



Relationships Between Paper Mills and Technological Evolution of Paper Production

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Abstract. The paper is about the evolution of paper mills in relation to the technological evolution of machines and mechanism for the production of paper. Industrial production techniques is a theme that involves the building and its development. The principles, technology, and even cultural aspects were analyzed in this paper to define the relationship between industrial building and paper making evolution. A Modern documentation needs identified the potential of Industrial Archeology researches in the recent years. Many architects, archaeologists, conservationists, engineers document and purpose possible solution to manage Industrial Archeology structures. The latest years, there are many developments in the Industrial Archeology field. In this review article, following a brief historic background for the papermaking, the analysis of the development factors in the territory of South Lazio focusing also on the cultural background, and of changes in the layout of industrial buildings due to the development of faster and more efficient machinery and methods to produce paper. The conclusion focuses on the future perspective to manage Industrial Archeology.

Keywords: Paper mills · Papermaking · Paper machinery
Building development · Machine representation

1 Introduction

In the areas of Southern Lazio, papermaking expanded immediately after the development of Amalfi's area that from the coast developed in the internal areas.

The first paper mill in the territory of Cassino was founded in 1516 in S. Elia Fiumerapido by the monks of Montecassino's Abbey, in order to make their industrious *scriptorium* more autonomous also from the standpoint of the production of supports (Cigola et al. 2001).

The research focuses the interest on the territory of Cassino, but with references to the waterways of the Liri Valley referring especially to the factories that from these watercourses take energy and identify in the graphic and cartographic equipment the basic documentary material for the knowledge and analysis of the main evolutionary

phases of the area. Since the beginning of the 19th century in Italy, and in particular in the South of Lazio, the paper mills developed their production using new technologies, that favored rapid changes in manufacturing rhythms, introducing modifications and expansions of existing factories on the territory, that changed the conformation of the surrounding territory to adapt it to the industrial use.

The analysis of the motivations of the development of these paper industries and of their removal has the objective of trying to predict their possible developments, not in contrast with the history that determined their growing.

2 Papermaking Guidelines

Until the early nineteenth century, the raw materials used for papermaking consisted of linen and hemp rags, which sorted into three categories – fine, medium and coarse – were used for the three different grades of paper: fine writing paper, regular paper and wrapping paper. After sorting, the rags washed for the first time and then set aside to macerate and ferment in stone or copper tanks or in wooden tubs, a process that lasted around one week.

Next, the rags shredded twice to produce a pulp, which then bleached with chloride of lime, diluted to form a stock slurry, or “stuff”, as it called, and warmed. As, this stock could not be kept for long periods without rotting, papermaking chiefly took place in cold weather.

Once the raw material had been prepared in this way, a rigid framework of wood covered by a fine metal mesh, called a mould, was dipped in the stock and lifted, leaving the mould screen coated with a thin layer of pulp. This sheet then turned over on a cloth called a felt. Another felt laid over the sheet, and the process, called couching, repeated to form a pile of interleaved sheets and felts known as a post. The post placed under a screw press to squeeze out excess water, after which the sheets separated from the felts and hung out to dry in the drying loft (Fig. 1). This followed by sizing, or in other words by dipping the paper in gelatin or glue to make it stronger and less absorbent, and by glazing or burnishing to make it easier to use.

Until the nineteenth century the paper process was well advanced, then, preparing the stock was the only part of the papermaking process that was in any way mechanized, and even this relied, naturally, on waterpower. From dipping the mould to form sheets onwards, the entire process carried out by hand. A number of fundamental advances for the paper industry came only in the second half of the 1800 s: there can be no doubt that the first of these advances was the development of alternatives to the industry’s traditional raw material. Thus, rags gave way to wood fibers produced either mechanically or through chemical-solvent processes that result in pure cellulose.

The second step forward was the introduction of mechanization to the processes used to produce sheets of paper: pulp, instead to be strained through the mould to make a single sheet, could now be run through the cylinder machine or the Fourdrinier paper machine (Fig. 2). The latter, however, were slow to gain ground, and as late as 1862 there were only 59 such machines in all of Italy. Handmade paper remained widespread, while machine-made paper continued to be an exception to the rule.



