheet. CANDULOR Company. 12 March 2008 /4/

Even though it uses a small amount of materials and resources as well as produces less waste it still affects the human health in the long run for the workers. The amount wastes per month vary the number of patients who needs a new prosthesis or needed repairing. The biggest problem in this production is during the trimming process of the acrylic resin. Some chemical composition can be found in ECHA websites but it is also stated on products material safety data. /5/

For instance, monomer has a hazardous component such as MMA and Butandiole dimethacylate that has a CAS no. of 80-62-6 90 and 2082-81-7, respectively. On the other hand polymer has PMMA and about 2 % of Benzoylperoxide (CAS No. 94-36-0) is added to make the polymer product. According to the safety data sheet

for liquid monomer, it takes 3 750 ppm of concentration for rats to be affected by the products at LC50 acute toxicity test. For oral dosage on rat is 7900 mg/kg in LD50 application dosage (Refer to figure 3 above). /4/

As shown in figure 2, polymer product has two chemicals that have an acute toxicity on rat. The LD50 for PMMA that may harmful to environment is 10 000 mg/kg and 7 710 mg/kg for Benzoylperoxide. It means that a small amount of polymer and monomer that is been using for production is lesser than the toxicity level that could harm the environment. /4/

Referring to the products safety data of the materials, it has shown that the products are less hazardous and proper disposal and handling of chemical is needed to avoid contamination to the environment. Most of the wastes are solid material that it will go through the landfill that is handled by each Municipal sector in Finland and it is treated as on of the household wastes.

There are some products to maintain the quality of the dentures for a long period. For example is *Polident Dental Cleanser*, a dental prosthesis cleaner instead of using toothpaste to clean the denture Corega is used as a replacement. It may occur as tablet that dissolves into the water; its chemical components are shown figure 4 below and its hazard detection. This product doesn't have any potential to make severe impacts into the environment and it is safe to use but it is not drinkable or can be chew by human. (Refer to figure 4 and 5) /4/

Multi-language response

2. COMPOSITION / INFORMATION ON INGREDIENTS

Ingredients	CAS RN	Percentage
CITRIC ACID	77-92-9	20
SODIUM CARBONATE	497-19-8	11
POTASSIUM PEROXYMONOSULFATE	10058-23-8	4.3
SODIUM PERBORATE MONOHYDRATE	10332-33-9	10
NON-HAZARDOUS INGREDIENTS	Unassigned	54.7

3. HAZARDS IDENTIFICATION

Fire and Explosion	Expected to be non-combustible.
Health	Exposure might occur via ingestion; skin; eyes. Accidental exposure or contact might produce: irritation; redness; pain. Health effects information is based on hazards of components.
* Environment	No information is available about the potential of this product to produce adverse environmental effects.

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Figure 4. Chemical Composition of Corega
Source: Safety Data Sheet. GSK. 28. April 2008 /6/

11. TOXICOLOGICAL INFORMATION

Oral Toxicity	Ingestion may lead to irritation of the throat and difficulty breathing.
Skin Effects	Minor irritation might occur following direct contact.
Eye Effects	Irritation might occur following direct contact with eyes.
Sensitisation	Sensitisation (allergic skin reaction) is not expected.
Genetic Toxicity	Not expected to be genotoxic under occupational exposure conditions.
Carcinogenicity	No components are listed as carcinogens by GSK, IARC, NTP or US OSHA.
Reproductive Effects	Not expected to produce adverse effects on fertility or development under occupational exposure conditions.
Other Adverse Effects	None known for occupational exposure.

12. ECOLOGICAL INFORMATION

Summary	No information is available about the potential of this product to produce adverse environmental effects. This material contains at least one ingredient that has been tested, and which may be harmful if released directly to the environment. Consult the MSDS of each ingredient for specific information about potential environmental effects. Appropriate precautions should be taken to limit release of this mixture to the environment. Local regulations and procedures should be consulted prior to environmental release.

Figure 5 Toxicological Information for Polident Dental Cleaner
Source: Safety Data Sheet. GS: 28 April 2008 /6/

7. CONCLUSION

Generally, production of denture can't be a big problem in environment but to the person who is doing the work because he or she is exposed to the chemicals and processes especially in trimming step. In trimming of dentures, it produces small particulates from the acrylic resins material that may irritate to skin and eyes. It is also dangerous when you breathe in the particles because it is not good to respiratory system and as well as if a person is having a lungs problem.

Each company has their own different materials used in making dentures and the quality of the material and end products varies from how it is made and materials applied. There some materials that are least expensive but have poor quality as a final product.

Europe countries have strong environmental legislation that works quite well in households, agriculture and industries. The environment is protected and sustained as much as possible to balance and produce less environmental impacts into the atmosphere. Chemicals and other products are goes through a system where it is assessed accordingly and identify whether it is hazardous or dangerous or safe to dispose and use for industrial and household purposes.

