Assessment of the CP Solutions in the Pulp and Paper Sector

January 9th to January 19th – March 12th to March 21st, 2001

China-Canada Co-Operation Project in Cleaner Production

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PRICEWATERHOUSECOOPERS

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INTRODUCTION

Over the past three years, methodologies to conduct Cleaner Production audits were developed in the context of the China Canada Co-operation Project in Cleaner Production. These methodologies were developed primarily as a result of CP auditing and implementation work done in the Anhui Paper Mill (the demonstration project). Upon completion of the demonstration project, the workplan called for project extension activities to other paper mills in Anhui Province. In total six mills were selected, namely Ma An Shan-Shan Ying mill, Tian Du mill, Jin Zhong mill, Chao Lun mill, Lu An mill, and Gao Sen mill.

In July 2000, a three day workshop on CP auditing pertaining to pulp and paper industries was held in Ma An Shan. Plant managers and technical staff from selected pulp and paper mills in Anhui province attended this workshop. Following the workshop, the participants were expected to return to their respective mills and develop CP implementation plans before the end of year 2000.

In December 2000, two specialists from Canadian Executing Agency went to Anhui province to assess the progress of the CP auditing activities. During this mission, the representatives of the selected mills presented their progress reports at a meeting that was held in Hefei on December 1st, 2000. Details concerning this mission are enclosed in the report titled *Progress Assessment of CP Auditing Activities*.

Following this mission, SNC-Lavalin Inc. organized two subsequent missions in January and March 2001 in order to validate the Cleaner Production solutions that were claimed to have been implemented at the selected mills.

The first mission took place from January 9th to January 19th 2001 and was conducted by Mr. Richard Lemieux, Eng., M.Sc. and by Mrs. Monya Pelchat, M.Sc., both from SNC-Lavalin Inc. During this mission the following mills were visited:

- Anhui Ma An Shan – Shan Ying mill
- Tian Du mill
- Jin Zhong mill

As for the second mission, it was carried out from March 12th to March 21st by Mr. Richard Campeau, Eng. and pulp and paper specialist and by Mrs. Monya Pelchat, M.Sc. from SNC-Lavalin Inc. At that time, the three remaining mills were visited. These mills are:

- Chao Lun mill
- Lu An mill
- Gao Sen mill

The purpose in visiting these six mills was to evaluate the implementation of the methodology presented at the Ma An Shan workshop last July. During the course of these two missions, it was not possible to assess implementation of all CP solutions identified by each mill. Instead, a representative sample of CP solutions was chosen for audit purposes.

The six mills visited, all in Anhui Province, represent 47% of the actual production capacity of the province (see table 1).

Table 1.1 Participating mills in Anhui Province

Mill	Production capacity (tonnes)	Actual Production (tonnes)	%
Ma An Shan - Shan Ying Mill	140 000	96 728	19%
Tian Du Pulp and Paper Mill	35 000	30 600	7%
Jin Zhong Paper Mill	75 000	30 000	6%
Chao Lun Pulp and Paper Mill	50 000	48 247	10%
Lu An Paper Mill	55 000	17 000	3%
Gao Sen Paper Mill	20 000	10 200	2%
Total	375 000	232 775	47%
Approximate annual production, all mills in Anhui Province		500 000	100%

Schedules of the visits and attendance lists are presented in Appendix A.

1 CP Solutions Assessment

The visit of the six selected mills allowed SNC-Lavalin Inc. delegates to review the CP solutions that have been implemented in the context of the China Canada Co-operation Project in Cleaner Production. The following sections introduce each mill and present the findings concerning the CP solutions already implemented and those to be implemented. For the purpose of this report, CP solutions appear in summary tables and are ranked from no cost solutions to high cost solutions. Thus, the order in which CP solutions are presented in this report does not correspond to the order presented in the individual reports produced by each of the mills; also the number of CP solutions is subject to some variation due to the fact that certain CP solutions were regrouped for analysis purposes. In the course of the two missions, only CP solutions having significant environmental and economical benefits were audited.

The calculations that are presented in this report are based on the numbers (operational costs and selling prices) that were provided by each mill. These figures are presented in appendix B. Some of the mills had already begun implementing CP prior to the training given last July. Therefore, this report distinguishes between those CP solutions which the mills had implemented prior to training, and those implemented after, so as to enable the reader to assess the impact of the training.