Fig. 1. D’Alembert J.B. and Diderot D., *Encyclopédie ou Dictionnaire raisonné des Sciences, des Arts et des Métiers*. Paris 1751/72; “Papetterie”

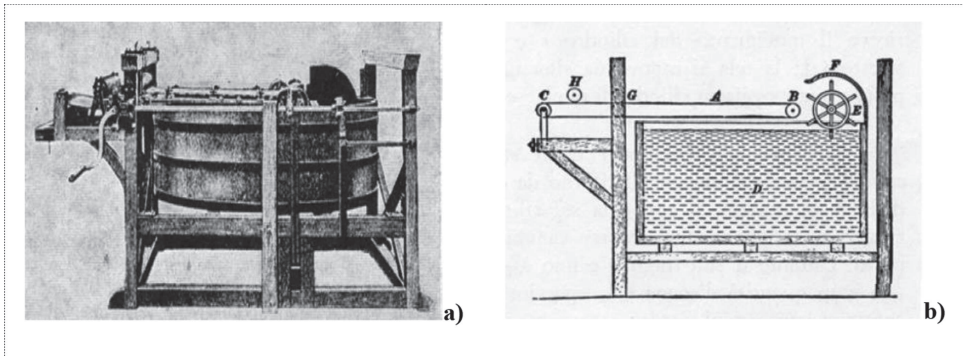


Fig. 2. (a) First machine continues, (b) Cross section of the first continuous machine by Robert (1798). In A. Dell’Orefice, *L’industria della carta nel Mezzogiorno d’Italia 1800–1870. Economia e tecnologia*, Genève, 1979, p.49.

As the nineteenth century proceeded, advances were limited to pulp preparation rather than to papermaking itself, as the introduction of stampers and Hollander beaters brought improved methods of processing rags and producing stock.

3 Analysis of Development Factors in the Territory of South Lazio

The analysis of the 'Context' in which developed the paper mills of South Latium is important to study on their growing considering the evolution of machinery.

In the Nineteenth Century the paper mills were in a difficult situation, because there were still antiquated methods of production. In this period Italy followed the example of Europe starting to use new raw materials such as wood pulp and cellulose. These materials are characterized by a radical rethinking of production that not all producers were able to support, for example the Amalfi's paper mills.

In the mid-nineteenth century, however, the Liri Valley's paper mills production increased thanks to the mechanized rag processing as well as all the development of the technological papermaking, even conforming the Fourdrinier machine. Since 1840, efforts to modernize production led the Liri area's paper producers to take rag substitutes: plant materials such as wheat, barley and oat straw, corn fiber or poplar wood pulp. (Cigola and Ceccarelli 2009).

The specific hydrographic conformation of Southern Lazio enabled the development of a copious industrial activity related to the exploitation of water resources. As seen previously for the production of paper, the need for significant amount of water of which the territory was rich. The rivers of the valley, swollen by torrents and streams, were rich in very pure waters, particularly suitable for the processing of the dough, the degreasing of rags and the functioning of the mills. This was the starting point for the paper mills development in the territory of Southern Lazio.

The social reasons of the development of paper mill in this area were related linked to the low level of education that prevailed than in Italy, while the demand for books and newspapers increased. It is, in fact, indicative of culturally backward areas such as the Papal States and the Kingdom of Naples that handmade paper existed for so long before the introduction of mechanized processes.

During the Napoleonic decade, from 1806 to 1813 some factories opened in Liri Valley. The newcomer do not change, in fact, the development policy is a clear sign of foresight as far as territorial management is concerned. The French continued the of growing pursued by the Bourbons with the granting of state property, the assignment of loans, tax relief and the opening of the market to foreign entrepreneurs attracted by the policy of protectionism, implemented specifically to increase production and therefore the income. Moreover, in Napoleon's economic policy, the innovation and knowledge, as well as culture, were essential preconditions for growth (Leonardi 2010).

From the beginning of the 19th century, new production technologies, favoured a rapid growth of the industrial settlements, increasing production rates. This consequently generates important transformations both in the expansion of the factories and in the structure of the territory, with the construction of locks and canals and the development of various service facilities structures necessary for the exploitation of hydraulic energy for industrial use.

Significant and numerous are the judicial-administrative events linked to the legislative changes introduced during the Napoleonic domination and implemented in the post-unification Kingdom on water regulation; there are in fact numerous traces in the

documentation of insurrections contrasts between adverse businessmen for the damages caused downstream by legitimate or presumed deviations made by the mill located upstream of the river.

4 An Example of Paper Mill Development: The Paper Mill of Atina

The study of the evolution of the Atina Paper Mill complex (Fig. 3) was an interesting test to highlight the industrial technologies used in the various epochs for the production of paper and how these transformed the ‘factory from the initial state to the final one’. This work used the iconographic and archival sources found in the municipal library, and they were helpful to advance hypotheses on the evolution of Atina’s paper mill.