Dental prosthesis belongs to the medical field, so, the products should be safe to human and not poisonous or dangerous. If the product is safe to human then it is must be safe to environment but except for those chemicals that is used to make acrylic resin. MMA and PMMA are chemicals that cannot be directly used by a person without proper protection such as gloves and masks.

MMA and PMMA are needed to be handled carefully and disposal of these components to water system in large amount may cause problem into aquatic ecosystem while if it will be disposed directly to soil may damage the soil fertilization. /4/

The inventory analysis and impact assessment is basing on each products safety data sheets and at the same time the quantity that is obtained during the process of

making dentures. Software program for material inventories and assessing the process would help to show and provide more specific and clearer data and results about its production emission, wastes, environmental impacts and its materials exploitation.

For instance, Umberto Software was supposed to be used for inventory analysis but using this software was not successful and difficult to use even though the data and information is known in the process. A deeper knowledge on how to use Umberto is very needed to manage and know how to use the Umberto effectively.

GLOSSARY

Acrylic resin
- A mixture of monomer and polymer

Monomer
- Liquid base in making resin that is composed by chemicals

Polymer
- Powder base that is used to mixed with monomer

Prosthesis/ Dental Prosthesis/ Denture
- Replacement of missing teeth

REFERENCES

Books

1. BUCHMAN, Jack and MENEKRATIS, Ajax. *Complete and Anchored Dentures*. J.B. Lippincott Company. USA. Copyright 1974. ISBN 0-397-50336-9

2. GIUDICE, F., LA ROSA, G., RISITANO, A., *Product design for the Environment: A Life Cycle Approach*. Taylor and Francis Group.2006. USA. ISBN-10: 0-8493-27229(Hardcover). ISBN-13:978-0-08493-2722-3 (Hardcover)

3. GUINEE, Jeroen (ed). *Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards*.Kluwer Academic Publishers. Netherlands. 2002. ISBN 1-4020-0228-9.

Internets

4. CANDULAR AG. Safety *Data Sheet: Polymer and Monomer Polymerisiat*. Copyright 2002- 2008. Cited: 12 March 2008. Online Available at WWW:
http://www.candulor.com/index.php?id=483
http://www.candulor.com/uploads/tx_stdokdb/Aesth_AP_Pu_e-1177_5_2007.03.3.pdf(POWDER)
http://www.candulor.com/uploads/tx_stdokdb/Aesth_AP_Fl_e-1108_5_2007.03.30.pdf (LIQUID)

5. EUROPEAN CHEMICAL AGENCY. REACH. Last Updated: 22 April 2008. Cited: 30 May 2008. Copyright 2007. Online. Available at WWW:
http://echa.europa.eu/home_en.asp

6. GLAXOSMITHKLINE. *Safety Data Sheets:Polident Dental Cleaner*. Updated 12 June 2008. Copyright 2001-2008. GlaxoSmithKline plc. Registered in UK. Cited: 1 June 2008. Available at WWW:
http://www.gsk.com/products/consumer_healthcare/index.htm
http://www.msds-gsk.com/consumer/12697006.pdf (Safety data sheet)

7. IVOCLAR VIVADENT. Separating fluid. Copyright 2008. Cited: 12 April 2008. Online. Available at WWW: http://www.ivoclarvivadent.com/content/products/detail.aspx?id=prd_t1_837884628&product=Separating+Fluid

8. KEMDENT. Modelling Wax:Astynax. Associated Dental Products Ltd. 2008. Cited: 5 May 2008. Online. Available at WWW: http://www.kemdent.co.uk/LabGroupDetails.asp?DescCode=Astynax

9. KETTENBACH. *Dental: Impression Materials*. Kettenbach GmbH & Co. KG. 2008. Cited: 30 April 2008. Online. Available at WWW: http://www.kettenbach.com/ http://www.kettenbach.com/pdfs/SDB-GB-Lastic-universal-PH-N-01-11.pdf(Safety Data Sheet Hardener Paste)

10. ZHERMACK SPA. *Download: Safety Date Sheet*. Cited: 20 April 2008. Online. Available at WWW: http://www.zhermack.com/Technical/Silicones/Masks/C400791.kl (safety data sheet)

11. PIRKANMAAN JÄTEHUOLTO OY. Cited: 23 June 2008. Updated: 28 April 2008 . Available at WWW: http://www.pirkanmaan-jatehuolto.fi/dev/AKP.nsf/frameset/frameset?opendocument&main=/dev/Contman.nsf/0/55549A2F9BD172A7C2256FDA00255155

12. Owned Pictures. Ma. Jovita Tortola