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Review

Ecological governance in rural areas: Finnish approaches and practices

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Along with the development of rural areas, rural ecological issues caused by inappropriate anthropogenic activities have not been drowned in the contexts of global environmental problems. The acceleration of rural development in developing countries would result in a series of potential threats to the deteriorating environment, if no effective governance strategies were applied. The significance of ecological governance in rural development has been widely recognized. Nonetheless, literature information available on successful approaches for ecological governance in rural areas is limited or fragmented. As a successful country in both urban and rural environmental protection, Finland has the advanced mechanism of ecological governance applied in all sectors of society. Based on an exploratory investigation, this study generally illustrates and discusses the Finnish approaches and practices in rural ecological governance. As a context of this research, the Finnish rural development in general has been discussed. Subsequently, this paper illustrates the Finnish approaches and practices in the governance of rural water, waste and land, followed by the discussion of the enlightenments for the promotion of rural ecological governance in developing countries. The main contribution of this paper resides in the experience sharing and learning to help developing countries or regions build up better ecological governance to support their rural development.

Key words: Ecological governance, rural development, environmental instrument, Finland.

INTRODUCTION

Over the past several decades, the global economy together with the population has been booming. Through industrialization, urbanization and modernization, the world is witnessing severe environmental problems due to inappropriate anthropogenic activities (Sivrikaya et al., 2011; Xie et al., 2014). Especially the developing

countries, such as China and India, have over-emphasized the economic development, bringing in the most serious environmental problems on the planet. Environmental terms, such as global warming and climate changes, water pollution and biodiversity loss, are not new at all for human beings. Natural disasters

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resulting from global warming can give rise to tremendous damages to local areas in terms of the economy, and people's health and safety (Cai et al., 2012). Water pollution from agriculture, industry, and municipalities is a major global problem. Nutrient imbalance in water can lead to eutrophication, causing disasters to the respective ecosystems and risking the integrity and development of biodiversity (Zhu and Ketola, 2011; Zuo et al., 2011).

Environmental degradation in developing countries is rapidly accelerating not only in cities but also in rural areas. Since stricter environmental regulations have been employed in urban regions, polluting corporations have moved to rural areas where environmental regulations still remain weak (Yu, 2014). Therefore, rural areas of developing countries have been shouldering the ever-increasing environmental burden. According to Massoud et al. (2009), up to 82% of rural populations in developing countries lack access to sanitation services. Wastewater from household in rural areas is found to flow into rivers, lakes and seas without any treatment, polluting the environment and threatening people's health and food security. The wastes in rural areas cannot be efficiently tackled, eroding the land and threatening the local hygiene (Al-Salem et al., 2010). It is reported that rural pollution during urbanization and economic development has contributed to the prevalence and exacerbation of allergic diseases in many Asian countries (Leung et al., 2012). In addition, rural areas in developing countries also witness a lack of efficient land resource governance, causing forest shrinkage and the change of agricultural land usages. The number of forest-dependent poor people in rural areas is increasing, and it is believed that 2 billion rural poor across the globe rely on degraded forest for their livelihoods (Kettle, 2012). Farmland use change is another emergent issue in developing countries. Taking China as an example, a serious replacement of farmland with urban and rural settlements, construction land and artificial ponds has been occurring, due to rapid industrialization and urbanization (Long et al., 2009).

As mentioned above, the accelerating rural development in developing countries would result in a series of potential threats to the deteriorating environment, if no effective governance strategies were applied. Ecological governance is significant in rural development. Ecological governance refers to the control and management of the environment and natural resources during the processes of decision-making (Robertson and Choi, 2010). Ecological governance issues mainly include water pollution, waste disposal, and soil deterioration, and it requires human beings to adjust their behaviors of living on the earth. Through relative rules, practices, policies and institutions, ecological governance shapes how humans interact with the environment, which helps us move towards a more sustainable future.

The instruments for ecological governance consist of law, economic and policy methods, which have been well developed in the context of current ecological governance. Especially new policy approaches such as tradable permits have obtained increasing political importance for ecological conservation in the past decades (Mann and Absher, 2014). Effective ecological governance at local, state and international level is critical in an attempt to seek solutions to these challenges (Pincetl et al., 2011). Many efforts have been made to establish participative, collaborative processes that contribute to the effective ecological governance (Robertson and Choi, 2010). Evans (2010) proposes integrated, collaborative, and adaptive governance, where the inclusion of a diversity of stakeholders and their knowledge and values in governance processes is advocated. Tang and Tang (2014) have illustrated incentive dynamics for collaborative governance in land and ecological conservation and found how various interactive dynamics affect efforts applied by stakeholders from multiple sectors. Investigating watershed ecological governance, Parkes et al. (2010) suggest that integrated governance is more likely as a basis for the fosterage of health, sustainability and social-ecological resilience.

OBJECTIVE AND STRUCTURE OF THIS STUDY

Finland is considerably successful not only in economic growth but also in environmental protection over the last thirty years. According to several international indicator comparisons, Finland is successful in competitiveness. The World Economic Forum (WEF), for instance, shows that Finland was the world's most competitive country in 2005 and ranked second after Switzerland in 2013. This success stems from substantial natural resource endowments, a low population density as well as effective governance of ecology. As to ecological governance, Finland's advantages include highly effective environmental legislation, and the ways that environmental protection is taken into account in all sectors of society (Lyytimäki, 2007). Ecological governance has a key role to play in the Finnish environmental protection not only in urban areas but also in rural regions. However, there is fragmented information published about the Finnish approaches and successful experiences of rural ecological governance in practice.

This is an exploratory study and it generally discusses the Finnish approaches and practices in rural ecological governance. Thus, it can add some advanced information into literature to help developing countries or regions build up better ecological governance in rural areas. In the coming sections, we first introduce the Finnish rural development. Afterwards, rural ecological governance approaches and practices will be presented and discussed, followed by enlightenments for developing countries to promote their rural ecological governance. Finally, a summary of this study will be concluded.

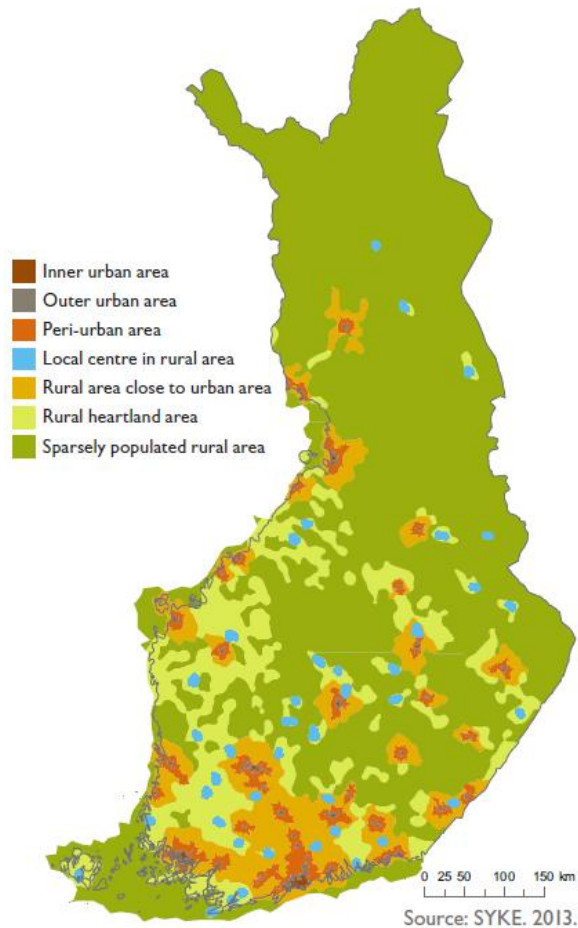


Figure 1. Urban-rural classification in Finland (Putkuri et al., 2013).

FINNISH RURAL DEVELOPMENT

As we all know, it is hard to define rural areas. One of the most popular definitions is based on a three-level division: urban-adjacent rural areas, rural core areas and remote rural areas (Muilu, 2010). In the last 2 decades rural issues have been increasingly researched in many countries. Undoubtedly, rural development is a hot topic, since it refers to the process of life quality improvement and well-beings of people who live in rural areas. One obvious characteristic of rural development is urbanization. During the urbanization, the drift of population away from the countryside is one of the main features, which have affected the regional structure in many countries. The process for the movement between countries might be different. Education, entrepreneurship, environment and infrastructure have important roles to play in developing rural regions. Unlike urban areas, rural regions are highly distinctive from one another. Therefore, a large variety of rural development approaches exist globally and Finland has its own properties in contrast to other countries.

Following Iceland and Norway, Finland is the third European country with the sparsest population (Muilu and Rusanen, 2003). According to the World Bank, population density in Finland was last measured at 17.7 inhabitants/km² in the later time of 2012. Finland has broad rural areas (Figure 1). However, the current rural population occupies only 16.15% of the total population in Finland. As shown in Figure 2, three development phases are classified in Finnish rural evolution: Urbanization, joining the EU, and globalization (Kivinen et al., 2006). As to each stage, some distinct properties are presented. The changes in rural population, age structure, entrepreneurship, facilities and industrial structure evidently occur during the Finnish rural development. Under this situation, environmental pressure has been increased accordingly. How to prevent and control rural pollution is not only an assignment but also an artwork for Finland.

ECOLOGICAL GOVERNANCE

The Ministry of the Environment formulates the Finnish Government's environmental policies such as ecological governance and environmental protection. The Ministry supervises the environmental work undertaken by the regional and local agencies. The Ministry is also responsible for strategic planning and management, new legislation establishment, and environmental co-operation at international level. Here, the main ecological governance in Finnish rural areas will be presented and discussed, including the governance of water, waste and land.

Water governance

Almost one million residents in Finland live in houses where the centralized sewage systems are not extended. It is reported that there are about 350,000 onsite wastewater systems serving about 300,000 permanent residences and 450,000 holiday cottages (Matikka, 2013). The discharge of phosphorus into water body in Finnish rural areas witnesses 50% higher than that in urban areas (Ruokojärvi, 2007). Rural waterbodies are subjected to eutrophication (Zhu et al., 2011) and thus rural water governance is essential in Finland. Compared to other EU countries, Finland has thorough and strict rural wastewater treatment policy, since a lot of lakes are located in Finland and they are sensitive to eutrophication (Matikka, 2013).

The constitution of Finland defines that every citizen is responsible for the environment, and authorities shall endeavor to guarantee every one the right to a healthy environment. The Environmental Protection Act states the general requirement to treat waste waters using appropriate methods to prevent any threats to the environment. In addition, the Water Services Act regulates

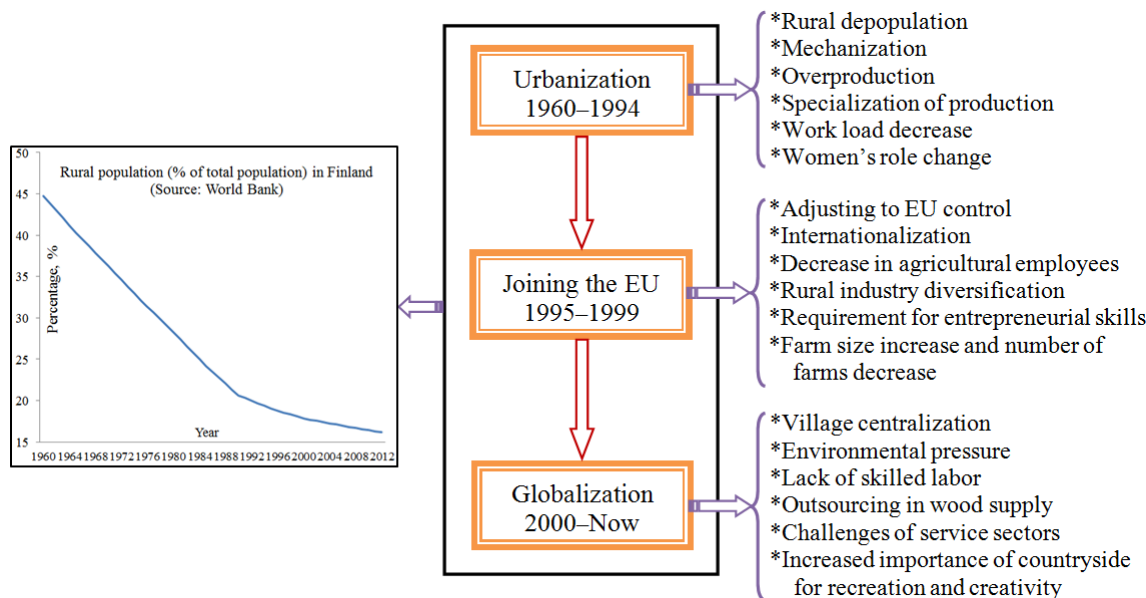


Figure 2. Rural development in Finland from the 1960s to now.

that every household which is within the municipal sewage network is required to be connected to the system. Targeted to treat rural wastewater, the Onsite Wastewater System Decree, which was established in 2004 and updated in 2011, sets minimum requirements for wastewater treatment in areas outside sewer networks. The decree stipulates that at least 90, 85 and 40% of the organic matters (BOD₇), total phosphorus and total nitrogen should be respectively removed from wastewater in rural areas. The local municipality who is the supervising authority, might also have their own stricter regulations.

Whenever it is possible, rural wastewater should be linked into the sewer network system for centralized treatment if costs are affordable. Due to the sparse population distribution in rural regions, decentralized wastewater treatment methods are preferable in Finnish villages (Figure 3). The wastewater within a village or from nearby households can be collected together, and a joint sewer system can be built. For example, 560 small wastewater treatment plants in Finnish rural areas were designed for over 5000 inhabitants in 2004 (Santala et al., 2006). However, a joint treatment requires share holders to cooperate in division of labor, allocation of costs as well as agreement of maintenance responsibilities.

If joining a centralized sewer system or building a joint treatment plant is not feasible, plenty of onsite wastewater treatment systems which are popular in Finnish rural regions can be considered for decentralized wastewater treatment. One approach is to treat the toilet waste and washing waters separately. This method is well used in summer cottages in Finland. A dry toilet (composting toilet) can be installed, and washing waters

can be treated separately with some simple methods such as leach field or sand filter. Modern dry toilets are found to be comfortable and odorless when properly used (Matikka, 2013). Another prevailing approach is to treat wastewater in a combined manner via a two- or three-stage septic tank and the subsequent treatment systems, such as batch plants, active sludge plants, biofilter, sand filter, biological-chemical plants and constructed wetlands (Zhu et al., 2013). Among all of the systems, a buried sand filter equipped with a separate unit for phosphorus precipitation is well employed in Finnish rural areas (Tuukkanen, 2006).

Waste governance

The rural population has been decreasing for a long time in Finland. Usually, the villages are small, and industry is also sparsely distributed. Thus, it is necessary to centralize wastes from different villages and deliver them to a certain place for the subsequent disposal (Figure 4). Waste governance in Finland aims to prevent the generation of wastes and promote the recovery of waste materials. During the waste governance a certain order of priority should be considered as follows (Ministry of Environment, 2013): The generation of wastes should be avoided; if wastes are produced, they must be considered for reuse or recycling; if recycling is not possible, wastes must be used to produce energy; and wastes may be landfilled only if recovery is not economically or technically viable. In 2008 the Finnish government established the National Waste Plan, where around 20, 50 and 30% wastes will end up in landfills, be

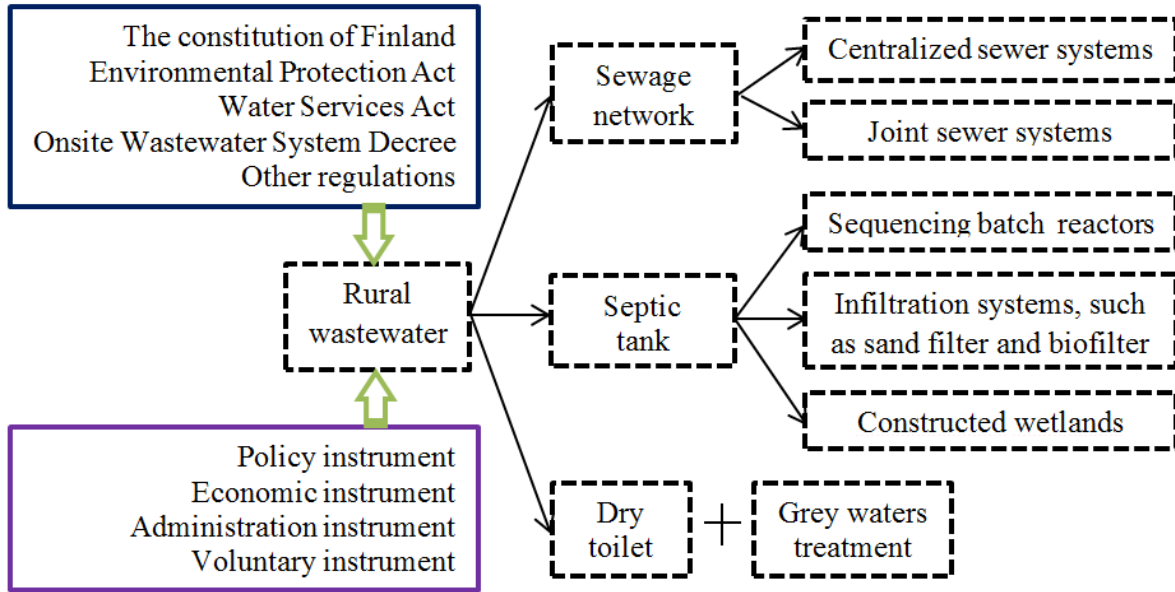


Figure 3. Finnish rural wastewater management and treatment technologies used in practice.

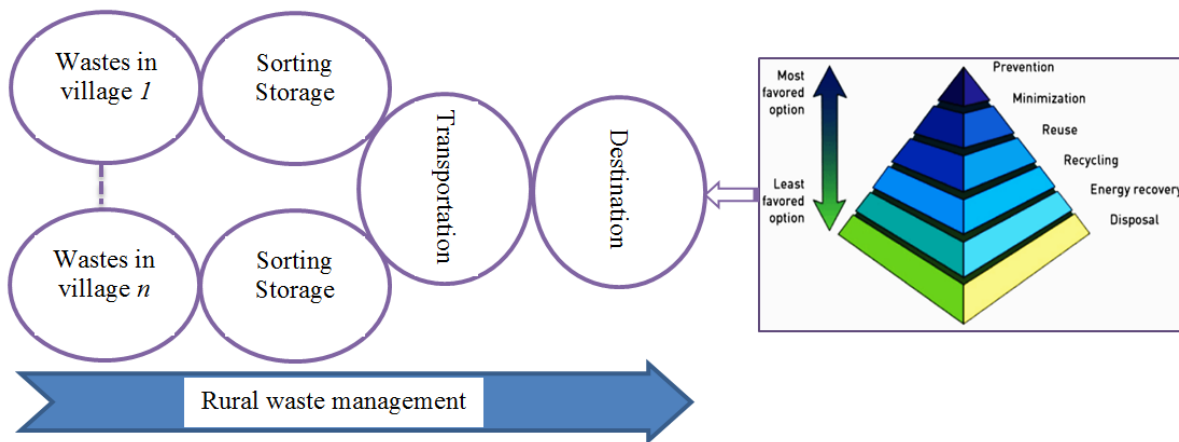


Figure 4. Rural waste governance in Finland on the basis of the waste disposal hierarchy.

recycled and be recovered for energy, respectively (Putkuri et al., 2013).