It is important to mention that these CP solutions were identified by the mills CP teams and occasionally from the suggestions of their employees as recommended in the CP program. The solutions were selected based on the CP program ranking system set out in the CP audit manual and guidelines for implementing CP in the pulp and paper sector.

The Chinese version of the reports that were produced by each mill are presented in Appendix E.

2 Ma An Shan – Shan Ying Mill

2.1 General Information

Anhui Ma An Shan - Shan Ying mill is located in Ma An Shan, approximately 260 km to the south east of Hefei, the capital of Anhui province. The mill is a state owned enterprise which was established in 1957. It presently has a workforce of 855 workers including 60 persons having a technical background. Its annual production capacity is of 140 000 tons. The mill operates seven paper machines producing cardboard, coated paper board, high and medium strength corrugated paper. The main raw materials used at the mill consist of commercial wood pulp, and domestic waste paper. Fresh water entering the process comes from the Yangtze river.

The mill is ISO 9002 certified. The mill sells its products to customers based in Anhui, Jiangsu, Shandong, Zhejiang, Fujiang, Guangdong, and Jiangxi provinces as well as in Shanghai.

2.2 Wastewater Treatment Facility

The mill is not equipped with a conventional wastewater treatment plant. White water generated by each paper machine is directed to a common flotation unit. A good portion of the clarified water coming out of this unit is recycled to the process while the rest is discharged to the Yangtze river. The mill is equipped with an environmental monitoring laboratory where pH, SS, COD, and BOD are monitored three times a day.

Table 3.1 presents the results of the analyses performed on the treated effluent of the mill in March 2001.

Table 2.1 Ma An Shan – Shan Ying Environmental Results

Month	pH *Standard[1] = 6-9*	SS (mg/L) *Standard[1] = 100*	COD (mg/L) *Standard[1] = 100*	BOD (mg/L) *Standard[1] = 60*
	Average	Average	Average	Average
March 2001	8.0	70	150	55

1. Source: Chinese regulation GWPB2-1999 (Paper making without pulping)

These results indicate that, except for COD, the mill appears to have complied with the national standards. However, a trend cannot be established since the results covering a longer period of time were not provided.

2.3 Cleaner Production Solutions

Ma An Shan – Shan Ying paper mill has implemented sixteen CP solutions. Out of these sixteen solutions, four are no cost solutions, six are low costs, four are medium costs, and two are high cost. These CP solutions are presented in table 3.2. In this table the solutions assumed to have been implemented after the Ma An Shan workshop are indicated.

Table 2.2 CP Solutions Implemented at the Ma An Shan – Shan Ying Mill

CP Solution Number	Implemented CP solution	Category of Solution
1	Budget revision – justification of consuming quotas[1]	No cost
2	CP solutions – employees suggestions program[1]	No cost
3	Raw material sorting[1]	No cost
4	Recuperation of used hydraulic oils resulting from equipment maintenance[1]	No cost
5	Starch addition to decrease the fibre content of the paper manufactured[1]	Low cost
6	Purchasing laboratory equipment to measure BOD and COD[1]	Low cost
7	Installation of a level indicator on the white water tank to avoid an overflow to the wastewater treatment plant	Low cost
8	Installation of an ultrasonic flowmeter at the outfall	Low cost
9	Selection of adequate wastewater treatment agents[1]	Low cost
10	Utilization of recycled water instead of fresh water to clean strainers[1]	Low cost
11	Installation of steam meters on each paper machine	Medium cost
12	Felt washing using mobile water pipe[1]	Medium cost
13	Replacement of existing screens by a pressure screen	Medium cost
14	Addition of an extra screen on pulp reclaiming equipment	Medium cost
15	Water recycling after air flotation unit	High cost

16	Fibre recovery used to produce low grade paper	High cost

1. CP solutions assumed to be implemented at the mill following the Ma An Shan workshop.

Among the sixteen solutions, CP solutions number 4, 5, 9, and 15 have been retained for analysis by the audit team. Photos illustrating some of these solutions are presented in Appendix C.

CP Solution #4

Used hydraulic oils resulting from equipment maintenance (approximately 40 L) are now collected twice a month in barrels instead of being disposed of in the sewer system of the mill as it was done in the past.

The benefit associated with this CP solution is mainly environmental.