Fig. 3. View of Atina Paper Mill 1960, Municipal library archive of Atina

Atina’s paper mill was founded in 1843 by a local businessman, Visocchi Pasquale, and a French owner, Peuche. Pasquale Visocchi took care of finding the area necessary to build the factory, while Peuche found the machinery for production that was imported from France. The building designed by the Engineer Patrelli of Naples, and probably the construction started in 1843, was inaugurated on May 8th 1845 (Scheme of the plant Fig. 4).

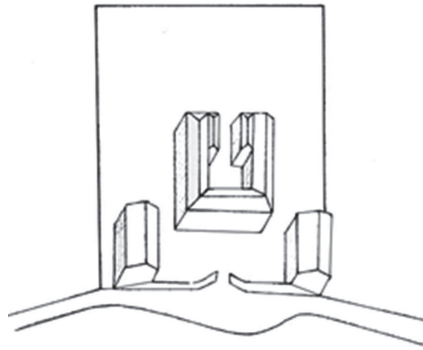


Fig. 4. Original State diagram of Atina's paper mill

In 1853 the paper mill of Atina gave employment to about a hundred workers, and in which were used twelve Dutch cylinders (Fig. 5), useful to prepare ten cantaja (that were 100 rolls of paper, equivalent to 89,09972 kilos) in a day. This paper mill was third in importance in the district, after the paper mill Lefevbre, which produced 35, and after the paper mill of Liri of Sorvillo that produced 25, and was followed by the paper mill Courier, which produced 8.



Fig. 5. Dutch pile of Isola del Liri's paper mill. Image taken from M. Scavia, *L'Industria*, pag.13

In 1856, for the production of paper, instead of rags, new materials such as poplar wood (Fig. 6), roots of licorice, brooms and grasses.

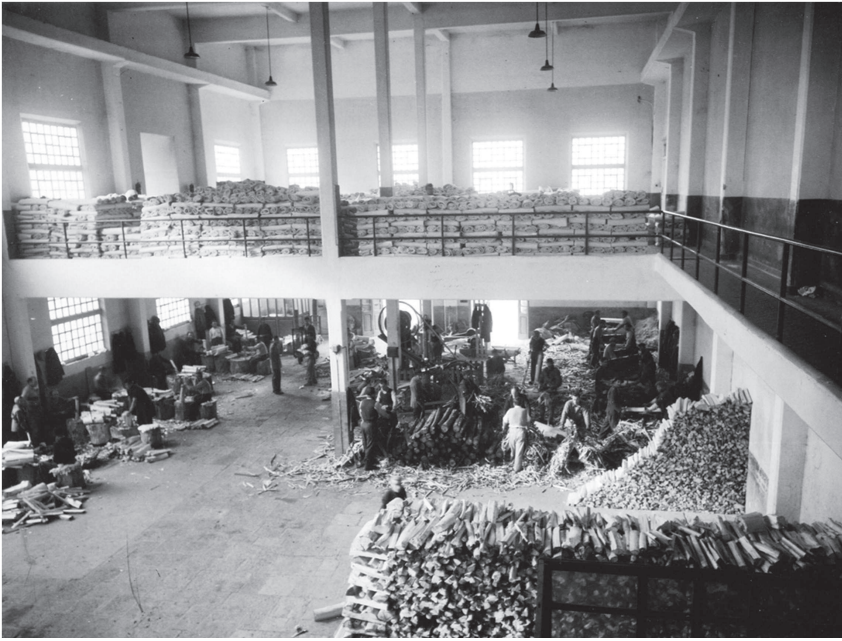


Fig. 6. Workers during the poplar wood processing. Atina's Paper Mill. Taken from Municipal Library of Atina

The first continuous machine (Fig. 7) was brought some years after the foundation, in 1861.