Another characteristic for Finnish rural waste management is effective sorting. This is attributed to Finnish education for environmental protection as well as waste sorting dissemination in rural regions. The sorting of wastes is regulated by Finnish law (Waste Act), and any activities related to littering, burning of garbage and leaving garbage on road sides are prohibited. Finnish rural wastes contain paper and cardboard, bio-waste, glass, metal, wood and plastic, all of which cannot be mixed before throwing (Piippo, 2013).

Property-owners and housing companies are obliged to organize waste collection points and containers. After

efficient sorting by waste producers, wastes should be taken into containers designed for different types of wastes at collection points. After transportation, where logistics are effectively organized by municipal waste companies, municipalities are obligated to organize the utilization and treatment of the wastes in an appropriate way.

In Finnish rural areas, economic instruments are also applied to create incentives for people to act a more environmentally preferable behavior (Finnish Environment Institute, 2010). These instruments include waste charges for the collection and transportation of wastes, oil waste charges for managing oil wastes, drinks packaging taxes for the reuse of drinks packages, and

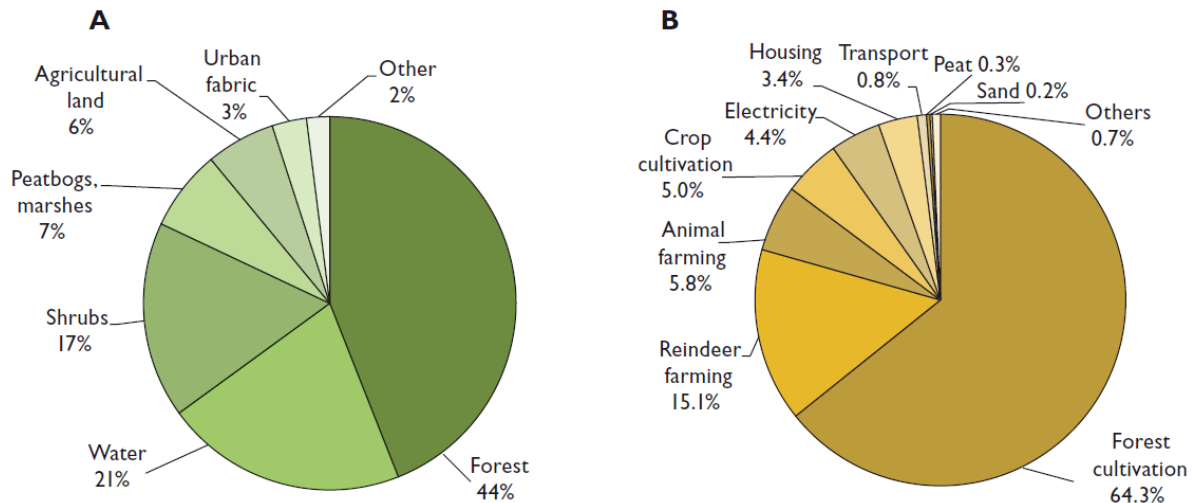


Figure 5. Current status of land in Finland. A: Total land surface coverage; B: Allocation of the inland area to different usages. Source: Mattila et al. (2011).

waste taxes for landfilling.

Land governance

A high-quality environment, which results from well-considered and integrated land use, presents one of Finland's strengths (Ministry of Environment, 2006). The objectives of land governance in Finnish rural areas are to preserve the prerequisites for forestry and agriculture, to diversify industry and business, and to provide good residential conditions. From the land coverage perspective, forests represent the largest share (Figure 5A). The share of agricultural land in the total land coverage is very small, and it maintains the biological diversity. From the land use point of view, forest cultivation accounts for 64.3% of the total, followed by agricultural activities (Figure 5B).

In Finland, land use planning at different levels is always participatory, which means that local communities and stakeholders are involved in all of the planning processes. Agriculture and forestry are practiced in the manner of economically and ecologically sustainable and ethically acceptable throughout the country (Ministry of Agriculture and Forestry, 2013). It is widely recognized that appropriate rural land management can solve five key environmental issues: biodiversity loss, landscape damage, water management deficiency, soil erosion and climate change (Figure 6).

Agriculture has an important role to play in the whole society, since it undertakes the responsibility to preserve the feasibility of farming, maintain managed agricultural landscapes, and provide products such as food for the people and other rural industries. Through the effective management of agriculture, landscape and biodiversity can be protected efficiently. Still, pollution stemming from

agriculture witnesses a positive decrease (Ministry of Agriculture and Forestry, 2014). Due to the more accurate utilization of nutrients and prohibition on the use of synthetic chemical fertilizers and pesticides, organic farming witnesses lower environmental and water loadings compared to conventional agriculture in Finnish rural regions.

Finnish forestry also has potential to help mitigate climate change and reach climate policy objectives through the appropriate usage of the natural forest resources and the production of bioenergy. Finland is the most forested country in Europe, and the share of forest land area in total is 73.9%, 36.1% higher than average value in EU-25 countries (Ministry of Agriculture and Forestry, 2014). In contrast to other European countries, Finland employs stricter regulations for forest protection. The area of protected forests has been tripled over the past 35 years (Lier and Parviainen, 2013). The average size of managed stand, which is the basic unit for forest governance in Finland, is 1.2 ha, the same as the average in Germany, Austria and France (Kellomäki et al., 2005). Forest governance on a mosaic-like basis is throughout the growth and regeneration phase. Seedling stands are managed by cleaning and thinning in the growth phase, while in the regeneration phase seed trees are left standing to seed the site. Each year, two thirds of the area of regenerated forest land, which is equal to about 0.8% of all forest land, is cultivated with seedlings, while one third is regenerated either naturally or by direct seeding (Lier and Parviainen, 2013).

ENLIGHTENMENT FOR DEVELOPING COUNTRIES

During the Finnish rural development, ecological governance plays a key role in rural environmental

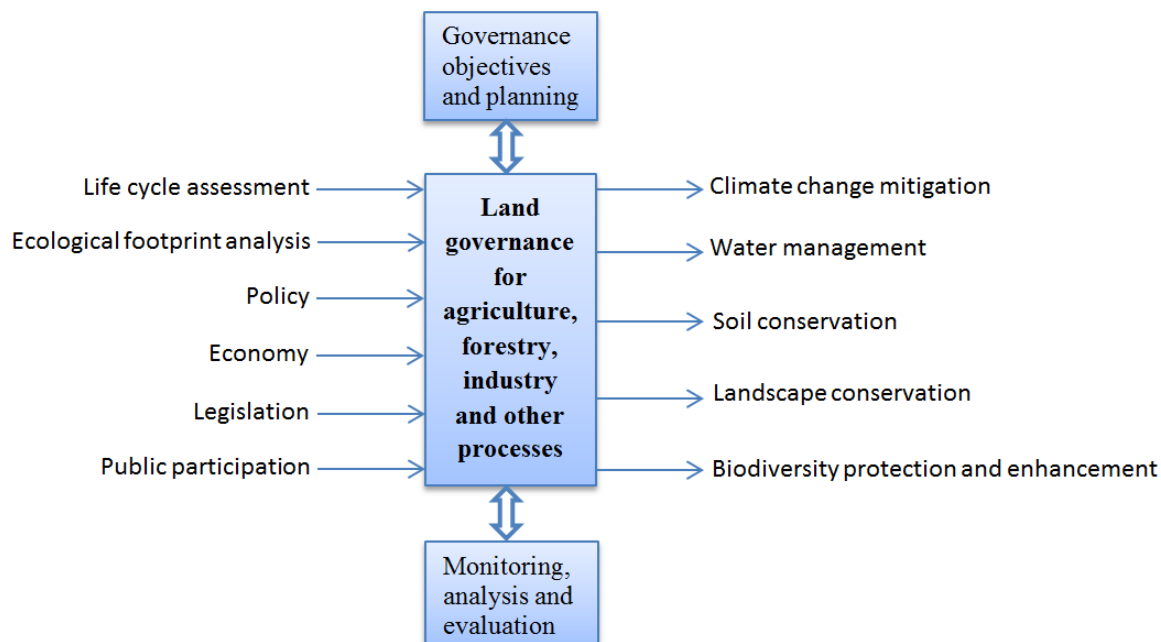


Figure 6. Land governance approaches and potential effects in Finnish rural areas.

protection and construction. The Finnish success has provided some enlightenment for developing countries or regions to promote their rural ecological governance. In order to achieve better rural ecological governance, several key areas should be emphasized as follows:

1. Reduce environmental load to water, soil and air from agricultural sources. Organic farming is recommended, since it will cause less loading to water, soil and air than conventional farming and thus increase local biodiversity (Ministry of Agriculture and Forestry, 2013). The rural areas have good advantages in the access to green manure and compost, which can become the organic fertilizers for crop cultivation. In addition, techniques, such as crop rotation and biological pest control, can also be applied in organic farming.

2. Reduce environmental load to water and soil from household. Developing countries cannot afford the funding to construct centralized facilities and lack the technical expertise to operate them (Zhu et al., 2013). Thus, decentralized wastewater treatment systems can be employed in rural areas. For small communities a decentralized system is a long-term solution with reliable and cost effective performance (Massoud et al., 2009). Environmental policy and reform including funding support concerning wastewater management in developing countries can help promote the process.

3. Minimize the generation of wastes and promote the recovery of waste materials. Villagers might lack knowledge about the waste sorting as well as awareness for this practice. If the wastes in country side can be

effectively sorted, the following disposal will be easy to proceed and the costs will be limited as well. Therefore, some relative dissemination and education is necessary to improve the public awareness and participation of waste management.

4. Maintain various landscapes no matter whether they are used to produce food or other raw materials. Landscapes with native wildflowers, grasses and trees can improve the local environment. In addition, landscapes can contribute to maintaining the habitats of large number of plant and animal species living in farming environments.

The efficient rural ecological governance can provide foundation for the construction of local eco-village (Figure 7), which develops the basic sources of livelihood and the competitiveness of business in the rural areas. Local residents, enterprises, municipalities and associations can be brought together to develop the residential areas, to preserve local culture, to enhance the local skills as well as to build the active network between the rural and urban areas.

CONCLUSION

Finland, as a country with very sparse population, is predominantly or significantly rural. Through urbanization, modernization and globalization, the structure of Finnish countryside has been changed not only in population but also in economy. Agriculture and forestry are still the

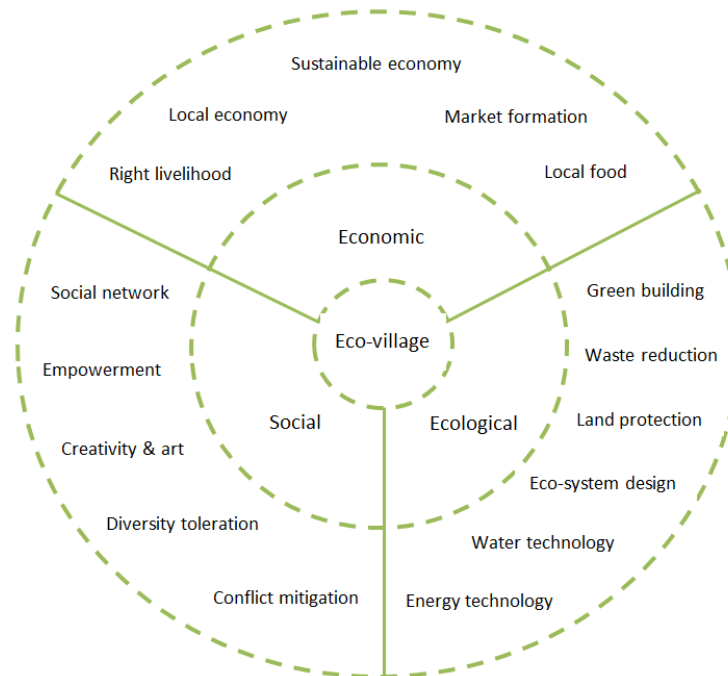


Figure 7. A proposed framework for eco-village construction and its elements.

main sectors during rural development. Along with the development of rural economy and the improvement of life quality, Finnish villagers have been attaching more and more importance to rural environment.

The role of rural ecological protection and management in Finnish rural development has received more and more attention. Finnish rural ecological governance mainly includes the governance of water, waste and land. From the water governance point of view, decentralized wastewater treatment systems have been successfully applied to purify rural wastewater. By following the order of priority applied to waste governance, rural wastes have been reduced through efficient sorting and recycling. From the perspective of land governance, efficient land use planning and regulations have ensured that Finnish agriculture and forestry are operated in an environmentally friendly manner. Organic farming and forest governance via growth and regeneration have contributed to biodiversity maintenance, landscape conservation, water quality improvement, soil restoration and climate change mitigation.

The Finnish approaches of ecological governance in rural development have been introduced and discussed in this paper. Via experience sharing, the study is beneficial to developing countries or regions to establish advanced ecological governance systems. This study may also be viewed as a starting point for practitioners, authorities and stakeholders to understand ecological governance practice in rural regions. Learning from

Finnish approaches, developing countries or regions can decide upon the specific objectives and forms of ecological governance in their rural development, thus hopefully achieving better rural living quality via the construction of eco-village.

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CONFLICT OF INTEREST

The authors have not declared any conflict of interests.
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Full Length Research Paper

Performance analysis of bandwidth and gain improvement of printed wide slot antenna using parasitic patch

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Here, a printed micro strip line fed wide slot antenna with rotated square slot resonator is presented. This article deals with design, modeling and simulation of slotted antenna. A parasitic patch is introduced to improve the gain along with the bandwidth. For bandwidth enhancement, a slotted approach is used in ground of antenna along with rotation in patch and a simple 50 Ω microstrip line fed is used to excite the slot in the antenna. The proposed antenna exhibits the return loss (S11) below -10 dB for the frequency mentioned and the effects of design antenna parameters such as slot width and patch width have been investigated. Results shows that a good amount of bandwidth (approximately 3 GHz) and gain (approximately 8 dB) is achieved ranging from 2.23 to 5.4 GHz which shows its application in world interoperability for microwave access (WIMAX) and wireless local area network (WLAN) bands.

Key words: High frequency structure simulator (HFSS), microstrip patch antenna (MSA), parasitic patch, wide-slot antenna.

INTRODUCTION

Nowadays, the demand for large bandwidth antennas is on rise as ultra wideband becomes more wide spread. Printed slot antennas are widely used in variety of communication systems because of wide-slot antenna as the two orthogonal modes in wide slot antennas are merged to create a wide impedance bandwidth (Kahrizi et al., 1993). By coupling between the feeding structure and slot, wide bandwidth is obtained. A printed wide slot antenna with fork like tuning stub fed by micro strip line provides good bandwidth (Sze and Wong, 2001). Wide slot antennas have various properties like low profile,

ease of integration, light weight, wider bandwidth, less interaction via surface waves and negligible radiation from feed network (Stutzman and Thiele, 1998; Girish and Ray, 2003). Wider is the antenna slot, wider is the impedance bandwidth. The impedance bandwidth has been broadened rapidly from 58 to 130% by using combination of different feed shapes and wide slots have been reported (Qu et al., 2006). In literature (Jan and Su, 2005), significant bandwidth is achieved just by rotating slot around centre of square slot. By etching a wide slot as fractal shapes can also improve bandwidth in proposed

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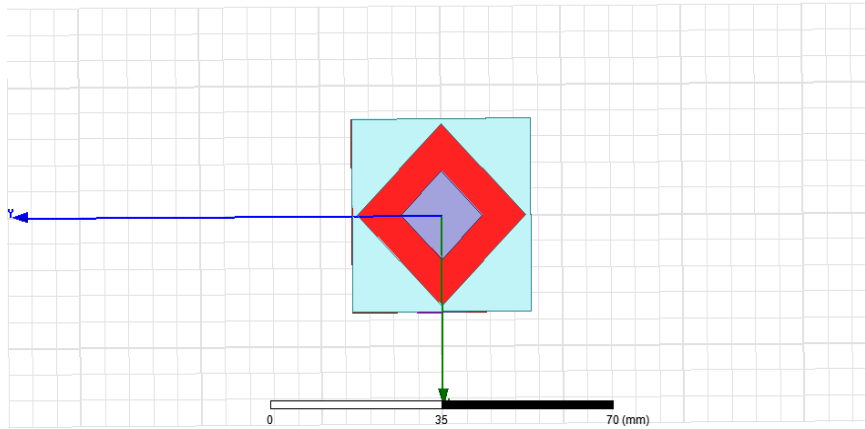


Figure 1. Design of slot antenna with parasitic patch.

slot antenna (Chen et al., 2009).

Use of parasitic patch is intended for gain maximization as well as bandwidth. Analysis of rotation of parasitic patch is also produced which satisfies that the gain and bandwidth are maximized at an angle of 45° . By use of parasitic patch in slot center, it is shown that f_1 (lower resonant frequency) is decreased and f_2 (higher resonant frequency) is increased thus, broad band characteristic is obtained. Then, by use of the parasitic patch printed symmetrically to the feeding line, the bi-directional radiation feature is changed into unidirectional with enhanced gain. UWB antennas helped in obtaining multi-standard functionality and higher data rate as compared to any other narrow band antenna.

From the simulated results, the achieved impedance bandwidth (determined from 10-dB reflection coefficient) of the proposed antenna can operate from 2.2 to 5.4 GHz covering the wireless local area network (WLAN) bands and world interoperability for microwave access (WIMAX) bands. By optimization, the dimensions of ground reduces from 70 to 37 mm for bandwidth and gain maximization along with reduced area constraint that is, about 72%. Both the mechanisms of high gain and bandwidth of some key parameters of the structure are also given and discussed in this paper. The proposed antenna is simulated using HFSS which is based on FEM.

ANTENNA GEOMETRY AND DESIGN

Proposed design of micro strip parasitic patch antenna is shown in the Figure 1. Yagi-Uda antenna offers a concept for improving antenna gain. In this approach, parasitic patches are printed on suitable position in the antenna and the effects on the gain are investigated. The proposed antenna has a simple geometry, consist of square slot and parasitic patch with some angle of rotation. The printed square slot antenna's dimensions are $24.7 \times 24.7 \text{ mm}^2$ which is printed on FR-4 substrate having thickness 1.6 mm and relative permittivity 4.4. The ground dimensions are taken as $37 \times 37 \text{ mm}^2$. The square slot is fed by 50Ω micro strip line which

is printed on substrate. The feed line shown in figure is having the dimensions of $3 \times 31.5 \text{ mm}^2$.