CP Solution #5

It is common in paper manufacturing to replace fibre by additives for quality/cost purposes. Ma An Shan-Shan Ying paper mill has added to its process some starch and polymer. The addition of starch increases paper strength by 12 % and also to partially replace fibre. Polymer helps in retaining starch and small fibre during sheet formation. This solution represents a modern way to operate a paper machine wet end.

The operating cost is of 50 Renminbi per ton of paper for starch and the saving is of 15 kg wood pulp per ton of paper produced. At a cost of 5 750 Renminbi per ton of purchased wood pulp, this solution represents a saving of 86.2 Renminbi per ton of cardboard produced for a net benefit of 36.2 Renminbi per ton of paper.

This represents a total saving of 3 500 000 Renminbi per year or *36.2 Renminbi per ton of paper * 96 728 tons of cardboard produced*.

CP Solution #9

The mill has recently tested 20 different wastewater treatment agents in its laboratory in order to select the most efficient ones. After these trials, three of these products were directly tested at the wastewater treatment facility of the mill. Out of these three products, only one was retained as the product that will be used for normal operation. This allowed the mill to reduce its treatment cost from 1.15 to 0.8 Renminbi per ton of wastewater representing a saving of 1 150 000 Renminbi per year calculated as follows:

*(1.15-0.8) Renminbi saved per ton of wastewater * 34 tons of wastewater per ton of cardboard * 96 728 tons of cardboard produced per year*.

CP Solution #15

A new type of filter at the outlet of the dissolved air flotation unit has been installed at a cost of 200 000 Renminbi for a capacity of 200 m^3/hour. The mill used to have a fresh water consumption of 43 tons of water per ton of paper produced based on the capacity of the pumps. Since the start-up of the white water recycling system, the actual fresh water usage is of 34 Tons of water per ton of paper produced. The financial saving associated with this solution is of 174 110 Renminbi per year. The calculation is as follows:

*(43-34) tons of water saved per ton of cardboard produced * 0.2 Renminbi per ton of fresh water * 96 728 tons of cardboard produced per year*

2.4 Comments

Prior to the CP workshop held in Ma An Shan last July, the mill had already initiated some environmental projects. Nevertheless, the mill made good use of this workshop by first forming a CP team, promoting CP awareness throughout the mill and by conducting a pre-audit according to the method presented during the workshop.

Then the CP team together with the mill management established two main long term objectives: Reducing COD by 60% in the wastewater effluent and reducing water consumption by 33%.

It appears that one of the major benefits of the CP training, for this mill, was to provide management with a more structured planning process in which to implement CP. In particular, faced with a multitude of possible CP solutions, the methodology enabled management to more efficiently prioritize actions and select priority CP solutions for implementation. Management also realised that the CP process is a continual improvement process.

The savings resulting from the audited CP solutions are presented in Appendix D.

3 Tian Du Pulp and Paper Mill

3.1 General Information

Tian Du pulp and paper mill is located in Fuyang city which is approximately 375 km to the north west of Hefei, the capital of Anhui province. The mill is a town-owned enterprise established in 1988. It presently has a workforce of 645 workers. The mill operates four paper machines producing medium to high strength corrugated paper. The main raw materials used at the mill consist of domestic waste paper and straw pulp which is produced on site. Groundwater is used in the process. Its annual production capacity is of 35 000 tons. The mill sells its products to customers based in Jiangsu, Zhejiang, and Anhui provinces as well as in Shanghai.

3.2 Wastewater treatment facility

Tian Du mill is equipped with a biological wastewater treatment plant having a design capacity of 250 m^3 per hour. It consists of primary and secondary clarifiers and an aeration basin. The treated effluent is monitored for COD, SS, and pH on a daily basis at the mill's environmental laboratory. The Local Environmental Protection Bureau (EPB) reviews their environmental data on a monthly basis. The treated effluent is discharged to a tributary of the Huai He river.

Table 4.1 presents the results of the analysis performed on the treated effluent of the mill.

Table 3.1 Tian Du Mill Environmental Results

Month	pH *Standard[1] = 6-9*	SS (mg/L) *Standard[1] = 100*	COD (mg/L) *Standard[1] = 400*
	Average	Average	Average
January 2001	7.0-7.2	89	378
February 2001	7.0-7.2	75	365
March 2001	7.0-7.2	83	352

1. Source: Chinese regulation GWPB2-1999 (Paper making with pulping)

Over the past three months the mill appears to have complied with the national standards.