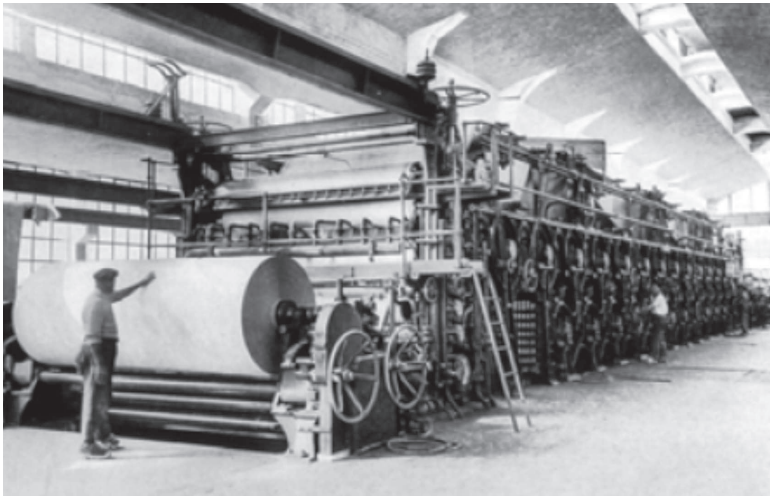


Fig. 7. Continuous Machine. Isola del Liri, Society of the Southern Paper Companies, Liri's Paper Mill. Taken from *M. Scavia, L'Industria, pag.97*

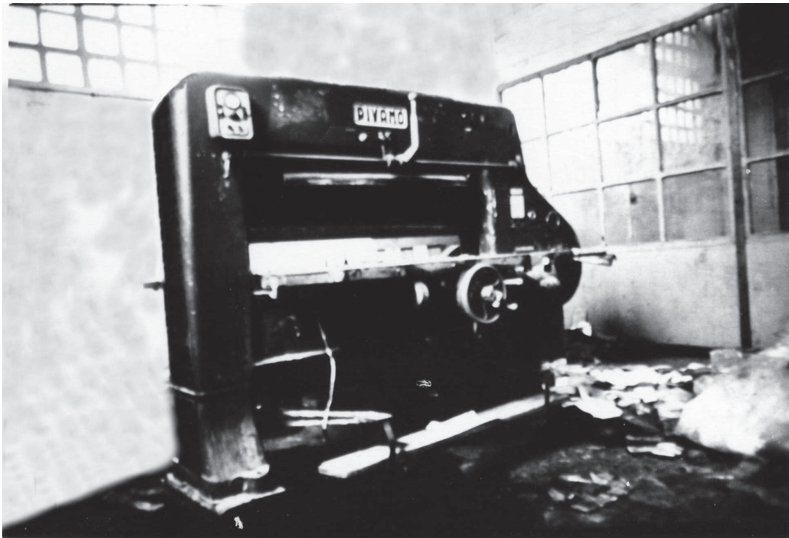


Fig. 8. Snick, Atina's Paper Mill. Taken from *Municipal Library of Atina*

In 1870 the paper mill had 110 workers in this period, but the daily production tripled, thanks to the introduction of two continuous machines, one for the production of paper and another for the production of cardboard, and a better operative organization. The two continuous machine have a width of 1.50 m, and in the Atina paper mill there were also: 9 Dutch piles, 3 steam boilers and other machinery to whiten and refine rags and to cut and glaze the paper (Fig. 8). There was only one pulp engine to pulp the wood pulp, so at this date the cellulose production was still in its embryonic state.

In 1878 the paper mill incorporated the factory of *pisto*, for the *production of wood pulp*, composed of three rooms distributed on two floors.

In this period the paper mill had totally 107 rooms of which 58 rooms for the production and an house of 15 rooms for the executives and their families. The owners of the paper mill always preferred to reside in the city center, but they built a building for the directors, often strangers with family in tow, perhaps also to ensure a continuous contact-control with the factory.

In 1887 the paper mill had a pulp machine with two smashing machines, one a steam engine and two hydraulic engines with a total force of 160 horses, and two 60 horsepower steam boilers for engine for engine and paper drying.

In 1895, the *cylinder rooms* were added, distributed on two levels and 5 rooms, came into operation, while all the remaining machines were dismantled and the loading and unloading channels were destroyed. The paper mill had 115 rooms, with 100 m² of heated surface, a 40-horsepower steam engine and two 150-horsepower hydraulic engines (Fig. 9).

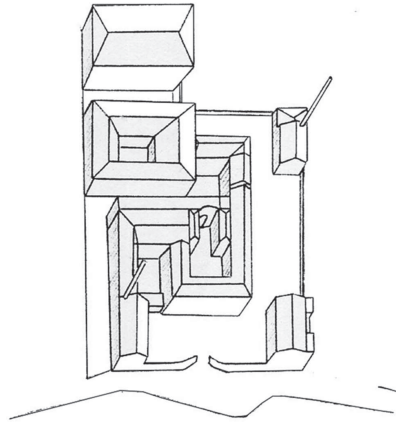


Fig. 9. Buildings built between 1861 and 1895

There was a decrease in the rooms, in the 30 s, because the space was certainly rationalized to the advantage of larger and more airy rooms than the smaller and more inconvenient ones of its foundation. More appropriate investigations make us understand post-war reconstruction, between 1945 and 1968, and in particular the transformation of the production department (Fig. 10).