For bandwidth maximization, the square slot rotation is performed at an angle of 45° and parasitic patch is applied having the dimensions of $12 \times 12 \text{ mm}^2$ and for gain maximization, the parasitic patch is also rotated at angle of 45° . Thus, angle of rotation of parasitic patch provides us gain improvement.

Parametric study

Here a parametric study is carried out to understand the effects of design parameters such as slot width and parasitic patch width on the bandwidth. Figure 2 shows the simulated reflection coefficient for the proposed antenna with different widths of slot in the ground plane. The dimensions of proposed antenna are as follows: ground $G = 37 \text{ mm}$, FR4 substrate, parasitic patch $p=12\text{mm}$ and slot dimensions as length of slot remains 24.7 mm and width t in the ground plane varies from 17 to 26 mm. As the width of slot decreases, the bandwidth increases up to 3.6 GHz. The bandwidth however does not increase any further when the width of slot is below 18 mm. When $t = 18 \text{ mm}$ and all other dimensions are same, the bandwidth of antenna obtained through simulation is 3.61GHz ranging from 2.45 to 6.06 GHz and gain so obtained in this case is about 3.56 dB. Thus, the shape of slot which is rotated at angle 45° changes from square to rectangular as shown in Figure 5. The return loss so obtained in this case is -49.6 and -30.04 dB at two resonant frequencies at 5.5 and 2.6 GHz as shown in Figure 4.

Figure 3 shows the simulated reflection coefficient for the proposed antenna with different widths of parasitic patch. In this case, the length of patch remains same that is, 12 mm and width of patch varies from 10 to 16 mm and all other dimensions are same as given in antenna geometry and design and square slot is to be considered.

The bandwidth of proposed antenna obtained through simulation and parametric is 3.2 GHz when width of patch $a = 12 \text{ mm}$ that is, square parasitic patch which is also rotated at an angle 45° and the gain so obtained in this case is 8.81 dB.

By applying parametric, the proposed antenna shows extreme bandwidth that is, 3.6 GHz when square parasitic patch is introduced in the rectangular slot and both are rotated at an angle 45° and gain is 3.35 dB. This is the case when bandwidth is the only criteria but when square parasitic patch is centered in the square wide slot with 45° rotation, the bandwidth so obtained is 3.2 GHz and gain is 8.81 dB. This is the case when both bandwidth and

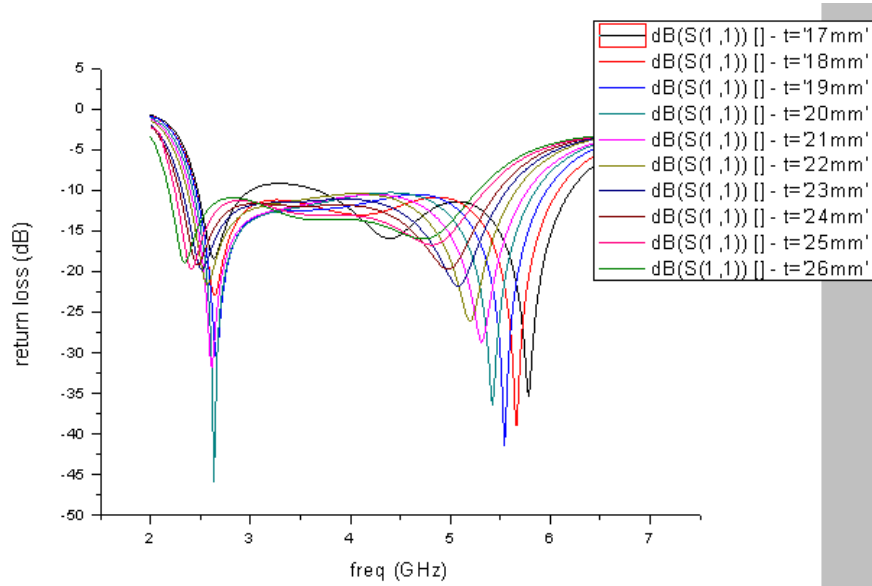


Figure 2. Simulated reflection coefficient of proposed antenna with different widths.

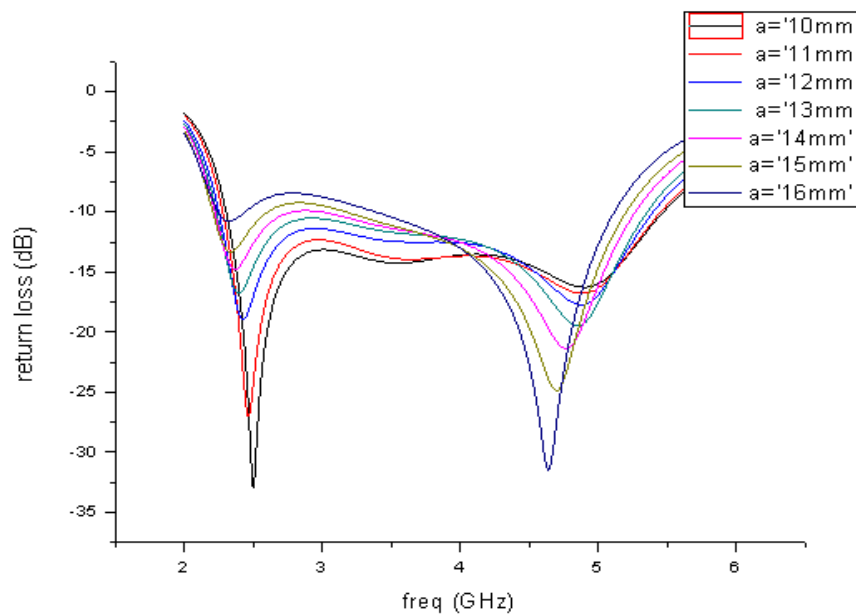


Figure 3. Simulated reflection coefficient of proposed antenna with different widths of parasitic patch.

gain is the criteria.

discussed in this section.

RESULTS AND DISCUSSION

The proposed antenna is simulated on EM solver Ansoft HFSS (High Frequency Structure Simulator) and various parameters such as return loss, bandwidth and gain are

Return loss of proposed antenna

Return loss is a measure of how well antenna matching is done. The return loss of proposed antenna when both patch and slot is square is approximately 19 dB as shown

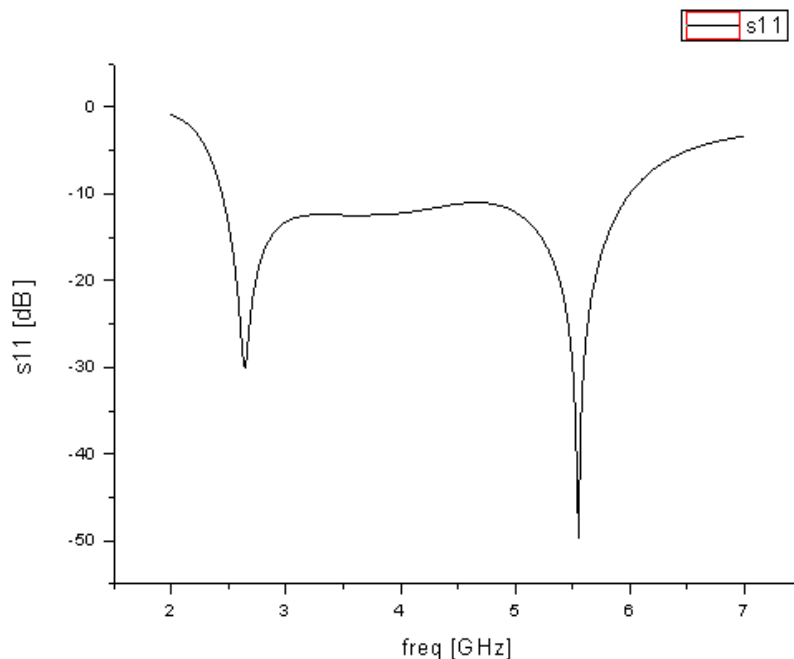


Figure 4. Simulated reflection coefficient of rectangular slot antenna with parasitic patch.

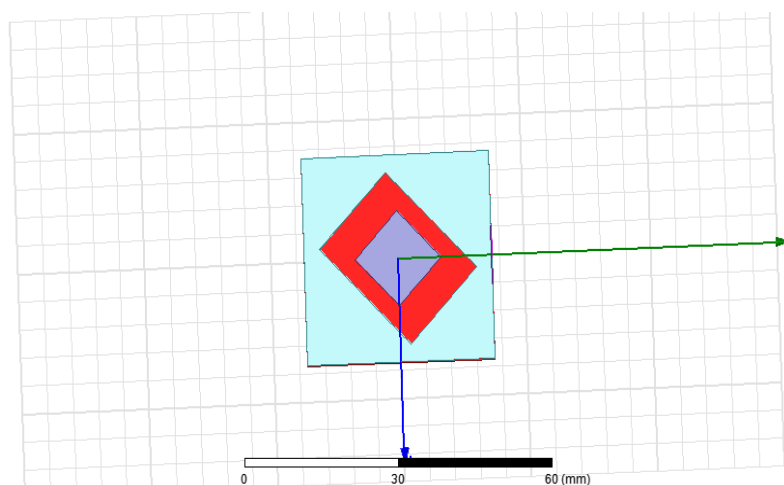


Figure 5. Design of rectangular slot antenna with parasitic patch.

in Figure 6.

Bandwidth of proposed antenna

Bandwidth describes the range of frequencies over which the antenna can properly radiate or receive energy. We can see that on changing the values of ground plane have effect on the bandwidth of proposed antenna. Substrate thickness is another important parameter in achieving wide band performance. The impedance

bandwidth obtained from the simulation results ranging from 2.2 to 5.4 GHz at 10 dB return loss, that is, 3.2 GHz bandwidth is achieved as shown in Figure 6.

Gain of proposed antenna

Gain is defined as the ability of antenna to concentrate energy in a narrow angular region (a directive beam). The results on the basis of rotation of parasitic patch are shown in Table 1. The gain so obtained at angle 45° is

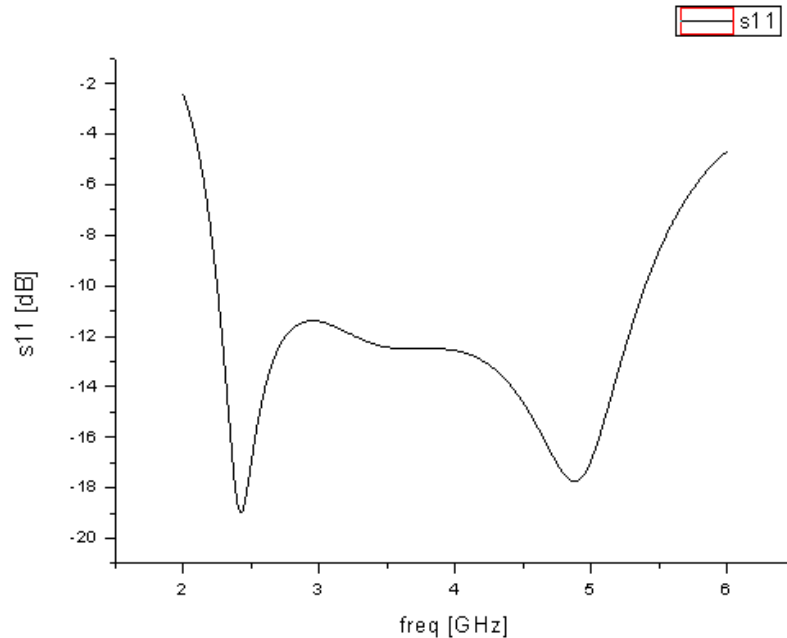


Figure 6. Return loss.

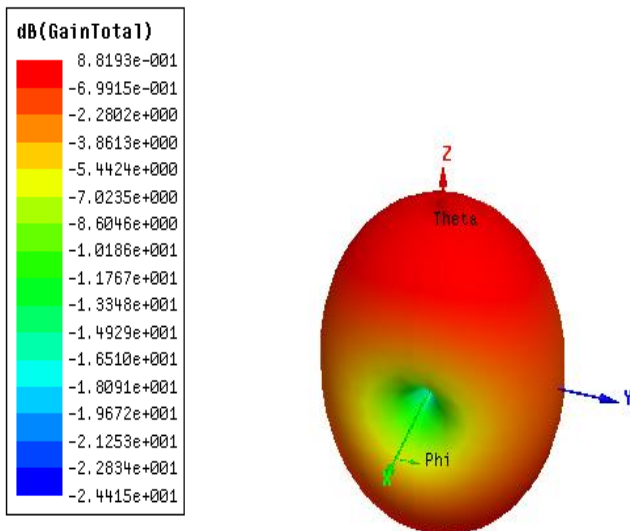


Figure 7. Gain.

maximum that is, 8.81 dB and is verified by the table as shown in Figure 7.

Comparison analysis

The comparison has been made between without parasitic patch and with parasitic patch on the basis of return loss, bandwidth and gain in square wide slot antenna. The reference antenna that is, without

Table 1. Results on the basis of rotation of parasitic patch.

Angle	Fr (GHz)	Bandwidth (GHz)	Gain (dB)
0°	2.4 & 4.7	5.3-2.3	2.47
10°	2.4 & 4.7	5.3-2.3	2.47
20°	2.4 & 4.8	5.4-2.2	-9.67
30°	2.4 & 4.8	5.4-2.2	1.9
40°	2.4 & 4.8	5.4-2.2	1.27
45°	2.4 & 4.8	5.4-2.2	8.81
50°	2.4 & 4.8	5.4-2.2	1.36
60°	2.4 & 4.8	5.3-2.2	1.24
70°	2.4 & 4.8	5.3-2.2	-6.31
80°	2.4 & 4.8	5.3-2.2	-2.52

parasitic patch has ground dimensions of $70 \times 70 \text{ mm}^2$ and with parasitic patch has dimensions of $37 \times 37 \text{ mm}^2$ thus, area is reduced up to 72%. The return loss of reference antenna is -39 dB at resonant frequency of 3.8 GHz is shown in Figure 9 which shows very good impedance matching. The bandwidth so obtained is about 2 GHz (5.4 - 3.4 GHz). The gain so obtained in this case is about 5.4 dB as shown Figure 10. The design of reference antenna without parasitic patch is shown in Figure 8.

The proposed antenna that is, with parasitic patch has ground dimensions of $37 \times 37 \text{ mm}^2$. The variations are in the dimensions of ground and all other parameters are

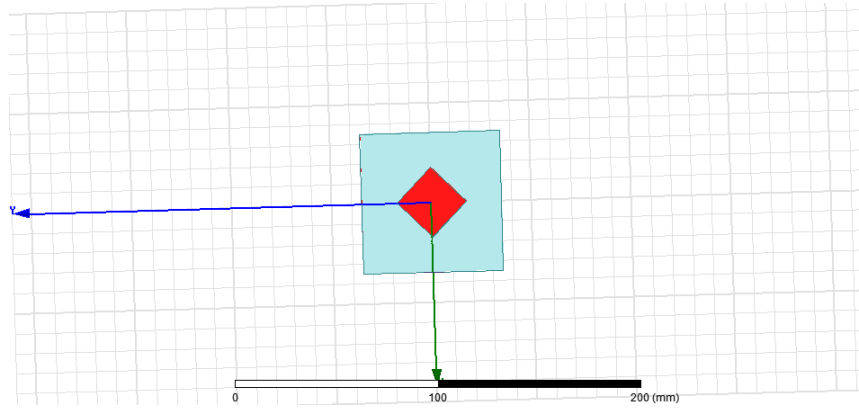


Figure 8. Without parasitic patch.

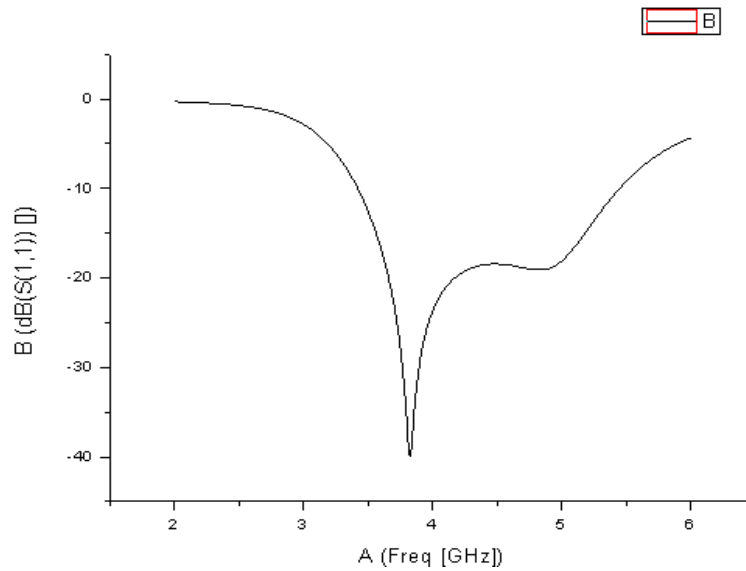


Figure 9. Return loss of reference antenna.

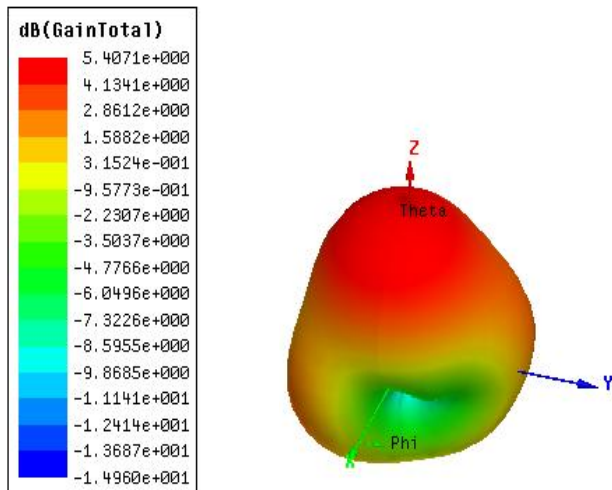


Figure 10. Gain of reference antenna.

same as given in design methodology. The return loss of proposed antenna is about -19 dB and the bandwidth so obtained is about 3.2 GHz which is far better than reference antenna. The results of gain are about 8.8 dB which is far better than reference antenna only by rotating the parasitic patch.

Conclusion

A printed wide slot antenna with parasitic patch has been implemented and studied in this work. By analyzing parametric, we can say that bandwidth increases from 3.2 GHz to 3.6 GHz by decreasing width of slot in ground plane that is shape of slot changes from square to rectangular. On rotating the parasitic patch at different angles and is centered in the square slot, the gain is enhanced up to 8.8 dB and when compared with and

without parasitic patch, the antenna performance is improved. The proposed antenna is applicable for WIMAX and WLAN bands. Furthermore, we are trying to do miniaturization of this antenna so that it will use comparatively lesser area for fabrication.

Conflict of Interests

The authors have not declared any conflict of interests.