3.3 Cleaner Production Solutions

In his introduction, Mr. Hao, the General Manager of the plant mentioned that over the past five years the mill has invested approximately 21 000 000 yuan Renminbi in environmental protection equipment. For example, the biological wastewater treatment plant was upgraded and a black liquor evaporation system was built.

So far, seventeen CP solutions were implemented at the mill. Out of these seventeen CP solutions, seven are no cost solutions, seven are low cost, two are medium cost, and one is a high cost solution. These CP solutions are presented in table 4.2. In this table the solutions assumed to have been implemented after the Ma An Shan workshop are identified.

Table 3.2 CP Solutions Implemented at the Tian Du Mill

CP Solutions Number	Implemented CP solution	Category of Solution
1	Raw material purchasing and storing is now organized to suit the need of the mill.[1]	No cost
2	Tasks to be performed by the personnel are now clearly defined.[1]	No cost
3	Employees are evaluated based on a reward system.[1]	No cost
4	The speed of the two modules of the straw feeder were adjusted to the same speed. This modification allows to recuperate the dust at the intersection of the two modules.[1]	No cost
5	Steam injection during digesters filling.[1]	No cost
6	Kappa number was changed from 45-55 to 50-60.[1]	No cost
7	Pressure was changed from 7 atm to 5 atm[1]	No cost
8	Deeper groundwater intake	Low cost
9	White water recycling via one pump[1]	Low cost
10	Black liquor extraction using higher efficiency equipment	Low cost
11	Change in cooking additives – $NH_4Na_2SO_3$ instead of MgO	Low cost
12	Installation of a mixer for chemical additives	Low cost
13	Addition of a calender	Low cost
14	Felt adjustments on the paper machine[1]	Low cost
15	Construction of a clarifier in order to enhance white water recycling.	Medium cost
16	Automated pulp consistency control[1]	Medium cost

17	Construction of a black liquor evaporator line[1]	High cost

1. CP solutions assumed to be implemented at the mill following the Ma An Shan workshop.

Among the seventeen solutions, CP solutions number 5, 6, 9, 15, and 16 were audited. Photos illustrating some of these solutions are presented in Appendix C.

CP solutions # 5 & 6

The injection of steam in the digester during filling allowed the mill to increase the straw charge per digester and also to reduce cooking time. With a more stable quantity of straw present per digester, the mill has been able to increase the Kappa number from 45-55 to 50-60 after cooking without reducing the quality of the pulp .

The yield (tons of finished products / tons of raw material entering the process), which was around 50%, has been increased by 1% based on pulp or 2% based on straw. This means that approximately 2% more pulp is produced out of the same quantity of straw cooked. These percentage increases, while small, are nonetheless significant when raw materials are measured over a year's time. It should be noted that these estimates are conservative estimates derived by experienced pulp and paper auditors on the Canadian audit team.
These solutions allowed the mill to save 832 320 Renminbi annually. This saving is calculated as follows:

*1700 Renminbi per ton of pulp produced * 40% (percentage of straw cost in total manufacturing cost) * 2% fibre saved * 30 600 tons of paper produced / 50% yield.*

CP solution # 9

A pump was recently installed in order to recycle the white water back to the pulp dilution process. In the past the white water was directed to a tank before being recycled. This tank was frequently overflowing (30% of the actual flowrate which is 180 m^3/hr). Therefore, the installation of this pump which can handle the totality of the white water leads to a total water saving of 503 982 Renminbi per year. The calculation is as follows:

*(180 m^3/hour * 22.5 operational hour per day * 340 operational days per year * 30% white water not overflowing to the wastewater treatment plant * 1.2 Renminbi per ton of liquid effluent treated) + (180 m^3/hour * 22.5 operational hour per day * 340 operational days per year * 30% white water replacing fresh water * 0.02 Renminbi per ton fresh water)*

CP solutions # 15 & 16

These two medium cost CP solutions (the construction of a clarifier to enhance white water recycling and the implementation of control systems in order to increase pulp consistency) have

generated a benefit of more than 0,5 million Renminbi per year. It is obvious that these CP solutions led to an important water saving. However, it is not possible to verify this saving since there is no local flow meter.

In terms of further CP solutions, Tian Du CP team is planning to implement an additional high cost solution, the installation of a hydro-pulper, which will allow the mill to use a higher quantity of recycled cardboard as raw material.