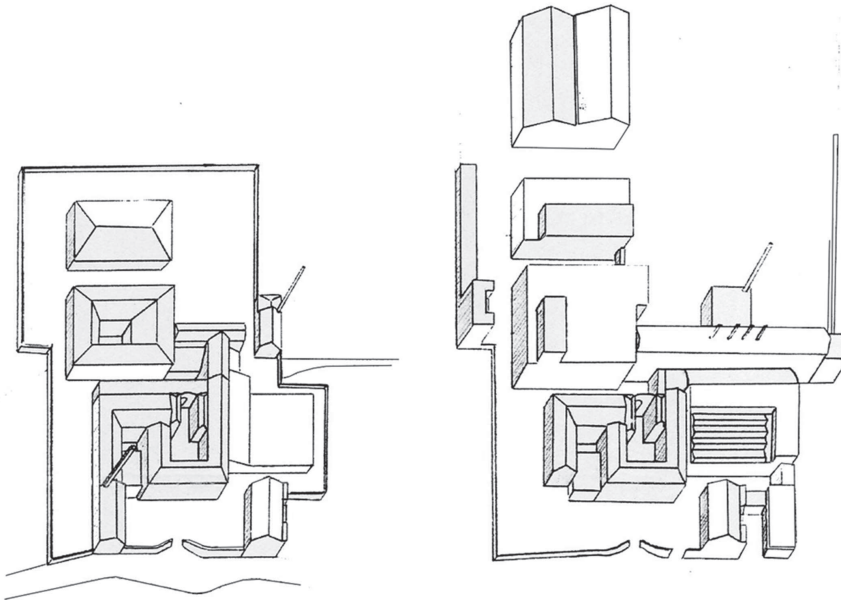


Fig. 10. Building built between 1895 and 1945 and current state

The distribution system of the production functions remained unchanged, in order to support the different phases of the production and processing of paper (wood pulp area, rags area, continuous machines, preparation area).

The entrance to the production department was underlined by a red brick arch adorned with stucco reliefs with floral motifs, placed at the bottom of an Italian garden (Fig. 11). This in order to create a family context in which the worker felt welcomed. The attention to the details of the factory had to reflect the order of a family context. The hypothesis that it was the main access to the production department was confirmed by the fact that behind the arch there are still some holes that had to contain beams to support another environment and that in the relief of 1945 was the room of the first continuous machine that lapped the arc.



Fig. 11. Actual fact of entry production area. Atina's Paper mill. Taken from the Municipal Library of Atina

At the time of the foundation dated back also the boundary walls decorated by two pine cones, at the main entrance and a two level building on the right of the entrance, whose façade is characterized by a tympanum on the road front on which the word "Ceprat" dating back to 1960 (Fig. 12).



Fig. 12. Front Elevation. Atina's Paper mill. Taken from the *Municipal Library of Atina*

The whole structure of the paper mill and the architectural features are similar to house of the period, in fact from the outside did not leave presage of the production function, except for the large dimensions and the elongated shape of the two rooms of the continuous machines.

The Behind the room of the continuous machine was to a square-shaped body, occupied by the area of the rags. The pulp department added later than the foundation and took the place of the rags that was transferred to a building isolated from the rest, perhaps for hygienic reasons.

The pulp wood building was crossed by the channel of water loading, then divided into two branches, one of which went towards the rags area, the other continued towards the continuous machines.

The preparation area, initially set in the central core, was moved to another square-shaped body probably built in the '30 s, but it did not have the current shed shape, with steel lattice beams resting on square-section pillars, dating back after Second World War. The factory was completed with same smaller buildings used for storage and the boiler room with the chimney visible clearly in a photograph of the early 1900s (Fig. 13).