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Full Length Research Paper

An investigation into the building-sanitary equipment in the traditional residential architecture

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Despite the developments and changes in the constructional domain, most of the best construction materials of the past are still the best and the buildings of the past have still been superior to the present buildings. In such a case, the traditional must be stuck to and traditional solutions must be taken as examples. Therefore, this study investigated the building-sanitation-related elements (water disposal systems, heating and chimney systems and drainage systems) and their uses in the traditional houses (their characteristics, the changes in their uses and the extent of these changes). The study also attempted to find out the principles and criteria on which the arrangements that are the products of accumulated experiences were based in the spaces or systems. Furthermore, the study investigated how and at what level the new equipment that the new age presents are reflected in the traditional house. The dimensional, positional, directional, constructional, equipment and material characteristics of these elements were investigated in accordance with the knowledge, theories and principles of architecture and instructive data about these were obtained from the traditional houses. The traditional houses in the city of Trabzon (Turkey) were chosen as the sample area of work.

Key words: Water disposal, heating and chimney systems, drainage system, equipment and material characteristics, traditional houses.

INTRODUCTION

In order to improve the comfort conditions in the space that separates man from the physical environment to a suitable state, some auxiliary equipment is needed. Buildings must have heat, water and moisture insulations and there should be enough ventilation. There must be enough skylight and heat (Ranson, 1991; Heyman et al., 2005; Jones et al., 2007). Fresh water, one of the most important needs, must be brought into the building and

waste water must be taken away from the building and in this way building conditions must be improved to make the use of different systems possible (Peter et al., 2002).

Building construction is a biological process, not an aesthetic one (Meyer, 1991). A building must, first and foremost, respond to a function and this requires the building not to fail in its use in any way. However, a successful building is in terms of aesthetics, if it does not

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perform this function, it can never be a healthy building (Ineichen, 1993, Zhong et al., 2012). Protection from the unwanted conditions of the physical environment is the most important need of man (Novoselac and Siegel, 2009). The above mentioned factors must be controlled through the help of building elements.

According to Özdeniz (1978), it is possible to remove the unwanted climatic variables from the building by the following:

- (1) Allowing enough of them to permeate in the building if they are necessary for the user's comfort,
- (2) Allowing the excess of them to permeate in the building if prevention of the possible effects of them is not economical,
- (3) Removing the rest of them from the building by controlling the forces that enable permeation.

At the time when there were no mechanical tools to control the physical environment and when building materials were simple raw materials, climate was a very important factor in the formation of buildings. Especially the buildings which were designed and built by the users show how wisely the climate can be controlled for a livable environment (Van den Bulcke et al., 2009; Huijbregts et al., 2012). Archaeological findings and modern day primitive examples have shown that the roof and roof covers, which are constructed to protect the user and building from the atmospheric effects, have been considered throughout the history as the most important things in terms of its importance in the whole of the building (Nauman, 1991). The traditional building materials and construction systems used in house construction have not changed remarkably until now (Edwards et al., 2005; Forrest and Izuhara, 2012). The natural materials found in the immediate surroundings of the building make up all kinds of building materials and therefore they are the main components of the building (Arthur, 1999; Ravetz and Turkington, 1995; Ravetz, 2001; Laidley, 2013). In today's buildings and in the buildings that have come from the past to the present day, the same building-sanitary equipment that is shaped by the same principles has been used.

Buildings consist of many elements that have different characteristics depending on their functions in the house. Depending on their functional characteristics, these elements can be classified as follows:

- (1) User-related building elements,
- (2) Building-related building elements,
- (3) User- and building-related building elements (Berksun, 1979; İpekoğlu et al., 2007; Denison and Ren, 2012).

The possibilities that the new age presents change of the user demands and needs. As a result of this change, traditional houses undergo some modern adaptations that aim to meet the needs of modern life. This results in

the removal of the traditional borders between the social groups at cultural, national and even local level (Dickens, 1988; Mazumdar, 1997; Kim and Kaplan, 2004; Youngen and Hostetler, 2005; Clark and Kearns, 2012).

This study aims to probe into the elements that are important for man and therefore for the building which accommodates man; that give the building a livable quality; and that are called building-sanitary equipment. The study investigates the needs of a building regarding sanitation, hygiene and comfort, and investigates these factors which will provide the environmental conditions to be evaluated and controlled. With a correct evaluation of the above-mentioned factors, buildings that have no technical failures in terms of vitally important uses must be built. As a result of the provision of these uses in the building and of the evaluation and control of these factors in the building, the building is equipped with some systems. Water disposal systems, fresh water systems, waste water systems, heating and chimney systems which are known as building-sanitary equipment and of which each architect should have full knowledge were conceptually discussed.

The study investigates the relationships between life and built-up environment in terms of building-sanitary equipment in the traditional houses. Another issue that this study investigates is the presence of suitability and unsuitability in the applications of the building-sanitary equipment and whether there are concrete and applicable solutions. The study also investigates the reflections of the possibilities that the modern life presents for the buildings, types of application and the direction of the preferences. The study covers such areas in the traditional houses as:

- (1) Water disposal,
- (2) Fresh water-waste water and
- (3) Heating and chimney systems.

FIELD WORK

The field of work of this study is the traditional houses in the historical settlements in the city of Trabzon in the Eastern Black Sea region of Turkey (Figures 1 to 3).

During the selection of the sample houses, attention was paid to the following:

- (1) The selection of the houses that were built before 1940,
- (2) The identification of the neighborhoods which were intensely populated by traditional houses,
- (3) Whether the houses had the characteristics of the traditional urban houses of Trabzon.

The reason for choosing the houses that were built before the industrial revolution in Turkey is to find out about the reflections of the industrial products in the traditional houses in terms of building-sanitary equipment

The study informs us of the users, preferences for and applications of building-sanitary equipment and questions the extent of the suitability of these preferences.

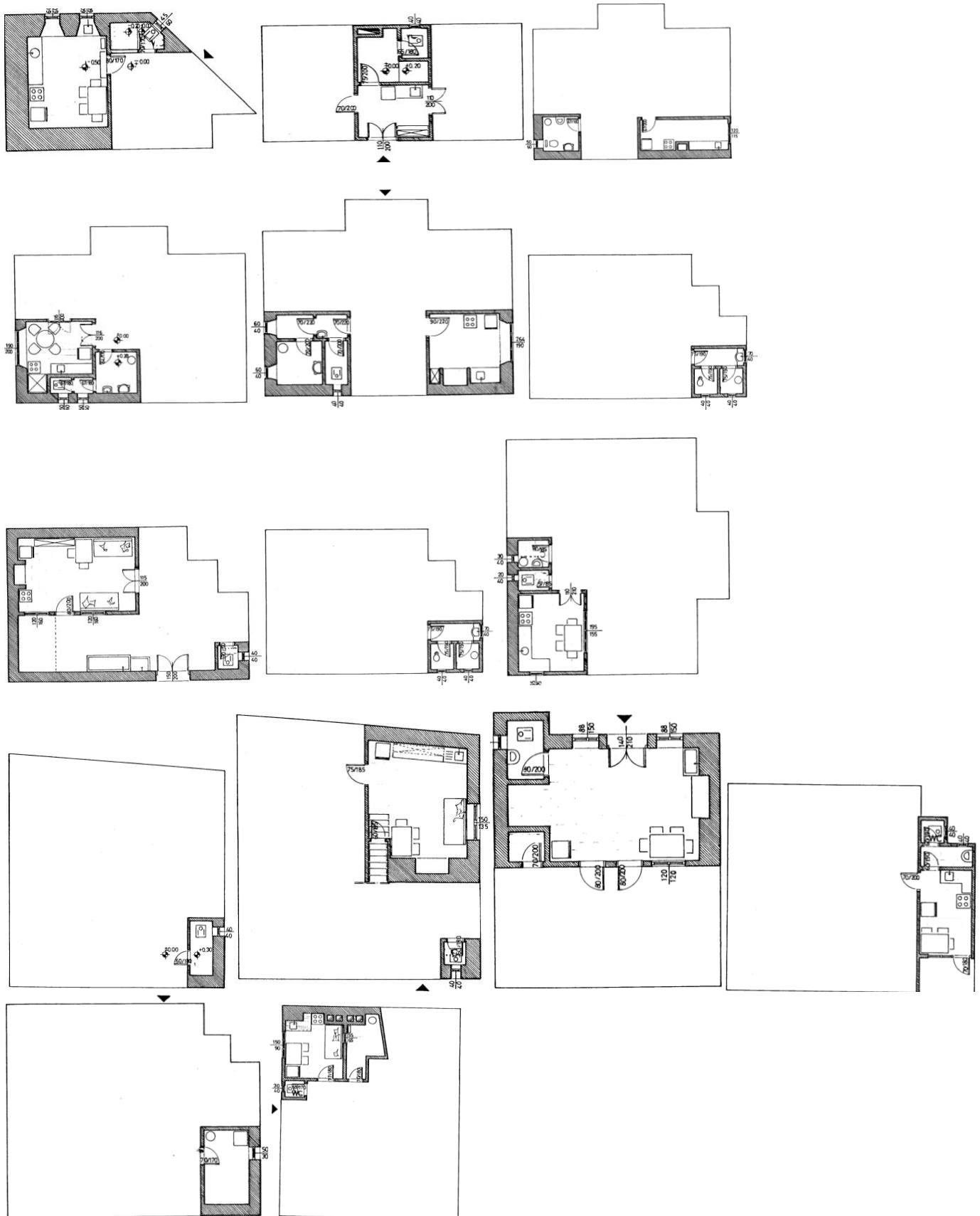


Figure 1. Plans of the building–sanitary equipment in the sample houses studied.



Figure 2. Plans of the building–sanitary equipment in the sample houses studied

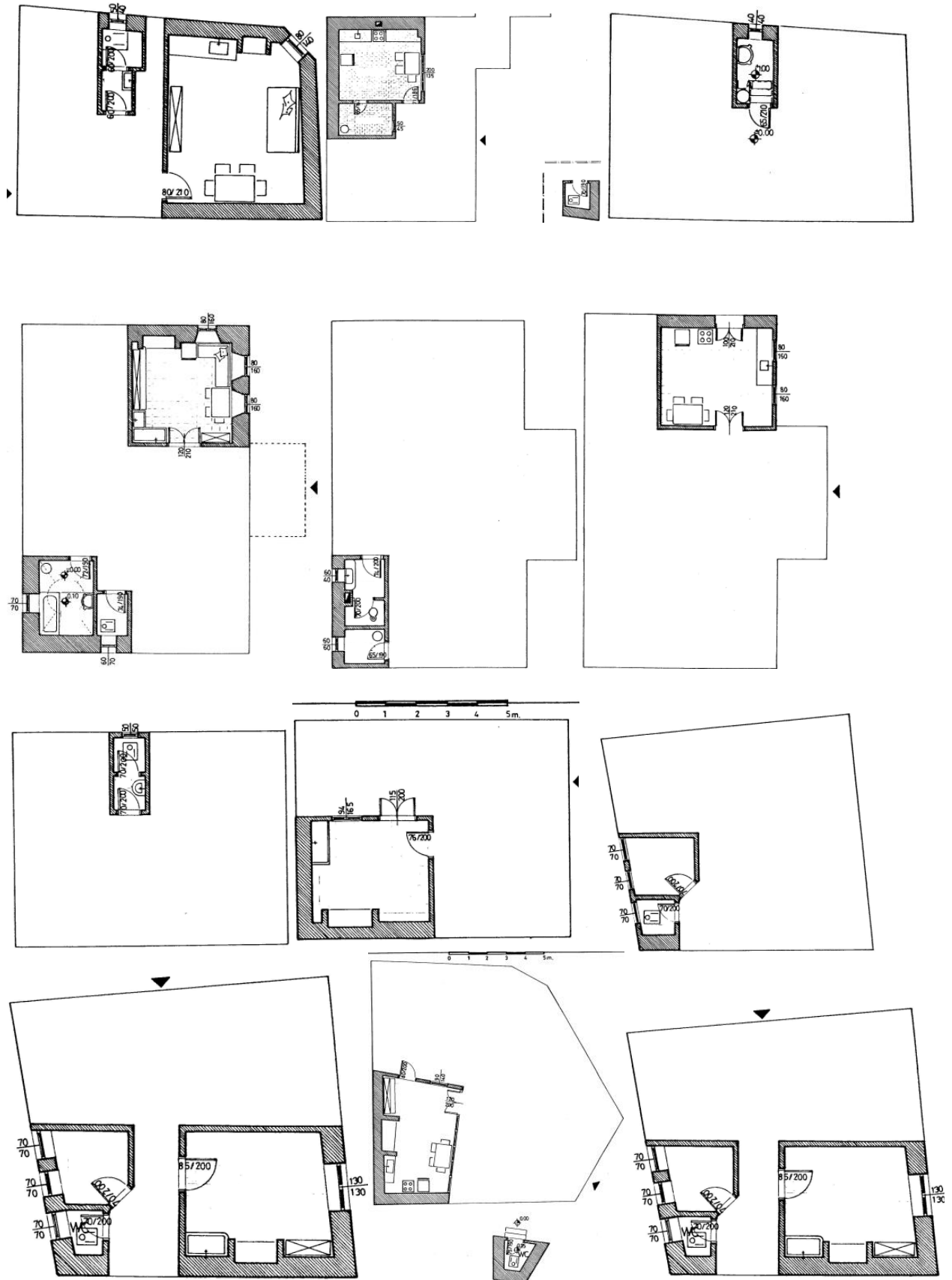


Figure 3. Plans of the building–sanitary equipment in the sample houses studied.

Methods

This study is a field work that aims to investigate building-sanitary equipment in the traditional houses. During the implementation process of this study:

- (1) The related literature was reviewed and the details of the aims of building-sanitary equipment were identified,
- (2) A questionnaire was developed in order to gather data about the general characteristics of the building-sanitary equipment in the traditional houses that this study investigated,
- (3) The sample houses in the study were selected with the observation technique,
- (4) The data that were obtained through observation, interview and identification about the general characteristics of the sample houses and about the building-sanitary equipment in the sample houses were recorded in the questionnaire and the measured drawings of the relevant spaces were taken in order to identify their institutional and technical arrangements.

By evaluating the data obtained, the following were intended to be made clear:

- (1) The consistencies and contradictions of the applications at system level,
- (2) The dimensional characteristics of the elements at space level,
- (3) The preferred sizes of the various equipments and the degree of the accuracy of preferences,
- (4) The consistencies and contradictions of the elements at system and space level in terms of material, size and application,
- (5) The consistencies and contradictions of the new possibilities (products) in the applications at the level of building-sanitary equipment in the traditional houses and,
- (6) Putting forward the special and general cases at the level of building-sanitary equipment and drawing conclusions about the comfort conditions in the traditional houses.

Designing the questionnaire

The aim of the questionnaire is to identify the general characteristics of the traditional houses (Appendix), and it consists of four parts:

- (1) Information on the structural characteristics: This part contains 7 items which aim to identify the general characteristics of the traditional houses and which elicit data about the construction system, direction and material characteristics of the traditional houses.
- (2) Roofs and water disposal: This part contains 9 items which aim to elicit data about: the roof forms and materials; characteristics of the eaves; the materials and diameters of the rain gutters and downspouts; and users' thoughts and reflections about the houses.
- (3) Heating and chimney systems: This part contains 19 items that aim to identify the materials and technical characteristics of the heating and chimney systems, and to elicit the users' complaints from, and expectations for, the houses.
- (4) Drainage systems: This part contains 5 items which aim to identify the plumbing systems to get water into the buildings and sanitary discharge systems, and the characteristics of these systems.

General information about the traditional Trabzon houses

The local architecture is of a character which has completed its evolution and which has started to disappear. This traditional architecture is known to be a superior architecture at its time (Gür,

1990). The houses that reflect the traces of a rich historical background show different characteristics in the areas in which they were built. Although the building materials are the same, the construction techniques and building formations show variety from region to region; however, each region makes its deep-rooted construction tradition felt and continues this tradition. The most obvious evidence of this continuity is the old urban houses themselves that have come down to the present day (Güngör, 1987).

The houses are the products of a heavily forested region with ample rain. Until the end of the 18th century, the open-sofa plan type was used and later on the inner-sofa and central-sofa plan types became common (Akok, 1991; Güner, 1994). The walls of the houses that face the north are usually blind. The entrances are usually protected from winds. In the houses, large sofas were built so as to face the east and everything was made to make use of the large scenery. Large sofas face the well-designed courtyards and the daily activities take place in this space. In the traditional houses, upper floors are usually used as living spaces and the ground floors are used as service spaces (Sümerkan, 1990). However, ground floors have undergone tremendous changes in the modern day.

The climate in the Eastern Black Sea region is very rainy, mild and humid (Özdeniz, 1987). In a very rainy and highly humid climate, a scattered settlement pattern was adopted for good ventilation of the houses (Orhan, 1994). There are a lot of diagonal windows so as to allow ventilation. The plans of the houses are zigzagged so as to let the hot air in the summers leave the house easily. The walls of the ground floor are made of stone due to the dampness of the soil. Upper floors are usually made of wood in order to prevent the accumulation of hot air in the summers.

FINDINGS OF THE FIELD WORK

Here, the study presents water disposal systems, fresh water systems, waste water systems, heating and chimney systems and their conditions.

Water disposal systems

Roofs are the uppermost parts of the buildings and protect the buildings against rains and atmospheric effects (Kindangen et al., 1997; Kharrufa and Adil, 2008). With the help of the shaped outer cover, rainwater is channeled to the ground and therefore is removed from the building. Removal of the water from the building is achieved by discharging water through elements that are placed slope-wisely on another (Fawcett et al., 2008; Bitsuamlak et al., 2009).

Water disposal in building eaves is based on removing water from the building with the help of projections. Even the smallest horizontal projections are effective in removing the rainwater from the building walls. As well as the width of the eaves, the correct detailing of the eaves is very important for water disposal. The widths and forms of the eaves are determined by the climatic conditions, building culture and roof construction in the region in which they are applied (Hasol, 1988).

In order to remove the rainwater and snow water from the roof, rain gutters and downspouts are also used. Collecting rainwater or snow water from the rain gutters, channeling them to the ground or connecting them to

Table 1. The roof characteristics of water disposal elements.

Roof characteristics		Number of houses	Percentage (%)
Roof type	Hipped roof	21	84
	Gable roof	4	16
Use of the loft	Used	5	20
	Not used	20	80
Gutter material	Zinc	10	40
	PVC	10	40
	No gutters	5	20
Downspout material	Zinc	8	32
	PVC	11	44
	No downspouts	6	24

sewage pipe is achieved through downspouts. Rain gutters and downspouts are made of zinc, galvanized sheet or plastic. The water disposal elements are explained as follows:

(1) Roof types: Two types of roof were found to be used in the traditional houses. When the distribution of the roof types in the traditional houses was investigated, it was found that 84% of them are hipped roofs and 16% are gable roofs. Gable roofs are usually used in the buildings with regular plan types. On the other hand, hipped roofs are used in the houses without regular plan types as well as in the houses with regular plan types (Table 1).

(2) Roof covers: It was found that roof tiles were used as the roof cover material in all urban houses that were included in the study.

(3) Eaves width: The average width of the eaves in the traditional houses was found to be 44.4 cm. The narrowest eaves were found to be 10 cm, and the widest to be 120 cm.