3.4 Comments

Over the past five years, Tian Du mill has invested an important sum of money in environmental equipment. Even with a CP program in place, this equipment would have been required. However, the size and the cost of these equipments could have been minimized through reduction at source as suggested in the CP method presented at the Ma An Shan workshop.

The managers mentioned that the CP program allows the mill to achieve environmental and financial goals in shorter periods of time than before.

With a closer look at the type of CP solutions put in place lately, it seems that the idea of reduction at source through innovative, simple and inexpensive solutions is moving forward. A look at the three first no cost solutions shows clearly that the management style is evolving. The pulping plant remains old and a preventive maintenance program could be of great help.

The savings resulting from the audited CP solutions are presented in Appendix D.

4 Jin Zhong Paper Mill

4.1 General Information

Jin Zhong paper mill is located in Hefei. The mill is a private enterprise which was established in 1978. It presently has a workforce of 820 workers, including 48 persons having a technical background. Its annual production capacity is 75 000 tonnes. The mill operates eight paper machines producing low, medium, and high quality cardboard. The main raw material used at the mill is waste cardboard. Depending upon the level of quality targeted, some market softwood pulp is also used in the process. Fresh water entering the process comes from South Wee river and wastewater is discharged to the Er Shi Pu river. The mill sells its products to customers based in Anhui province as well as in neighbouring provinces.

4.2 Wastewater Treatment Facility

Jin Zhong mill is equipped with a wastewater treatment plant having a design capacity of 200 to 250 m^3 per hour. It consists of a series of inclined screens followed by a settling tank and a primary clarifier. The treated effluent is discharged to a channel going to the Er Shi Pu river. The treated effluent is monitored for COD, SS, and pH by the local Environmental Protection Bureau (EPB) since the mill does not possess its own environmental monitoring laboratory.

Table 5.1 presents the results of the analyses performed on the treated effluent of the mill in March 2001.

Table 4.1 Jin Zhong Environmental Results

Month	**pH** ***Standard[1] = 6-9***	**SS (mg/L)** ***Standard[1] = 100***	**COD (mg/L)** ***Standard[1] = 100***
March 2001	7.0-7.2	50	105

1. Source: Chinese regulation GWPB2-1999 (Paper making without pulping)

In general, the mill complies with the national standards except for COD which slightly exceeds the compliance level. However, a trend cannot be established since the results covering a longer period of time were not provided.

4.3 Cleaner Production Solutions

Jin Zhong paper mill has implemented twenty CP solutions. Out of these twenty solutions, three are no cost solutions, twelve are low cost, four are medium cost, and one is high cost. These

CP solutions are presented in table 5.2. In this table the solutions assumed to have been implemented after the Ma An Shan workshop are identified.

Table 4.2 CP Solutions Implemented at the Jin Zhong Mill

CP Solution Number	Implemented CP solution	Category of Solution
1	Raw material (waste cardboard) sorting[1]	No cost
2	Good housekeeping procedures[1]	No cost
3	Process optimization[1]	No cost
4	Coal blocks are now crushed to smaller size. Jin Zhong set up its own standard for coal. [1]	No/low cost
5	Installation of a filter at the water inlet to prevent clogging [1]	Low cost
6	Installation of two cyclone dust removal [1]	Low cost
7	Reduction of consumption quotas pertaining to coal, electricity, and additives. [1]	Low cost
8	White water recycling to the raw material feeder instead of using fresh water.	Low cost
9	Employees training – environmental protection awareness sessions and sessions pertaining to operations. [1]	Low cost
10	Trimming of the paper roll is carefully monitored[1]	Low cost
11	Training sessions for the managers[1]	Low cost
12	Equipment maintenance [1]	Low cost
13	Ashes from boilers are now sold to brick manufacturers[1]	Low cost
14	Use of antiwear on compressors allowed to decrease the production cost by 3 yuan per ton of paper produced. [1]	Low cost
15	Water from the vacuum pump is reused for paper roll trimming[1]	Low cost
16	Addition of 10% talc to the pulp in workshop #7 & #8 [1]	Medium cost
17	Fibre recovery from the wastewater	Medium cost
18	Set up of a flotation unit allows to treat 50 000 tons of wastewater per year compared to 20 000 tons per year before the construction of this unit	Medium cost
19	Insulation of the steam pipes (5% energy consumption reduction) [1]	Medium cost
20	Boilers replacement 10% energy saving	High cost

1. CP solutions assumed to be implemented at the mill following the Ma An Shan workshop.

Among the twenty solutions, CP solutions number 4, 13, 16, 17, and 19 were audited. Photos illustrating some of these solutions are presented in Appendix C.