Fig. 13. View from the canal of Atina's Paper mill. Taken from the Municipal Library of Atina



Fig. 14. Cutting board and calenders in the preparation area. Atina's Paper mill. Taken from the Municipal Library of Atina

The bombings and the looting of the Second World War caused the reorganization and in some cases the reconstruction of some portions of the paper mill. The occupied surface maintained almost unchanged, even if were done some modifications to plant. A typical example of reconstruction is that of the rags area, before placed near the river, then replaced by the papermaking area. For the preparation of the dough created a special large room connected to the hall of the continuous machine. The cutting board and the room of the calenders (Fig. 14) for the satin finishing of the paper was joined with the preparation area. The joinery, first adjacent to the garden, was transferred to a building to the left of the entrance between the deposit of raw materials and a roof built specifically to accommodate the bicycles, which were the means of locomotion mainly used by the workers up to 60's. The porter's lodge moved to the ground floor of the office building and replaced by a storage and the room for the preparation of mineral fillers for paper coloring. The two new power plants and the thermal one built in front of the room of the continuous machine (Fig. 15).

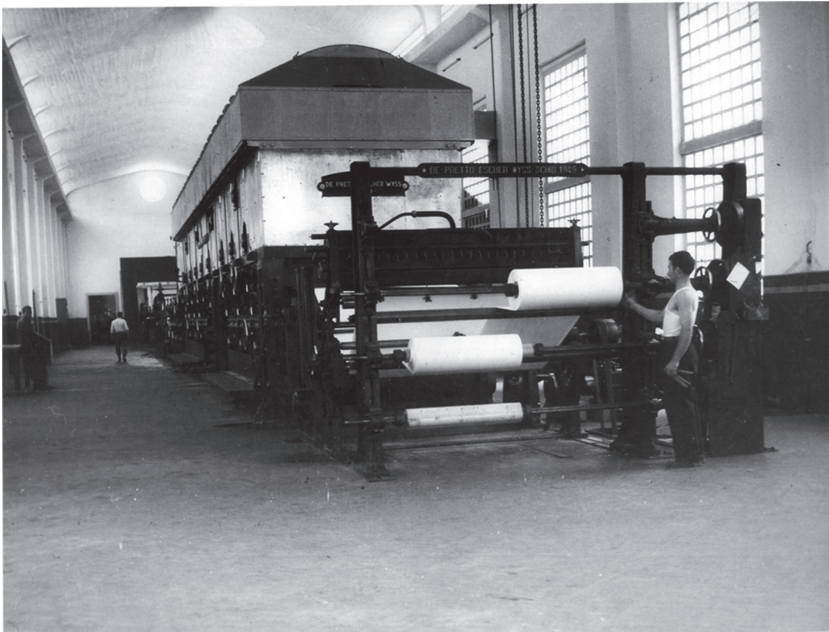


Fig. 15. Continuous machine. Atina's Paper mill. Taken from the Municipal Library of Atina

During the reconstruction and modernization of the building the two continuous machines were replaced by a single 60 m machine that required the construction of a rectangular building. It has a reinforced concrete structure, covered by ribbed frames that frame large ventilation fans resting on semi-pillars of rectangular section (Fig. 16).



Fig. 16. Continuous machine. Atina's Paper mill. Taken from the Municipal Library of Atina



Fig. 17. Local view of boilers. Paper Mill of Atina. *Municipal Library of Atina..*

The latter building, like the rag and pulp area and like the electric cabin is characterized by pure and simple volumes, by rational shapes and glass-block fixtures with circular and rectangular openings. Overall, these four buildings have a typically functionalist structure. From the flat roofs emerge the cylindrical chimney pots (Fig. 17) and the slender red brick chimney, rebuilt, which still today marks the landscape of the valley.

The buildings, which make up the big production complex, are connected through numerous hanging paths and covered passages.

In the 1960s, were built the finished products deposit near the banks of the Melfa river, with a steel and reinforced concrete structure, covered with eternit roof and the company canteen building, located behind the building used as the director's residence. On the ground floor of this last building, instead of the deposits, showers were created, the changing rooms for the workers and the company store.

5 Conclusions

In this paper, we presented the historical development of paper mills in function of the change in the machinery used for paper production with the analysis of the development of Atina's Paper Mill. The historical analysis started from its foundation in 1843, near an existing watermill, to the decommissioning at the end of the '60s. The study of the plants evolution has done using documents and drawings that allowed us to trace the historical evolution of the structures and machinery for the production of paper in the southern Lazio area.

The results have identified and characterized the peculiarities of the architectures and production processes that have allowed an excellent technical development, which however due to the crisis of the sector and the lack of modernization of the machines, led to the decline and then to its abandonment.

These machines examined and their historical evolution traced to understand the process of development of the paper mill plant according to the machines evolution. The production cycle and the analysis of a working approach allowed to study the context in which paper mills developed to hypothesize the possibilities of reuse.

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