(4) The use of the lofts: It was found that lofts are used in 20% of the traditional houses and not used in 80% of the houses. It was found that lofts in the houses in which they are used are used for storage purposes (Table 1).

(5) Rain gutter materials: It was found that the rain gutter materials that are used in traditional houses are zinc and plastic. In the houses which have undergone repairs, zinc rain gutters are replaced by PVC rain gutters. In all traditional houses, zinc rain gutters had been used before repairs. During the repair, PVC rain gutters are preferred due to their low cost and easy availability instead of zinc which requires a lot of labor and therefore, which costs more (Table 1).

(6) Downspout materials: It was found that 24% of the traditional houses do not have downspouts. These houses do not have rain gutters either. The reason for this is that the downspouts come off in time due to various factors and they are not replaced by the new ones. In some houses, the rain gutter and downspout

materials are different. This reason for this is that although the downspouts that came off were replaced by the new ones with new material, the rain gutters were not (Table 1).

(7) Rain gutter diameters: The diameter of the rain gutter should be 1 to 0.8 cm² for each m² of the roof surface area where the rainwater is collected (Anonim, 1987).

$$\text{Roof surface area (m}^2\text{) / rain gutter diameter (cm}^2\text{) = 1 - 0.8}$$

It was found that the rain gutters in all traditional houses were half-round (semi-circular) (Table 2). According to this, 20% of the traditional houses do not have rain gutters and the diameters of the rain gutters in 20% of the traditional houses are adequate.

(8) Downspout diameters: The diameters of the downspouts should be 1 cm² for each m² of the roof surface area where the rainwater is collected.

$$\text{Roof surface area (m}^2\text{) / downspout diameter (cm}^2\text{) = 1}$$

The proportional values obtained by the division of the downspout diameters by the roof surface areas are shown in Table 3. According to this, it was found that:

- (1) 24% of the traditional houses do not have downspouts
- (2) The diameters of the downspouts in 12% of the traditional houses are adequate
- (3) The diameters in 64% of the traditional houses are not adequate

It was observed that the necessary requirements for water disposal from the houses are provided. The eaves widths that have important functions show a wide range where the smallest and largest values are found together. Rain gutters are usually more durable than the downspouts. It may be inferred that this is caused by the number of repairs that the downspouts undergo. This

Table 2. Adequacy of the gutters.

Sample No.	Roof surface area (m ²)	Gutter cross-sectional area (cm ²)	Rate (m ²)/(cm ²)	Adequacy
1	136	88	1.55	Inadequate
2	89	88	1.01	Adequate
3	72	66	1.09	Adequate
4	141	–	–	–
5	146	56	2.61	Inadequate
6	178	–	–	–
7	63	66	0.95	Adequate
8	196	88	2.23	Inadequate
9	142	61	2.33	Inadequate
10	141	61	2.31	Inadequate
11	96	66	1.45	Inadequate
12	74	72	1.03	Adequate
13	180	88	2.05	Inadequate
14	140	48	2.92	Inadequate
15	65	61	1.06	Adequate
16	105	88	1.19	Inadequate
17	143	88	1.63	Inadequate
18	125	88	1.42	Inadequate
19	104	88	1.18	Inadequate
20	114	–	–	–
21	115	94	1.22	Inadequate
22	114	88	1.30	Inadequate
23	121	66	1.83	Inadequate
24	60	–	–	–
25	337	–	–	–

may be caused by some inadequacies in application or by the fact that downspouts are more prone to the atmospheric effects.

Heating and chimney systems

When the minimum thermal difference between a healthy person's body temperature (Eker, 1991) and the environmental temperature is 20 to 23°C, it is considered to be the ideal temperature in the natural environmental conditions cannot provide this, the adequate level of temperature is obtained through heating in the inner spaces (Wall, 1973; Bae and Chun, 2009; Liu et al., 2009). Among the important factors that affect the heat in the houses are the building types (detached house, semi-detached house, terrace house), direction (of the rooms, that is, facing north, south, etc), thermal process of the building and the design of chimney elements (Baytin, 1951; Chen et al., 2009).

According to this, the following are the factors that reduce the chimney draft:

(1) Inadequate chimney height,

(2) Low smoke heat,

(3) High outer temperature,

(4) Long chimney surface area,

(5) Incorrectly built chimney pots,

(6) Larger- or smaller-than-necessary chimney diameters.

Among the chimney types are stove chimneys, fireplace chimneys, kitchen chimneys and some other chimney types (central heating chimneys, natural gas stove chimneys, Turkish bath chimneys, industrial chimneys, ventilation chimneys, and refuse chimneys).

It was found that heating in the traditional houses is achieved through single heating tools such as stoves and that the main heating fuels are the traditional fuels such as wood, coal, and hazelnut shells. However, high-tech heating tools and fuels are also commonly used in the above-mentioned houses. The fireplaces which were once the center of the house and around which the daily activities were once carried out have lost their significance and are not used any more. The center of the house is the section of the house which is used as the living space and which is usually called the living room. In the traditional houses, the priority is given to the heating of these spaces.

Table 3. Adequacy of downspouts.

Sample No.	Roof surface area (m ²)	Downspout cross-sectional area (cm ²)	Rate (m ²)/(cm ²)	Adequacy
1	136	79	1.72	Inadequate
2	89	50	1.78	Inadequate
3	72	64	1.13	Inadequate
4	141	–	–	–
5	146	39	3.74	Inadequate
6	178	–	–	–
7	63	79	0.78	Adequate
8	196	79	2.48	Inadequate
9	142	44	3.23	Inadequate
10	141	79	1.78	Inadequate
11	96	44	2.18	Inadequate
12	74	79	0.94	Adequate
13	180	79	2.28	Inadequate
14	140	–	–	–
15	65	79	0.82	Adequate
16	105	79	1.33	Inadequate
17	143	123	1.16	Inadequate
18	125	79	1.58	Inadequate
19	104	79	1.32	Inadequate
20	114	–	–	–
21	115	79	1.46	Inadequate
22	114	79	1.32	Inadequate
23	121	50	2.42	Inadequate
24	60	–	–	–
25	337	–	–	–

Table 4. Heating systems and use of fireplace.

Heating and chimney systems		Number of houses	Rate (%)
Heating system	Central heating	–	–
	Single heating	25	100
Use of fireplace	Yes	–	–
	No	25	100

The chimney system is usually found in the spaces where the fireplace is. There may be chimney systems in the heated spaces; however, there may not be chimney systems in such spaces and the smoke here may be discharged by using stovepipes extending outside through a chimney hole that is opened in a suitable wall or window. There is also a small number of examples of other spaces which have chimney systems as follows:

(1) Heating systems: It was found that spaces in the traditional are heated by single heating tools. There are no central heating systems in any of the traditional

houses in this study (Table 4).

(2) Use of fireplaces: Until recently, fireplaces had an important place in the traditional houses; however, they are not used any more (Table 4). Instead of these fireplaces which also have the heating function when cooking, newer cooking tools are preferred due to some practical concerns. Furthermore, instead of using the fireplaces for the purpose of heating the space, various other heating tools are preferred.

(3) Number of chimneys: The average number of chimneys in the 25 traditional houses in this study is 2.08 (Table 5).

Table 5. Chimney forms.

Variable	Characteristics	No. of chimneys	Percentage (%)
Chimney form	Square	34	65.39
	Rectangular	16	30.77
	Circular	1	1.92
	Polygonal	1	1.92
Chimney material	Brick	33	63.46
	Stone	18	34.62
	Concrete	1	1.92
Chimney characteristic	Single chimney	44	84.62
	Grouped chimneys	8	15.38
Chimney position	Inner wall	5	9.60
	Outer wall	47	90.40
Chimney height	Above the ridge line	37	71.11
	Not above the ridge line	15	28.89
More than one connection to a chimney	Yes	6	24
	No	19	76
Chimney-wall materials	Stone-stone	20	38.47
	Brick-stone	14	26.92
	Brick-infill	14	26.92
	Brick-brick	3	5.77
	Stone-concrete	1	1.92

(4) Chimney forms: Various chimney forms were found in the traditional houses and their distribution is given in Table 5. By the chimney form, the form of the horizontal diameter of the chimney is meant. Circular chimney form which has the best chimney draft was found only in one sample. The polygonal form, too, has a good draft like the circular form. Stone and brick are the most commonly used building materials for the chimneys. Therefore, because of the ease of their use in application, rectangular or square forms are preferred, which affects the preferences in terms of forms of the chimneys. Square form was found to be the most common chimney form in the traditional houses.

(5) Chimney materials: The materials used for the construction of the chimneys are not different from the materials used in the construction of the building. The most common building material used in chimneys are stone, brick and concrete. When we have a closer look at the proportional distribution of the materials used in the chimneys of the sample houses, we see that stone and brick are the main building materials (Table 5). Brick has the highest rate of heat insulation and is the most suitable chimney material. Therefore, it has been preferred as the material in the construction of chimney element in the

majority of the traditional houses.

(6) Grouped chimneys: Of the 52 chimneys in the traditional houses that the study investigated, 8 have the characteristic of grouped chimneys (Table 5). It can be said that 15.3% of the traditional houses have correct and conscious chimney applications.

(7) Walls on which chimneys are built: The majority of the houses that were investigated have stone walls to which the houses lean and which surround the houses on one or more sides. The fireplaces are usually built on one of these stone walls, and the chimneys reach up the roofs along these walls. Because wood is widely used in the traditional houses, chimneys are built on these stone or brick walls. When we consider the infill walls with wooden bases, chimneys are built on the outer walls (because wood is not heat resistant) (Table 5).

(8) Chimneypots: In all chimney applications in the traditional houses, chimneys have pots.

(9) Chimney heights: In order for a correct chimney draft to take place, the chimney must be at least 50 cm higher than the highest structure around the chimney and then the roof ridge (Baytin, 1951). In 71.11% of the houses that were investigated, the chimneys are not higher than the roof ridges. It is a well known fact that the majority of

chimneys are built on the outer walls. In this case, in order for the chimney to be higher than the roof ridge, the trunk of the chimney must be very long (Table 5). A long chimney trunk negatively affects the load bearing and drafting of the chimney. However, this should not create any problems considering the fact that chimneys are usually built on the outer walls; that this requires the chimney to be higher than the roof ridge and then any structure around the chimney on the roof; and that the chimney can get enough wind.

(10) Chimney diameters: In all chimneys in the traditional houses that were investigated, it was found that the vertical diameters of the chimneys are the same along the chimney heights.

(11) Connections to the same chimneys: Chimneys function well when maximum three stovepipes are connected to the same chimney from different floors and two stoves from the same floor. It was found that there was only one stove or stovepipe connection to the same chimney in 76% of the traditional houses and that there was more than one connection to the same chimney in 24% of the houses.

(12) Spaces with chimney systems: No samples without chimney systems were found in the field of work (Table 6). The spatial distribution of the 59 chimneys in 25 traditional houses is given in Table 7. When we look at the distribution rates of the chimneys in terms of spaces, we see that 40.68% of them are in the kitchens, 25.42% in the bathrooms, 22.03% in the living rooms, and 11.87% in the bedrooms.

(13) Chimney systems found in the heated spaces: In the traditional urban houses, the rooms without chimney systems are also heated (Table 8). If there are no chimneys in the heated spaces, the stovepipes are extended to the outside by opening a hole on a suitable wall or window. When we look at the distribution of the chimney systems in the traditional houses, we see that 69 spaces are heated in 25 houses and 85.50% of these spaces have chimneys. 14.50% of these spaces do not have chimney systems.

(14) Chimney weep holes: The soot accumulated in the chimneys is cleaned easily through weep holes that are opened on the chimney trunks a little higher from the ground on each floor. However, no houses that the study investigated have chimney weep holes.

(15) The materials of the chimneys and walls on which chimneys are built: The materials of the chimneys built on the stone walls in the traditional houses can be either stone or brick. The material of all the chimneys built on infill walls or brick walls is brick. On the other hand, only one house has a concrete chimney, and this chimney was built on stone (Table 5).

In real terms, there is only one chimney in each house. Chimneys are found in the kitchens which are the centers of the houses and where the fireplaces are. All of the chimneys in the traditional houses reach the outside

environment. The chimney elements in the houses have usually been applied correctly.

Drainage system

The most important element of building-sanitary equipment is water. A drainage system consists of getting the water in (fresh water) into the house, branching it to the spaces where it is used, and the waste water (foul water) (Gormley and Campbell, 2007). The oldest pressurized water transportation installation was found in Northern Syria (Nauman, 1991). In old settlements, as in some examples of modern day rural areas, there was a well almost in each courtyard (Ögel, 1978). Great care was taken when getting the drinking water. The same care was taken when draining the wastewater and rainwater. In suitable areas, leakage pits were dug. Depending on the tools that existed at the time, different sewer systems were built. Conic telescopic clay pipes with oval weep holes took the waste water from the storage pits, passed it through the lower pipe, and conveyed it to a sewer system which was covered with huge stones and whose flow was away from the city gates (Hasol, 1988).

Getting water into the building can be achieved in 4 ways. These are:

- (1) Old type of water installation with a water tank in the loft,
- (2) Manually pressurized tanks in the basement,
- (3) Electrically pressurized water tanks in the basement,
- (4) Electrically pressurized automatic water tanks (air pressure water system) in the basement (Nauman, 1991).

The pipes to be used in the fresh water installation in the houses must be rustproof. The whole domestic water installation must be installed horizontally slightly elevating towards the place of use, airlocks must be avoided and there should be water relief valves at the highest points of the installation (Anonim, 1987). Regional operating pressure, length of pipes, flow and flow rate are important in choosing the right pipe sizes (Sahal and Lacasse, 2008; Huang et al., 2009).

A sewer system is needed in order to remove or neutralize the waste water and rain water collected in different buildings and in different places. Waste water is usually connected to the city sewer system through pipes or cement pipes laid underground. If there is not such a sewer system in a city, cesspools are built for individual houses or groups of houses (Anonim, 1987).

As much as possible, waste water pipes should be without twists and turns. The main pipes should be freeze-resistant and must be installed at least 3 m away from the potable water sources. Furthermore, there should be weep holes in the waste water installation in

Table 6. Spaces with chimney systems.

Sample No.	Kitchen	Bathroom	Living room	Bedroom	Bedroom
1	*				
2	*				
3	*		*		
4	*	*	*		
5	*		*		
6	*				
7	*	*			
8	*	*			
9	*		*		
10	*	*	*	*	
11	*	*	*	*	*
12	*		*		
13	*	*			
14	*			*	
15	*	*			
16	*	*	*		
17	*	*			
18	*	*			
19	*				
20	*		*		
21	*	*	*		
22	*	*			
23	*	*	*		
24	—	*	*		
25	*				

Table 7. Distribution of chimneys according to spaces.

Spaces with chimney systems	Number of spaces	Percentage (%)
Kitchen	24	40.68
Bathroom	15	25.42
Living room	13	22.03
Bedroom	6	10.17
2 nd bedroom	1	1.70

order to be able to repair any possible clogging and to regularly check the system.

(1) Cisterns: 20% of the traditional houses that the study investigated have cisterns and they are used for various purposes except for drinking. 80% of these houses do not have cisterns; although cisterns were identified in some examples, it was found that they did not have any functional uses (Table 9).

(2) Wells: It was found that 32% of the sample houses have the element of well and 38% don't (Table 9). It was also found that 37.50% of the identified wells were sealed so as not to be used again, 25% of them were sealed and not used though they had water in them, and 37.50% had

water which was used for various uses except for drinking when the city water was cut. The well water was never used as drinking water.

(3) Getting fresh water into the building: In all houses, both the potable water and utility water are provided by the city water supply network.

(4) Disposal of waste water from the house: Disposal of waste water from the houses is achieved through a connection to the city sewer system. No other types of waste water disposal system were found in the traditional houses that this study investigated.

The study, which aimed to investigate the building-sanitary equipment in the traditional houses in Trabzon,

Table 8. Chimney systems in the heated spaces.

Sample No.	Kitchen	Bathroom	Living room	Bedroom
1	C	O	O	-
2	C	O	-	-
3	C	C	C	-
4	C	C	C	C
5	C	C	C	C
6	C	O	C	-
7	C	C	-	-
8	C	C	O	O
9	C	O	C	-
10	C	C	C	C
11	C	C	C	C
12	C	O	C	-
13	C	C	-	-
14	C	C	-	-
15	C	C	-	-
16	C	C	C	-
17	C	-	-	-
18	C	C	O	-
19	C	-	-	-
20	C	-	C	-
21	C	C	C	-
22	C	C	O	-
23	C	C	C	-
24	-	C	C	-
25	C	-	-	-

C = Chimney; O = Other systems.

Table 9. Water elements.

Water element	Presence	Number of houses	Percentage (%)
Cistern	Yes	5	20
	No	20	80
Well	Yes	8	32
	No	17	68
	Condition	Number of wells	
	Covered	3	37.50
	Not used	2	25.00
	Water is bucketed	3	37.50

found that the fresh water and waste water systems were successfully applied.

CONCLUSIONS AND RECOMMENDATIONS

This study investigated the building-sanitary equipment in the traditional Trabzon urban houses that have completed

their evolution and that have original characteristics. The study aimed as follows:

- (1) To make the reader have an insight into the building-sanitary equipment in the traditional houses,
- (2) To reach some conclusions and identify some applications that can be taken as the bases for today's works and applications. The study investigated the notions

of water disposal, heating and chimney systems and drainage systems under the title of building-sanitary equipment.

(3) When the notion of water disposal was investigated, it was found that although there are some successful roof applications in the traditional houses, rain gutters and downspouts are inadequate in disposing the rainwater and snow water that collect on the roof surfaces.

(4) When the heating and chimney systems were investigated, it was found that priority was given to the heating of the kitchen and that the heating of other spaces was neglected. On the other hand, although the chimney system applications are usually correct, the number of chimneys is not enough for the houses.

(5) As for the drainage systems, it was found that the traditional fresh water supply systems have been deactivated today, that all the fresh water needs are met by the city water supply network and that the waste water of the houses is disposed of by direct connections to the city sewer system.

(6) Despite the developments and changes in the constructional domain, most of the best building-sanitary equipment in the traditional houses have still been the same and superior. In this case, we must definitely stick to the traditional. If we are in unnecessary attempts to try again and again, we shall deprive ourselves of a sturdy basis. Consequently, the need for the investigation of the samples that belong to the past but that give us information about the building-sanitary equipment is apparent. As a result of such an investigation of such samples, the findings must be presented clearly.

It is necessary that the relationships between the sanitation needs and other needs (visual needs, security needs, hygiene needs, comfort needs, etc.) of the houses be identified and investigated. These needs of the houses must be dealt with not individually but altogether within the way of life of the society. This can be achieved only when the needs are dealt with altogether.