CP solution # 4

Coal blocks are now crushed to smaller size; Jin Zhong set up its own standard for coal quality hence increasing the efficiency of the boilers. The overall effect has been a decrease of 8.2

Renminbi per ton of paper produced. Since standard coal usage is roughly 1.3 ton of coal for one ton of paper produced with a boiler efficiency increase of 3% leads to an annual saving of 245 700 Renminbi or *3% efficiency increase * 1.3 ton of coal per ton of paper produced * 30 000 tons of paper produced per year * 210 Renminbi per ton of coal.*

The main environmental benefit resulting from this solution is that there will be less particulates emitted to the atmosphere.

CP Solution #13

Ashes generated from the boiler are sold as filling agent in construction materials. One ton of coal is required to produce one ton of paper; the type of coal used by Jin Zhong has an ash content of 25%. Knowing that the annual production of the mill is of 30 000 tons and that the estimated selling price of ash is of 66 Renminbi per ton, the yearly saving is calculated to be of 495 000 Renminbi (30 000 tons/year * 1 ton of coal / ton of paper * 25% * 66 Renminbi per ton).

Putting ashes in bricks as a filler means that ashes generated by the boilers will not be landfilled.

CP Solution #16

It is common in paper manufacturing to replace fibre by additives for quality/cost purposes. Jin Zhong paper mill has added some talc along with starch and polymer on paper machines #7 and #8 . The addition of talc is to increase the opacity of the sheet while starch gives strength to the sheet and polymer retains talc and starch in the sheet. This solution represents a modern way to operate a paper machine wet end.

Using these additives, it allowed the mill to reduce its production cost by 10 to 15 Renminbi per ton of paper while increasing paper strength by 15 %.

CP Solution # 17

Fibre found in the wastewater is now recovered using inclined screens, a settling pond having a volume of 1000 m^3 and a buffer tank having a volume of 400 m^3. Before the implementation of this solution, it seems that the mill was losing a tremendous amount of fibre in its white water. Based on the information provided by the mill, this solution allows the mill to produce 5000 tons of low grade paper from the recovered fibre. The mill has invested 600 000 yuan Renminbi for the construction of the inclined screens, settling pond, and buffer tank. The financial benefit associated to this solution is estimated to be of 10 million Renminbi per year.

By recycling these fibres to produce low grade cardboard, the organic content of the treated effluent that is discharged to the Er Shi Pu river will be greatly reduced.

CP Solution # 19

Insulation of steam pipes has saved around 5% in energy. It is considered to be a medium cost solution but, in fact, it depends upon the number and size of pipes involved. At the Jin Zhong mill the steam pipes located outside were insulated using asphalt products whereas the pipes located inside the facility were insulated with asbestos. It should be mentioned that asbestos is not considered to pose a risk to human health as long as the material remains in good condition. It is a simple solution having a very good return on investment and it is also a management issue: The next time a steam pipe will be repaired it will systematically be insulated. This demonstrates that CP has become a way of thinking for mill management.

This saving comes from the fact that the mill saved 5% in coal consumption based on 1.3 ton of coal per ton of paper produced. This solution brought a financial saving of 409 500 Renminbi per year or *1.3 ton of coal per ton of paper produced * 5% coal saving * 30 000 tons of paper produced per year * 210 Renminbi per ton of coal.*

The mill is planning to pursue the implementation of CP solutions. Table 5.3 presents further CP solutions that the mill is planning to implement in the future.

Table 4.3 Future CP Solutions

CP Solution	Category of Solution
Pressure screen auto-control	Low cost
Automatic injection of additives in settling tank	Low cost
Establishment of a technical department related to the mill's operations	Low cost
Enforcement of preventive maintenance program	Low cost
Sand removal autocontrol	Low cost
Crown adjustment on paper machine #8 press	Low cost
Utilization of antiwear oil for driers	Low cost
On site equipment repair by state owned enterprise experts	Medium cost
Purchasing of steam flow meters and water flow meter	Medium cost
Monitoring of chemical additives used in the process	Medium cost
Switch hydro-pulper operation from batch to continuous	Medium cost
Replacement of inclined sand removal screens by a rotating screen	Medium cost
Installation of an additional buffer, settling and flotation unit	High cost
Modification of the motor of the hydro-pulper in order to increase pulp consistency from 3-4% to 8-10%	High cost
Change cylinder size on paper machine #5 to improve dewatering	High cost

4.4 Comments

The Jin Zhong mill has established a CP program which is well balanced between management issues and manufacturing issues. The CP solutions that were implemented so far are numerous and diversified. This indicates that the various departments of the mill have been significantly involved.