The increase in the number of such studies is important in that it gives us an opportunity to investigate and interpret what we should make use of.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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APPENDIX

Questionnaire

Address :
 Sample no :
 Owner :
 Age of building :

A. Information on the structural characteristics of the building

- 1. Type of residence:
 - Detached house
 - Semi-detached house
 - Terrace house

- 2. Outer wall construction:
 - Cell infill
 - Triangular infill
 - Plasterboard
 - Timber-frame
 - Ruble infill
 - Firebrick infill
 - Briquette infill
 - Other

- 3. Inner wall construction:
 - Plasterboard
 - Timber-frame
 - Ruble infill
 - Firebrick infill
 - Briquette infill
 - Other:

- 4. Plaster on the outer surface:
 - No plaster
 - Plaster on the filling material
 - Plaster on all surfaces

- 5. Paint on the outer surface:
 - No paint
 - Paint on the filling material
 - Paint on all surfaces

- 6. Direction of the entrance façade:

- 7. Flooring material:
 - Ground floor (.....)
 - 1st floor (.....)
 - 2nd floor (.....)
 - 3rd floor (.....)

B. Kitchen

- 1. Any repair work, addition or change carried out in the kitchen.
 - None
 - Repair work
 - Change (pipe, cistern, etc)
 - Replacement
 - Enlargement

- 2. Date of, and reason(s) for, change: (.....)

- 3. Kitchen is:
 - Inside the house
 - Outside the house

4. Cooking equipment Stove
- Spirit cooker
 - Kerosene cooker
 - Bottled gas cooker
 - Electric cooker
 - Electric oven
 - Combination oven

5. Kitchen sink is: High from the floor
- On the floor

6. Height of the kitchen sink from the floor: cm.

7. Fresh water pipe system:
- Lead pipe
 - Copper pipe
 - PVC pipe
 - Galvanized pipe

8. Fresh water pipe diameter: cm.

9. Waste pipe system:
- Cement pipe
 - Cast iron pipe
 - PVC pipe

10. Waste pipe diameter: cm.

11. Faucets:
- ground-key faucet
 - Screw faucet
 - Slide faucet

12. Kitchen material:
- Wall
 - Floor covering
 - Ceiling

13. Complaints from, and remarks for, the old (and new if any) kitchen equipment:

C. Bathroom

1. Any repair work, change or addition made in the bathroom.

- None
- Repair work
- Equipment (pipe, cistern, etc.)
- Change
- Replacement
- Enlargement

2. Date of, and reason(s) for, change: (.....)

3. Number of bathrooms in the house:

4. Number of rooms with private washing spaces:

5. Water heating system in the bathroom:
- Water heater
 - Thermosiphon
 - None

6. Fresh water pipe system: Lead pipe

- Copper pipe
- PVC pipe
- Galvanized pipe

7. Fresh water pipe diameter: cm.

8. Waste pipe system: Cement pipe
- Cast iron pipe
 - PVC pipe

9. Waste pipe diameter: cm.

10. Washing equipment in the bathroom:
- Marble basin
 - Shower tray
 - Bathtub
 - None

11. Bath trap: Yes
- No

12. Faucets: ground-key faucet
- Screw faucet
 - Slide faucet

13. Bathroom material:
- Wall
 - Floor covering
 - Ceiling

14. Complaints from, and remarks for, the old (and new, if any) bathroom condition:

D. Toilet

1. Any repair work, change or addition made in the toilet.

- None
- Repair work
- Equipment (pipe, cistern, etc.)
- Change
- Replacement
- Enlargement

2. Date of, and reason(s) for, the change: (.....)

3. Direction of the toilet:

4. Number of toilets in the house:

5. Toilet is: Inside the house
- Outside the house

6. Fresh water pipe system: Lead pipe
- Copper pipe
 - PVC pipe
 - Galvanized pipe

7. Fresh water pipe diameter: cm.

8. Waste pipe system: Cement pipe

Cast iron pipe
PVC pipe

9. Waste pipe diameter: cm.

11. Cistern Yes
No

11. Faucets: ground-key faucet
Screw faucet
Slide faucet

12. Measures taken for malodor in the toilets with no cisterns: No measures
Use of stopples
Use of metal lids

13. Toilet material: Wall
Floor covering
Ceiling

14. Complaints from, and remarks for, the old (and new, if any) toilet condition:

Full Length Research Paper

Feasibility study of chromium electroplating process in stamping tooling

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Due to the great need for reducing production costs, productivity increasing quality improvement of products, the study had its start drafting surface treatment of dies process development, where the first step was a market study looking for the treatment types and their applications. These treatments are intended to stabilize the production process so that there are no variations on the production and increasing the useful life of dies and their appropriate tools. It was determined through analysis, that the parts had problems in dies drawing which influenced on productivity, quality and cost. It had been realized that those parts had similar problems and the treatments could generally minimize such problems. The following step was to apply the treatment of dies and tools, and then realized that the results achieved certain goals, managing to stabilize the stamping process of those parts.

Key words: Automotive stamping, covered tools, electroplating of chromium.

INTRODUCTION

General Motors Corporation (GM) is the largest vehicle manufacturer in the world and it is the global industry sales leader since 1931. It designs, builds and sells cars and trucks around the world. Established in 1908, GM today employs about 325,000 people around the world. Operates in 32 countries and its vehicles are sold in 200 countries. In 2004, it sold nearly 9 million cars and trucks. GM's global headquarters is located in Detroit-USA.

The General Motors of Brazil (GMB) is the largest facility of this company in South America and the second

largest operation outside the United States. On 26th January, 2014 had completed 90 years of activities in the country. In 1925, GM came to Brazil and settled in warehouses at Ipiranga, Sao Paulo city. In 1930, it was transferred to Sao Caetano do Sul at Sao Paulo state. Over the years, it achieved several milestones and became a reference not only in this country, as worldwide, through high standards and innovative procedures.

This work was done in the automotive industrial

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complex at Sao Jose dos Campos, in stamping area, which now holds approximately 7,000 employees working in three shifts, and two of them assembly cars. It has a daily average of 780 cars. The GMB's production of Sao Jose dos Campos is intended to supply the domestic market and to export to all over the world. Several problems were found and observed, and then tools to receive hard chromium coatings were selected to this study. Chromium electroplated coatings are widely used in industry for protecting mechanical components against corrosion and wear, to the worn components and dimensional recovery in applications where its repellence is required, as in stamping tools and rubber and plastic extruders.

In industry, it is used mainly with electroplated chromium coating thickness greater than 10 μm , which is called hard chromium to differentiate it from the chromium used as decorative coating, which has typically layer thickness between 0.2 and 10 μm . Hard chromium coatings are used on more than 70 years in the industry, and it is proven their excellent cost/benefit ratio. The application of chromium as coating has the need to increase the service life of the tools because of the high cost of replacement components. Chromium is used as coating when it wants to associate with corrosion resistance and to decrease the wear rates. Electrodeposited chromium presents high surface hardness, which can facilitate crack surface, and it can provoke the superficial degradation.

For this reason, it is proposed in this paper the use of an electrochemical technique to determine and to evaluate the behaviour of this coating. The electroplating is one of the most used methods for obtaining metallic coatings, as it allows the control of important parameters of deposits such as: chemical composition, phase composition, microstructure and layer thickness. Few works are found in literature on electroplating of chromium and stamping process, specially related to automotive sector.

Deqing et al. (2005) reported their work on the study of the temperature effects, current density and time on thickness of nickel, copper and hard chromium coatings produced by a multiple electroplating process. Svenson (2006) listed properties of chromium and its application on plating.

In Abdel Gawad et al. (2006), carbon fibre of PAN (plasma assisted nitriding) type was electrolytically coated with chromium layer, which was transformed to chromium carbide using *in-situ* process. The influence of plating parameters such as current density and plating time on the coating thickness of chromium deposited layer was investigated. Alternating pulsed electrolysis was investigated for the surface modification of carbon steel substrates with carbon contents of 0.2, 0.6 and 0.8 mass% (Yagi et al., 2008).

Bin Sobhi (2008) investigated and analysed the scrap reduction in automotive manufacturing parts, specially the car door production and process, where the stamping

process is the main process used. Kumar et al. (2010) had developed structural models for effluent treatment system for electroplating, indentifying benefits to the electroplaters and to end users. Mandich and Snyder (2010) described properties, features and applications of electroplated chromium, such as it deposits rank among the most important plated metals and that is used almost exclusively as the final deposit on parts. Lin and Hsieh (2011) had studied strength of relationships with the partners in supply networks in the automotive industry and their influence in raw materials quality. Khodadad and Lei (2014) reported their work, where the trivalent chromium coatings were deposited on the pure aluminium substrate using a thin zincates interlayer.

Problem statement

The use of stamped parts in the automotive sector is extremely important, so General Motors of Brazil has been invested in its stamping units at Sao Caetano do Sul, Sao Jose dos Campos and Gravatai facilities, to eliminate waste, and loss of productivity and for continuous improvement in the quality of its products. In stamping unit of the GMB at Sao Jose dos Campos exists losses during the productive process due to problems caused by stamping tools used in the manufacturing of parts. Stamping tools present: Wear, griffin, dirt, weld marks and broken. These deficiencies are generating low availability of stamping tools, high rate of waste parts, rework and overuse of stamping oil. Figure 1 show some of these deficiencies.

Chroming process

According to Newby (2000), the chromium plating is produced by chromic acid solution, which contains one or more catalytic anions. The anions have great influence on chromium deposition, mainly the sulphate found in commercial chromic acid, which may not exceed a certain amount (0.1 mg/m^3 of air) in the relationship of chromic acid for sulphate ion. Therefore, it is essential to use free chromic acid to meet and to take into account the content of these anions, which should be low in chromic acid. Usually admits a maximum content of anions in chromic acid of 0.2% sulphate ion (Weiner, 1973).

According to Silman (1955), the concentrations of chromic acid and sulphuric acid in the bath have secondary importance related to the main factor, which is the relationship of chromic acid and sulphuric acid, which needs to be maintained around 100:1. The concentration for the hard chroming varies from 250 to 350 g (chromic acid)/L, in special cases using extremely high concentrations up to 500 g/L. The properties of a chromium layer, however, do not only depend on the

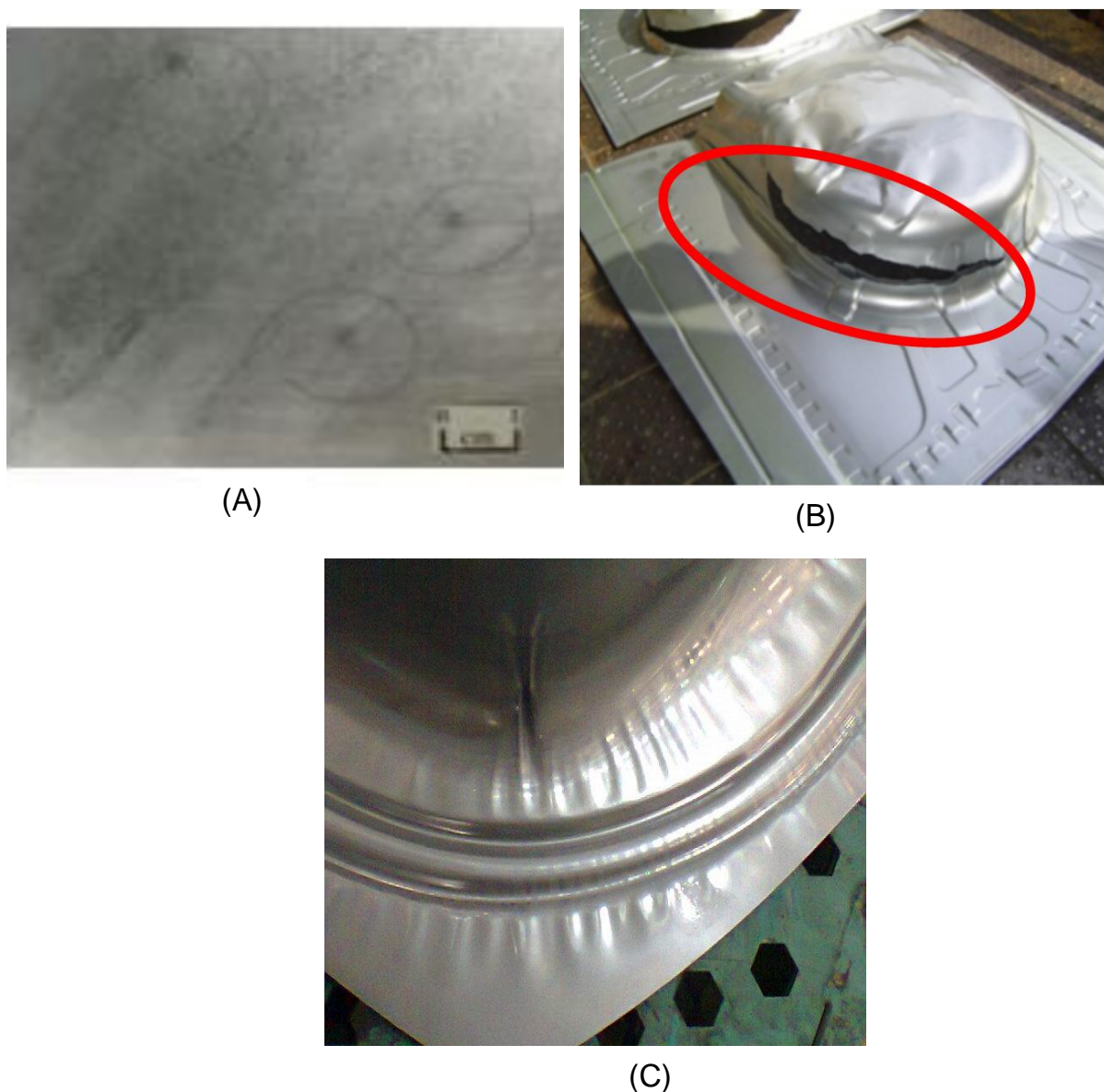


Figure 1. Faults occurring in the process: (A) excess lumps; (B) excessive breaks (cracks); (C) wrinkles (courtesy: General Motors).

concentration of chromic acid in electrolyte. Depend of, above all, catalyst and working conditions of electrolysis, for example, current density, temperature, and time deposit (Panossian, 1997).

First working electrodes were built with coating, that is, substrate coated with chromium and uncoated electrodes (only the substrate). The material used in the manufacture of electrodes without coating was carbon steel 1020 (ABNT, 2000). After that, the following steps were determined:

- (i) Passivation solution of substrate;
- (ii) Ideal concentration of passivation solution;
- (iii) Scanning ideal speed of passivation;

(iv) Selection of potential where the chromium does not have chemical reaction and the substrate suffer passivation;

(v) Determination of loads density of substrate passivation of coated and uncoated electrodes for the calculation of porosity;

(vi) Determination of coating thickness;

(vii) Manual polishing (sandpapers with granulation of 600 and 400) for the electrodes without coatings.

MATERIALS AND METHODS

Here, the research classification and the preparation steps of this



Figure 2. Opening doors structure (courtesy: General Motors).

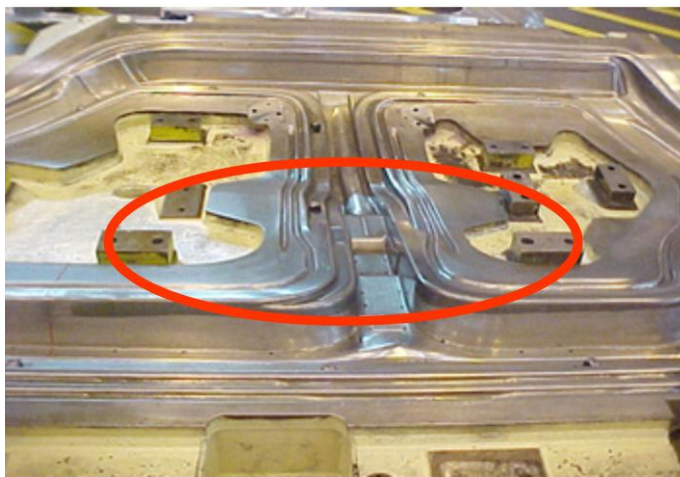


Figure 3. Array of drawn of metallic radius (courtesy: General Motors).

work are explained. The exploratory-descriptive was chosen as research methodology, where the field research and data collection might be previously performed through company data file and also through demonstration of improvements in performance results of metallurgical equipment (tool), specially the process of applying chromium plating. To start the implementation of chromium plating process of the tools, it did a survey of some operational data of the company, and they were:

- (i) Index of losses with waste and scraps from total produced;
- (ii) Number of returns during the year by the client;
- (iii) Amount of material released to experiment;
- (iv) More defective and critics products.

Some stamping companies were surveyed, in order to obtain documented procedures and data collection with the suppliers Torata Chromium Plating and Cascadura Coatings, which were evaluated throughout the development of the work.

Development of experiments performed at GMB

Analysing the current process of the company where the problem appeared that the requirements of internal customers had been met partially, since faults such as cracks, wrinkles and tool marks on parts during the manufacturing process steps were found. Based on the practices already adopted by companies in the automotive sector there were developed proposals for modification of the manufacturing process by changing some of its parameters and evaluating variables with reset of this process parameters. All responses generated by the process after the changes suggested were analysed. Recommendations and suggestions for changes on process had been given to reach the expected results by the company and by internal clients.

Once the approximate borders of the situation-problem are identified, also the techniques to be adopted for the full study and decisions which require consideration of the findings obtained in the preliminary exploration of the application of the chromium plating in tooling are defined. It was possible to define the main phases of the project, briefly described hereafter. To maximise the benefits and to minimise the disadvantages of the collection instrument selected, Torata Chromium Plating and Cascadura Coatings recommend the procedures that they had adopted:

- (i) Focus group – formed by production processes engineers, materials engineers, and the leaders of the departments of metalwork and CKD export, which have interest in the issues of study, as well as direct clients of services provided;
- (ii) Pre-test – the pre-test was conducted following the standards and guidelines established by the companies Torata Chromium Plating and Cascadura Coatings to establish clarity, acceptability and comprehensiveness of product used (hard chromium);
- (iii) Note *in locu* – this observation had provided the capture of views, information, and product quality characteristics.

Treatment application

Monitoring and analysis was carried out during the production process to develop the treatments to be applied on the surface of stamping. It has been found through experiments that require surface treatments applications which result in better efficiency possible. Therefore, in order to a more effective study, the treatment of hard chromium in the input radius of drawn matrix part of opening doors structure (Figure 2) in order to analyse the treatment.

After that, it had been taken off the hard chromium layer from tool and the treatment of plating had been applied within the matrix radius, according to Figure 3. There was also another study, applying in the drawn stamping of inner panel part of the trunk cover (Figure 4).

Survey with suppliers

A survey was conducted via the internet and contacts with other plants of the GMB to know which companies of surface treatments are prepared to receive large tools. Due to the average stamping weight 10 tonnes, it is difficult for many companies to perform this work, so it was possible to register two companies:

- (i) Torata: Company located in the city of Porto Feliz, in the Brazilian state of Sao Paulo which holds hard chromium surface treatment dies with maximum weight of 16 tonnes;
- (ii) Cascadura: Company located in the city of Sorocaba, in the Brazilian state of Sao Paulo that performs processing of hard chromium plating and tools metallization with a maximum weight of 10 tonnes.



Figure 4. Array of back cover of the trunk (courtesy: General Motors).



Figure 5. ES4 model Schuler presses (courtesy: General Motors).

These two suppliers make the budget of surface treatment to be performed and the time for execution.

The stamping setting

Tools adjustment is the most important set to this process, because after the surface treatment is not possible to modify the stamp without damaging treatment. The following procedure was determined for adjustment before treatment:

- (i) Punch and matrix: Setting across the surface to eliminate deformations caused by wear, cracks due to heat treatment, welding, and polishing brands in general;
- (ii) Press-plate: Ring setting, copying the shape of the array, setting controlled flow of material and determination of equalizers of the press-plate.

Experiments at GMB

The stamping tools to be treated superficially were defined through quality and productivity graphs issued monthly indicating which critical parts with highest rate of problems. The tools were

developed in nodular cast iron GM 238, G3500 standard method GMDDS section 85 with graphite Types I and II, pearlitic/ferritic matrix structure, obtained by heat treatment. It has high mechanical properties, good harden ability and good surface finish. The material has behaviour of tensile strength and yield strength similar to SAE 1040 (AISI, 2013) steel hot-rolled, in condition melting gross. It consists of graphite in the form of nodules (spheres), forms I and II, sizes 6 to 8, according to ASTM A247-10 (ASTM, 2014). The matrix is a pearlitic/ferritic structure, with approximately 50% of perlite and a maximum of 5% of carbides dispersed. The carbon content ranges are specified for each group of gauge, in order to control the type and size of the graphite. The variation within a song is about 0.20%. Magnesium is added with the goal of favouring the formation of spheroidal graphite. The pieces were stamped on semi-automatic mechanical presses, ES4 model Schuler of five operations (Figure 5) which have the following specifications:

- (i) Head area: 4,572 × 2,500 mm;
- (ii) Strokes per minute: 7 a 14;
- (iii) Press capacity : 2,000 tonnes;
- (iv) Standard height for tools: 1,220 mm;
- (v) Mobile table: 4,500 × 3,000 mm

Product validation and decision-making

After stamping of parts, a visual assessment was performed following the internal procedures used at GM, they are used for evaluation of a normal part of production. In this evaluation took into account the surface aspects (deformations, brands, tearing of material etc), structural aspects (cracks, remounting, sprains) and aspects of dimensional and form (number of holes, wrinkles, lack of material). 100% quality control of all parts manufactured by performing a visual assessment of the same is accomplished during the production process of parts, with the aim of observing any faults in the production process, for example, pits, cracks, wrinkles, overlap etc. The results obtained from this quality control showed a significant contrast between the materials. The use of phosphatised material generated a great reduction in the number of total defects, especially in the pits, with a reduction from 3.2 to 0.8% of lumps in the total production of parts in a same period of time. It was observed that the lumps are due to the tearing of the galvanized coating layer during the stamping process. The images obtained through the MEV shows clearly the low grip between galvanized and metal coating base.

The use of phosphatised materials, as the BH 180, 210, 260 and 280 used in precision metal stampings, showed greater efficiency, especially when it concerns the lumps, improving the adhesion of the coating to the metal base compared to materials using only the electro-galvanized layer. It is observed from this study and tests that, the use of materials with layered phosphatised becomes feasible in parts that will be used in external panels of vehicles, where its quality control is more accurate when compared to internal parts. The use of chromium plating done in tools has a number of advantages for both the stamped parts and the tools employed in these experiments. The chromed surfaces showed a layer of superficial hardness of approximately 900 HV (Vickers), giving a high wear resistance and durability of the tool.

RESULTS

Then it can observe the results obtained after the chroming processes of 14 tools of three vehicles selected for the study, for those two study cases will be presented. The external side panel part LD for car model Montana



Figure 6. External side panel LD (courtesy: General Motors).



Figure 7. External side panel LD (courtesy: General Motors).

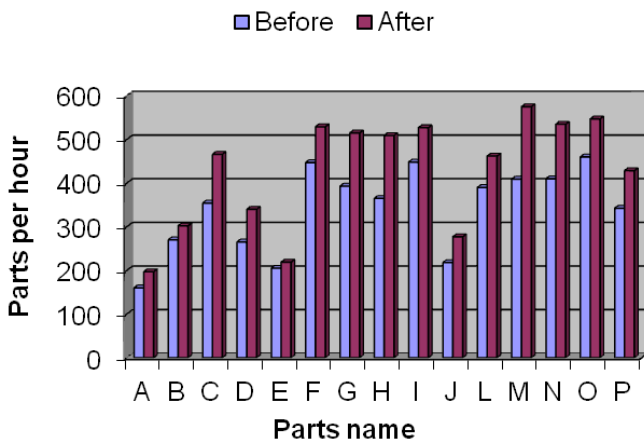


Figure 8. Productivity of the pieces studied.

had low productivity due to interference caused in the production process by the tool to eliminate rework from gripping (Figure 6). After it had been held the plating treatment of incoming rays of productivity matrix had a gain of 112 parts per hour due to non-interference of the productive process by the tooling department. Table 1

shows the other gains for the surface treatment of plating. The external panel on the right side of the car model Corsa featured a high number of wastes, totalling 37 parts per month (Figure 7). After presented the superficial treatment of chroming on the press-plate and at the matrix of the stamping of fountain there was drawn a decrease of 35 parts per month in the number of waste. Table 2 shows the gains for the surface treatment of chroming. Then, it is shown that the increase in productivity of the parts studied, compared to productivity before the achievement of surface treatments and after the completion of the work (Figure 8).

It can be checked in the Table 2 that the productivity of the parts studied in three vehicles had an increase of 87 parts per hour being indicated by the letter P in Table 3, which corresponds to a 26.4% gain in productivity. Table 3 presents the legend adopted in this work to indicate the parts studied.

With the work performed, the number of scraps of the parts studied decreased from 354 parts to 14 parts per month, with a 96% reduction. Figure 8 shows a reduction in the number of scraps. Table 4 shows the legend adopted in this work to indicate the parts studied used in Figure 9. It has been gotten through the surface treatments carried out in the studied parts reduce the rework of 712 parts to 29 parts per month, which is equivalent to a gain of 96%. Figure 10 corresponds to gains in all parts studied. Figure 11 shows that the economy hit with elimination of lubricating oil known as Green Rust which it was used around 800 L/month and it was generated a monthly cost of R\$ 7,848.00 (US\$ 3,246.06 in February 4th, 2014) in the processes of the parts, which have a unit value of 9.81 R\$/L (4.06 US\$/L in February 4th, 2014).

DISCUSSION

It was possible to observe that chromium has low coefficient of friction, allowing the reduction or even elimination of lubricants, and therefore the operating cost in a chromed surface, due to its high repellence characteristic, there is no particle adhesion, eliminating the risk of fouling, and avoiding even the rework of tools. When adorn galvanized sheet metal, chromium coating does not allow for accession of zinc particles on the surface of the tool, avoiding the need for polishes, and improving the quality of the surface of the stamped parts. The chromium job enabled greater efficiency in printing, from the use of cheaper cast irons. The use of cast irons also results in advantages in the machining of parts, given the lower hardness of material which facilitates its processing, promotes increase in service life of cutting tools and more efficient use of the machine. Other benefits were observed:

- (i) Reducing and eliminating the need of lubrication in the stamping process, also reducing environmental problems

Table 1. Monitoring of the parts gain: external side panel LD.

Variables	Before	After	Gain	Gain (%)
Productivity (parts/hour)	354	466	112	31.6
Scrap (parts/month)	0	0	0	0
Rework (parts/month)	37	0	37	100
Hours of downtime (hours/month)	3.68	0	3.68	100
Maintenance hours (hours/month)	41	2	39	95

Table 2. Monitoring of external panel LD gains.

Variables	Before	After	Gain	Gain (%)
Productivity (parts/hour)	447	529	82	18.3
Scrap (parts/month)	37	2	35	94.6
Rework (parts/month)	8	1	7	87.5
Hours of downtime (hours/month)	1.7	0	1.7	100
Maintenance hours (hours/month)	18	0	18	100

Table 3. Caption of Figure 8 letters.

A	Column "B" inside	H	Inner panel of front door LE
B	Rear floor Panel extension	I	Inner panel of front door LD
C	External side panel LD Corsa	J	Rear floor panel
D	Inner Wheel box LD/LE	L	Inner panel of the trunk lid
E	Door structure of S10	M	External side panel LD of Montana
F	Rear door inner panel LE	N	External front door panel LE
G	Rear door inner panel LD	O	External front door panel LD
P	Average		

Table 4. Parts studied subtitles.

A	Column "B" inside	H	Inner panel of front door LE
B	Rear floor Panel extension	I	Inner panel of front door LD
C	External side panel LD Corsa	J	Rear floor panel
D	Inner Wheel box LD/LE	L	Inner panel of the trunk lid
E	Door structure of S10	M	External panel LD of Montana
F	Rear door inner panel LE	N	External front door panel LE
G	Rear door inner panel LD	O	External front door panel LD
P	Total		

involved;

(ii) Reduction of downtime spent in stamping process, after reducing the need of polishing during the process, due to low adherence of material, reduction of faults or problems occurred during the stamping parts resulting in quality and productivity gains;

(iii) Increase in tool life and greater ease in the recovery of the same, being need only the replacement of the chromium layer.

Conclusions

The application of hard chromium surface treatment used in this work represents an advantage in critical parts stamping process, achieving stability in the production. With the study conducted in selected parts, it was defined as procedure that helps in treatment analysis to apply. This procedure enables to apply the surface treatment in order to achieve the best efficiency, increasing the life of

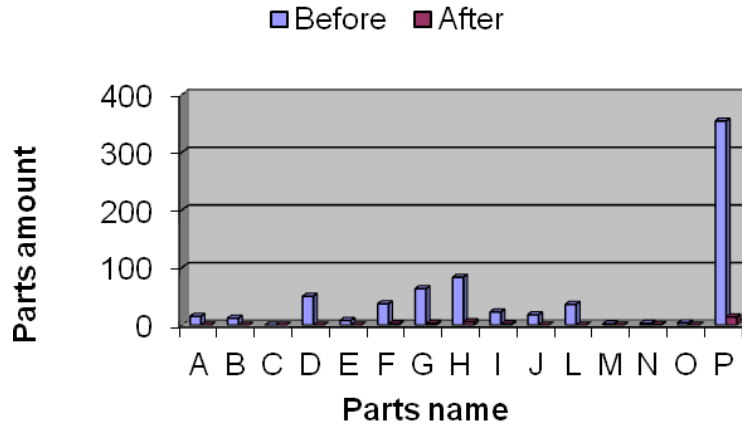


Figure 9. Studied parts waste.

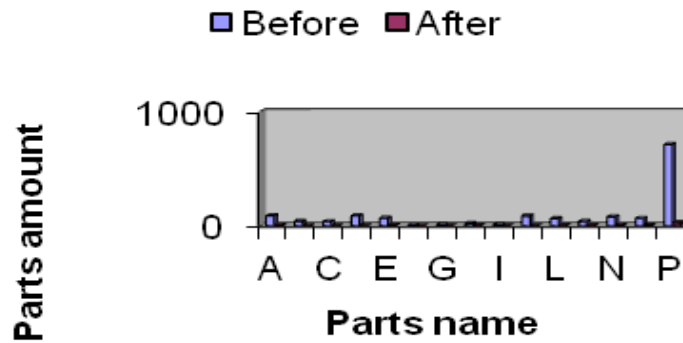


Figure 10. Rework of the parts studied.

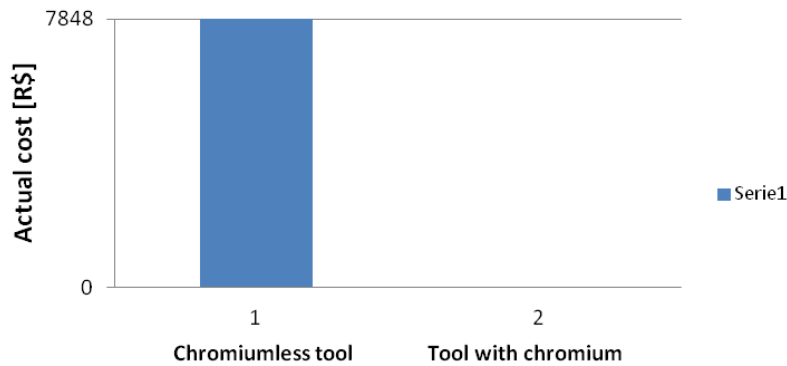


Figure 11. Cost of representation with oil consumption.

stamping and achieving greater stability of the process. It has to follow the procedure for the application of two types of treatments used in this project:

(i) Plating: used when the part shows constant and located gripping caused by rays of matrices and puncture;

(ii) Chroming: used when the part shows gripping in the press-plate, scratches on the surface of the punch and matrix, cracks and wear on tooling.

It was concluded that all these results and previously cited gains are coming from the properties that the chromium plating gave to the tools used in this work,

analysed and previously described and carried out at General Motors presented high performance during the process. A large etching efficiency factor of this project lies in the use of high strength steel plates, which provide the high mechanical properties, to the vehicle and smaller thicknesses used for manufacture of structural elements and automotive panels, resulting in more resistant vehicles and at the same time lighter and economical.

In order to shape these plates, due to its characteristics and properties, it was necessary the development of new techniques, which were designed to ensure an efficient production of automotive elements, otherwise it would not be possible using conventional techniques. Watching the production losses of parts by quality problems, it has been seen that this indicator has increasingly strategic importance in the production chain of automotive group from which General Motors is part.

The strategic importance due to the fact that the guarantee of quality of the final product must be sustained once, if not only supplies products directly to the internal client such as metalwork, as well as for external customers of other productive areas of the group as its dealers, parts for export and other plants of the corporation in Brazil and South America.

In the years 2011 and 2012, the goal of production loss was established taking into account the history of the equipment and the process, being respectively 25 and 20%. The lost production is a percentage; in this case, it was adopted a tolerance range since this is a measure of reliability of the processes production equipment (tools). The actual values of production losses and losses of processes affected in the years cited were respectively 30.15 and 22.20%, which demonstrates a performance improvement in product quality and in the process between the years 2010 and 2011, but the range of the goal is still the challenge.

Conflict of Interests

The authors have not declared any conflict of interests.

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Full Length Research Paper

An experimental study on establishment of a high-volume common carotid-external carotid bypass model in dogs

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High-volume intra- and extra cranial artery bypass surgery has been widely used, but it remains a difficult technique for most of surgeons. The objective of this study is to explore a training mode and platform. Six healthy dogs were divided into three groups at random. Twelve high-volume common carotid-external carotid bypasses were operated on both sides of six dogs (n=12). Digital subtraction angiography (DSA) and color Doppler sonography were taken to measure the hemodynamic parameters of grafts one week (n=4), four weeks (n=4) and 24 weeks (n=4) after the operations. The grafts were taken out for histopathological examination 24 weeks after the operations. The high-volume common carotid-external carotid bypass model (n=12) was successfully established in six dogs under microscope. Post-operative DSA in Week 1 (n=4), Week 4 (n=4) and Week 24 (n=4) showed bilateral external carotid blood flow was supplied by contralateral common carotid grafts. Both ends and the whole grafts were patent. Color Doppler sonography showed clearly that the blood flow volume of grafts was higher than 90 ml/min. Histopathological examination taken 24 weeks after the operations showed intimal hyperplasia of grafts. Dog model of high-volume common carotid-external carotid bypass has the advantages of similar material, high volume, similar blood pressure, feasible operation and high patent rate compared to the traditional microsurgery model, making it a better simulation training platform which is closer to the real surgical procedure for surgeons willing to master the technique of high-volume bypass operation.

Key words: Dog, animal model, bypass, high-volume, vascular anastomosis.

INTRODUCTION

In recent years, extra cranial–intracranial bypass has been playing a more and more important role in the treating of diseases including ischemic cerebrovascular diseases, complicated aneurysms and skull base tumors (Eliason et al., 2002; Evans et al., 2004; Deshmukh et al.,

2005; Mohit et al., 2007; Sekhar et al., 2008; Patel et al., 2010; Xu et al., 2011; Ramanathan et al., 2012; Kalani et al., 2013; Loughheed et al., 1971). The indications for this technique are usually classified into two categories, flow replacement and flow augmentation (Amin-Hanjani, 2011).

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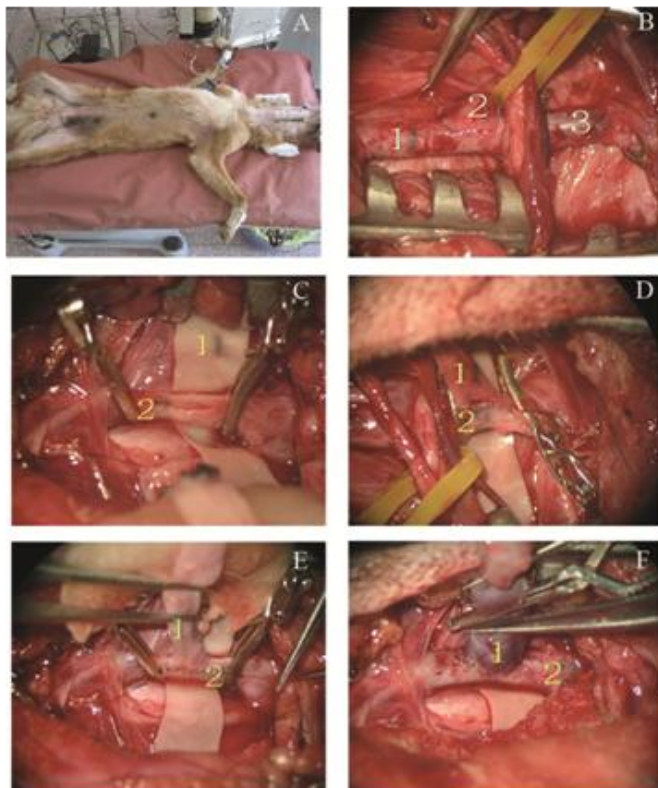


Figure 1. (A) Exposure of incision: cervical incision, lower-limb incisions and body posture. (B) Exposure of cervical vessels: 1 common carotid; 2 internal carotid; 3 external carotid. (C) The anastomosed position on the common carotid and the incision (arrow) on the artery. (D) Anastomosis (arrow) of the posterior wall was completed and the clamps were not released yet. (1) The common carotid. (2) The graft. (E) Anastomosis (arrow) of the graft was completed and the clamps were not released yet. (1) The common carotid. (2) The graft. (F) The anastomosis (arrow) was completed and the clamps were released with no leakage. (1) The common carotid. (2) The graft.

While technically, there are two modalities of extra cranial–intracranial bypasses (Amin-Hanjani et al., 2010). The first is termed as “high-flow” bypass usually using a vessel graft. The commonly used grafts include the saphenous vein and radial or ulnar arteries. Bypass using radial artery is sometimes referred as “intermediate-flow” (Prinz et al., 2014). The second is termed as “low-flow” bypass usually using in situ pedicles. The superficial temporal artery to middle cerebral artery revascularization is a typical “low-flow” bypass.

Nowadays, “high-flow” bypass is becoming the research focus of neurosurgeons. For example, endovascular stenting has been used for the management of graft stenosis (Maselli et al., 2011), and self-closing U-clips used for interrupted intracranial microanastomosis (Ferrolì et al., 2007). The objective of this study is to establish a dog model of high-volume common carotid-external carotid bypass for peri-operative observation, to explore a training mode for the

popularization of high-volume intra- and extra cranial artery bypass and to provide a simulation training platform for concerning neurosurgeons, vascular surgeons and skull base surgeons.

MATERIALS AND METHODS

Experimental animals

Six healthy dogs, male or female, with weight of 10 to 12 kg were provided by the animal experiment center of Tianjin People's Hospital.

Randomization

Six dogs were sequentially numbered (No.1 to 6) and allocated into three groups at random. DSA and color Doppler sonogram were planned 1 week (for No. 1 and 4 only), 4 weeks (for No.2 and 5 only) and 24 weeks (for No. 3 and No. 6 only) after the operation. The vascular anastomosis was completed with interrupted suture for No.1 and No.2 dogs or continuous suture for No. 3 to 6 dogs.

Pre-operative preparations

Aspirin 300 qd was administered for three days before the operation. Preoperative fasting for 12 h was mandatory but the dogs had free access to water.

Skin preparation

Skin preparation was completed under basal anesthesia 30 mins before the surgery. The skin area included cervix and bilateral femoral regions. The cervix area covered the middle part of mandibular body anteriorly manubrium posteriorly and body surface projection of the transverse process of cervical vertebrae laterally. Bilateral femoral regions were bounded superiorly by inguinal ligament and inferiorly by knees and laterally by lines 5 cm away from the incision (Figure 1A).

Anesthesia

Intramuscular atropine 0.05 mg/kg and ketamine hydrochloride 10 mg/kg were injected for basal anesthesia. After anesthesia induction with intravenous hydrochloride 2 mg/kg and propofol 1 to 1.5 mg/kg, oral intubation were performed using laryngoscope (inner diameter: 6.5 to 7.5 mm) with muscle relaxation. Propofol and enflurane were used for anesthesia maintenance.

Model establishment

Cervical incision

At supine position on the operating table, the neck of the dog was exposed adequately with fixation of limbs, hyperextension of the head and pillow under the cervix (Figure 1A). After sterilization with iodine and alcohol and draping, the incision was made. Along the anterior boundary of musculus sternocephalicus, straight incisions were made to cut open the skin and subcutaneous tissue bilaterally.

The connective tissue surrounding musculus sternocephalicus, sternothyroid and the sternohyoideus were bluntly dissected to expose the common carotids on both sides. Then the common

carotids were dissected distally to the bifurcation to expose 1 to 2 cm of external carotids (Figure 1B) for future anastomosis. The nerves nearby were protected carefully and the adventitia was reserved temporarily.

Harvest of grafts

Cut the skin 1 cm below the inguinal ligament and 1 cm medial to the most obvious place of femoral artery pulse to expose and dissect 8 to 10 cm of femoral veins. Branches of femoral veins were ligated, coagulated and cut off. After thorough dissection of femoral veins, ligate the distal part with 1 to 0 sutures and then the proximal end after emptying the blood flow. Cut the vein at 3 mm proximal to the proximal end and 3 mm distal to the distal end separately. The vein should be handled carefully to prevent mechanical trauma and vasospasm. Distend the vein with heparinized saline to look for overlooked tributaries. Then work the graft between the index finger and thumb to overcome the spasm in the vein. Then unligated branches will be secured and reinforced (Sia et al., 2013).

Vascular anastomosis

The right common carotid-left external carotid bypass was operated first. With presence of venous valves, the grafts were put inversely along the blood flow. Then the adventitia at the ends was trimmed. The external carotid at the anastomosis between the inguinal artery and internal carotid was dissected and then a vascular cushion was put under it. A 4 mm oval incision was made with smooth edges on the external carotid after occlusion of both ends with temporary clamps. Repeat flushing the mural thrombus with heparinized saline. The proximal end of femoral vein was anastomosed with the end of external carotid with interrupted or continuous suture using 8 to 0 micro sutures. Before the last two stitches, heparinized saline was injected to eliminate air inside the artery. During the process of anastomosis, saline was dripped continuously to the surface of vessels for moisture. After anastomosis, the graft was occluded first and the clamps at the distal end of external carotid were released for vascular filling. No exudation was observed and then the clamps at the proximal end of external carotid were released. The total duration of occlusion should not exceed 30 mins. No or little exudation was observed and resolved easily by compression. The graft was anastomosed proximally (distal end of the femoral vein to the end of the contralateral common carotid) through a subcutaneous tunnel made with clamps anterior on the front of the neck. The external carotid proximal to the distal end of the anastomosis was ligated. According to the above method, left common carotid-right external carotid bypass was completed and the external carotid was ligated. Finally, the blood flows of the external carotids on both sides were supplied by the contralateral common carotids through grafts (Figure 1C and D).

Post-operative treatment

After the dog restored normal autonomous respiration, the tracheal catheter was removed after consciousness recovery. Dogs were in fasting condition but had free access to water on the day of surgery. General diet was given on the first post-operative day and aspirin started to be administered at 300 mg qd for lifetime.

Measurements and specimen collection

Occlusion time of vessels was recorded during the operation. DSA and color Doppler sonosound examinations were taken 1, 4 and 24

weeks after the surgery according to the group. During the examination, measure and record hemodynamic parameters of grafts. Grafts were taken out 24 weeks after the surgery for histopathological examination.

Statistical analysis

All measurement data would be expressed with $\bar{X} \pm s$ and analyzed with SASS software (SASS version 9.0, SASS Inc.).

RESULTS

Six dog (12 sides) were operated high-volume common carotid-external carotid bypass under a microscope for model building.

General condition of the dogs

The surgeries were successful with no anesthetic accident. All grafts were patent. The operating time was 5 to 8 h. All dogs were of similar mental state, physical activities, foraging and feeding state with before except for one dog that had choking induced by nervous laryngeal injury during the surgery.

Vessel occlusion time

Interrupted suture and continuous suture were performed for No. 1 to 2 dogs (n=8) and No. 3 to 6 dogs (n=16), respectively. Continuous suture took less time than interrupted suture ($P < 0.05$) (Table 1).

DSA

DSA on bilateral external carotids showed blood flow provided by the contralateral common carotid through the grafts and patent anastomotic ends and grafts 1 week (n=4), 4 weeks (n=4) and 24 weeks (n=4) post-operatively (Figure 2A and B).

Color Doppler sonosound

Clear Doppler pictures were taken 1, 4 and 24 weeks post-operatively (Figure 2C to D) for measurements of inner diameter and hemodynamic parameters of grafts (Table 2).

Histopathological

Histopathological examination taken 24 weeks after the operations showed intimal hyperplasia and arterialization

Table 1. Vessel occlusion time with interrupted suture and continuous suture.

Group	Number	Vessel occlusion time (min)
Interrupted suture	8	36.25±5.18
Continuous suture	16	20.81±5.27

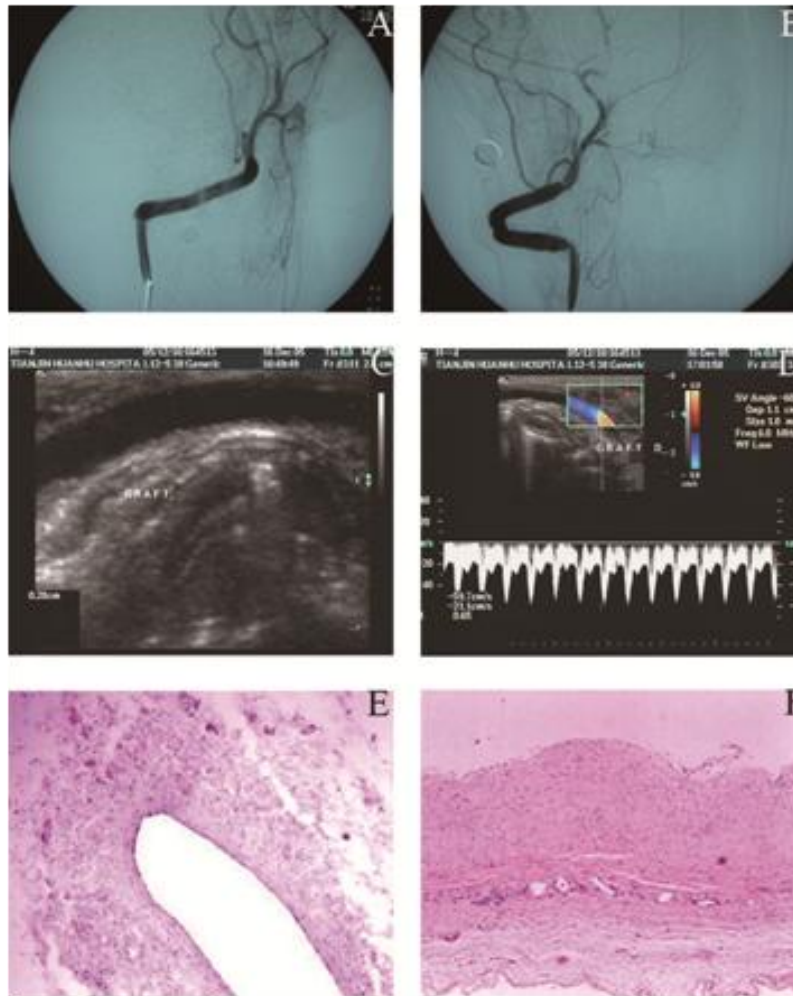


Figure 2. (A) and (B) shows blood flow from the right common carotid to the left external carotid through the graft on DSA. (C) and (D) shows Co-lor Doppler sonosound pictures of cervical vessels (C The graft. D Hemo-dynamic measurements of the graft.). (E) and (F) shows histopathological examinations (E Normal femoral vein of dogs. F Intimal hyperplasia of the graft 24 weeks post-operatively).

Table 2. Inner diameter and hemodynamic measurements of grafts.

Table	Vs (cm/s)	Ved (cm/s)	PI	D (mm)	Q (ml/min)
1-week group	82.8±17.0	24.6±3.2	1.29±0.14	2.75±0.05	205.9±43.9
4-week group	87.7±6.9	21.5±1.9	1.51±0.16	2.50±0.08	194.7±22.5
24-week group	80.9±7.0	21.7±0.7	1.42±0.10	2.57±0.10	184.9±24.8

Vs, peak systolic velocity; Ved, end-diastolic velocity; PI, pulsatility index; D, diameter; Q, blood flow quantity.

of grafts compared to pre-operative veins in the dog model of high-volume common carotid-external carotid bypass (Figure 2E to F).

DISCUSSION

In 1953, saphenous vein bypass was firstly applied by Conley, a head and neck surgeon, in a surgery of a patient with tumor invasion of internal carotid (Conley, 1953). Afterwards, high-volume bypass operations have been improved by various surgeons and widely used. In 1971, Lougheed, a Canadian neurosurgeon and his colleagues described common carotid-internal carotid bypass with saphenous veins (Lougheed et al., 1971). Then (Sundt Jr et al., 1986; Sundt 3rd and Sundt Jr, 1987) improved this technique by using the M2 segment of middle cerebral artery and the P2 segment of posterior cerebral artery as the receiving vessels.

In late 1980s, Sekhar, Spetzler and their colleagues (Sekhar et al., 1987, 1990; Spetzler et al., 1990) reported a technique of intracavernous internal carotid artery reconstruction by direct bypass with saphenous veins. The technique of employing radial artery as a coronary artery bypass graft was firstly induced in intracranial bypass by (Ausman et al., 1978). These years, Giuliano Maselli and his colleagues have reported the possibility of endovascular stent in the event of a narrowing of the bypass (Maselli et al., 2011).

Over the years, with application of intra-operative DSA, improvement in neurosurgical skills and more appropriate choice of patients, high-volume intra- and extra cranial artery bypass has become an important treatment for various intracranial diseases gradually (Eliason et al., 2002; Evans et al., 2004; Deshmukh et al., 2005; Mohit et al., 2007; Sekhar et al., 2008; Patel et al., 2010; Xu et al., 2011; Ramanathan et al., 2012; Kalani et al., 2013). However, high-volume bypass surgery is not an easy-to-master technique, requiring special training. Trainees should first practice suture with gloves, mice and cadavers in labs, read books, literature and see videos as reference and assist experienced surgeons in surgeries (Sekhar and Kalavakonda, 2002). Only through these trainings can surgeons improve knowledge and operation ability for this technique. Nevertheless, these trainings are still of quite large difference with actual practices. For example, the suture feeling of non-biological materials is of great difference with that of mammal vessels. Blood flow volume of small animals cannot meet the demand of high-volume vascular anastomosis. In training with the head of cadavers, hemodynamic measurements could not be monitored. For better surgical results, we chose dogs to build an animal model of high-volume bypass because the internal diameter of canine vessels is close to that of human vessels. This model can resolve the problem of different suture feelings with non-biological materials, meet the volume demand in high-volume bypass and

monitor hemodynamic measurements simultaneously.

In the pilot experiment, we found the internal carotid of dogs was too small (about 1.5 mm) to be used in high-volume bypass while the external carotid had a much bigger internal diameter on DSA. External carotid is more vital than internal carotid, it in combination with vertebrovascular artery provides intracranial blood flow, in consistent with the observed results by (Jung et al., 1975). There are many anastomotic branches between internal and external carotid making longer occlusion of carotid more endurable. For the above reasons, we chose canine common carotid and external carotid as the blood donor and acceptor in the model of high-volume bypass, respectively.

Though saphenous vein is commonly used for "high-flow" extra cranial-intracranial bypass on human, we found it is not suitable for such surgery on a dog. Canine saphenous vein is much thinner compared with that of humans and the drainage is incorporated into the femoral vein at the middle part of femoral region. The diameter and anatomical position are not fit for grafts. However, canine femoral vein is larger and more suitable for grafts in diameter. Besides, the deep femoral vein drainage is incorporated directly into the external iliac vein above the inguinal ligament thus lower-limb deep vein drainage through the deep femoral vein will be observed after ligation of the femoral vein. It is safe to remove of femoral vein as the graft. So canine femoral vein was used as the graft in our study.

Canine carotid system used in experiments has been reported (Crowell and Yasargil, 1973). Once performed end-to-end anastomosis with canine superficial temporal artery and a branch of middle cerebral artery (Asari et al., 1976). Performed anastomosis with the biggest branch of canine external artery, that is maxillary artery and the middle cerebral artery to build an animal model of extra- and intracranial artery anastomosis. Utilization of canine external carotid in high-volume bypass has not been reported yet. The difficulties in building a dog model of high-volume common carotid-external carotid bypass lie in difficult control of anesthesia and high demand for microsurgery. Some experience in our study is discussed subsequently

Vascular dissection technique

Vascular micro dissection technique is the key to success of high-volume bypass. Blood vessels should be dissected with care in avoidance of branch rupture obscuring the operation field before performing the bypass procedures. At the internal carotid root on common carotid, we often encountered a cluster of nerves and vessels, including anterior cervical ganglion, nodosum ganglion, vagosympathetic trunk, and sinus nerve, pharyngeal branch of vagus nerve, nervus laryngeus cranialis, recurrent laryngeal nerve,

glossopharyngeal nerve and hypoglossal nerve. Rough dissection might injure these structures causing various symptoms accordingly. The most commonly seen symptom was choking cough and refusal of drinking induced by injuring the nervus laryngeus cranialis, which would cause surgery failure or death. We used rubber band to pull the neurovascular bundle during operation to protect nerves and vessels and provide necessary space for the surgery in the mean while.

Harvest of grafts

As stated above, we chose the femoral veins as grafts. The hind legs in abduction and external rotation would provide a better operation field for surgeons. The position of femoral vein was ascertained medial to the point of maximum impulse in the femoral artery. The femoral vein is located superficially under the skin but it goes backward at the knee into the popliteal vein covered with muscles, causing difficulty in operation. In order to harvest grafts with enough lengths, the incision should be made superiorly. Branches of the graft should be ligated or fully electro-coagulated at 1mm from the trunk. More distal or proximal ligation will have negative effects. We gained satisfying results by using self-made vessel flusher (with a trocar and a 5 ml syringe) to flush the removed grafts with heparinized saline and examine the presence of any leakage.

Anastomosis technique

The opening shapes of common carotid and external carotid are important determinants of post-operative anastomosis stenosis. We employed linear incision at the beginning, which resulted in varying degrees of anastomosis stenosis possibly induced by scar contraction at the incision. Later oval incision was employed and the incidence of anastomosis stenosis was greatly reduced. Anastomosis technique is also a key to the success of high-volume bypass. Too spacing stitches might cause leakage or breakage, while too dense stitches might induce thrombosis or anastomosis stenosis. Veins usually have thinner walls, so wider margin could be adopted. The stitch length was 0.3 mm and the margin was 0.2 mm in our study. The ends of grafts were trimmed with a slope of 45°, thus the anastomosis angle would be 45° along the blood flow. Veins would extend a little under arterial blood pressure, so the anastomosis should be performed under certain tension. Before the anastomosis, the adventitia should be trimmed and eversion suture is recommended to avoid the exposure of adventitia in the lumen. We used 8 to 0 monofilament nylon suture with a length of 7 cm for the anastomosis. Longer suture would affect the operation while too short suture is not favored for knot tying. Three knots should be made and a 1-mm tail is preferred in

prevention of slipping. Signs of success are good vascular filling after releasing the clamps, obvious impulse and no leakage or little leakage which could easily stopped with compression for 1 to 2 mins. During the process of anastomosis, continuous suture needed less knot tying and shorter vascular occlusion time (36.25 ± 5.18 min) than interrupted suture (20.18 ± 5.27 min) ($P < 0.05$). However, compared to continuous suture, the interrupted suture of the bypass still has its advantages. Firstly, the interrupted suture can avoid the purse string and puckering effects associated with the continuous suture. Secondly, there is greater physiological compliance and fewer disturbances to the flow waveform in interrupted anastomoses. (Ferroli et al., 2007)

Conclusions

The results demonstrated a successful animal model by using autologous femoral vein through subcutaneous tunnel to perform common carotid-external carotid bypass leaving the dogs in good health after the surgeries. DSA showed the grafts were patent, which was confirmed with volume above 90 ml/min by color Doppler sonosound.

The histopathological examination showed intima hyperplasia and arterialization and good coverage of endothelium at the anastomosis. All above results suggested the model could be used for further study and application.

In conclusion, this study showed the model of common carotid-external carotid bypass using autologous femoral vein through subcutaneous tunnel was safe and effective. Many factors could affect the successful building of the model, in which improvement of microsurgical skills and anastomosis techniques played a key role.

Conflict of Interest

The author(s) have not declared any conflict of interest.

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