The mill established ambitious environmental targets. Before the end of year 2001, the mill is planning to proceed with the implementation of some low to high cost solutions (as presented in table 5.3). The implementation of these future CP solutions are expected to lead to a further 3% reduction in raw material consumption as well as a 10% reduction of energy consumption.

The savings resulting from the audited CP solutions are presented in Appendix D.

5 Chao Lun Pulp and Paper Mill

5.1 General Information

Chao Lun pulp and paper mill is located in Guo Yang city approximately 400 km to the north-west of Hefei. The mill is a state owned enterprise which was established in 1990. It presently has a workforce of 750 workers, including 96 persons having a technical background. Its annual production capacity is of 50 000 tons. The mill operates a pulping line whose raw material is straw and nine paper machines. Recycled cardboard is also used as a raw material. In year 2000, 21 000 tons of straw pulp were produced and 12 000 tons of recycled cardboard were bought. Fresh water entering the process comes from both surface (Guo He river) and groundwater sources. The finished product consists of high strength corrugated paper. The mill sells its products to customers based in Zhejiang, Jiangsu, Guangzhou provinces as well as in Shanghai and Shenzhen.

5.2 Wastewater Treatment Facility

Chao Lun mill is equipped with a biological wastewater treatment plant having a design capacity of 420 m^3 per hour. It comprises primary and secondary clarifiers as well as an aeration basin. The treated effluent is monitored for COD, SS, and pH on a daily basis at the mill's environmental laboratory and the local Environmental Protection Bureau (EPB) reviews their environmental data every three months. The treated effluent is discharged to the Guo He river which is a tributary of the Huai He river.

The following table shows the recent environmental results obtained from the tests performed on the treated effluent of the mill before being discharged to the receiving water body.

Table 5.1 Chao Lun Mill Environmental Results

Month	pH *Standard[1] = 6-9*		SS (mg/L) *Standard[1] = 100*		COD (mg/L) *Standard[1] = 400*	
	Average	Days out of compliance	Average	Days out of compliance	Average	Days out of compliance
July 2000	8.0	0	90	1	430	28
August 2000	8.0	0	90	0	425	30
September 2000	8.1	0	80	0	410	27
October 2000	8.1	0	85	1	425	27
November 2000	8.0	0	80	0	410	26
December 2000	8.0	0	75	0	400	20
January 2001	7.9	0	80	0	390	7

February 2001	7.9	0	80	0	385	5

1. Source: Chinese regulation GWPB2-1999 (Paper making with pulping)

Based on the given results, the CP solutions put in place (see section 6.5) had a very positive effect on the COD content of the treated effluent discharge. In the past, the mill was out of compliance most of the time whereas presently the mill complies with COD regulation nearly 80% of the time.

5.3 Cleaner Production Solutions

So far, twenty-six CP solutions were implemented at the mill. Out of these twenty-six CP solutions, thirteen are no cost solutions, ten are low cost, one is a medium cost, and two are high cost solutions. It should be mentioned that among these twenty-six solutions eleven were implemented following the workshop that was held in Ma An Shan last July. These CP solutions are presented in table 6.2.

Table 5.2 CP Solutions Implemented at the Chao Lun Mill

CP Solution Number	Implemented CP solution	Category of Solution
1	Raw material de-dusting	No cost
2	Cooking process optimization	No cost
3	Pressure reduction for digester blow out	No cost
4	Dust removal equipment upgrade	No cost
5	Capacity increase of the black liquor extractor	No cost
6	Improve monitoring management[1]	No cost
7	Internal technical training[1]	No cost
8	Internal operating procedures enforcement[1]	No cost
9	Personnel involvement for CP solution suggestions	No cost
10	Cooking time reduction and Kappa number adjustment	No cost
11	Installation of steam save all on some paper machines	No cost
12	Establishment of an equipment maintenance schedule [1]	No cost
13	Use of recycled water to clean the floors	No cost
14	Introduction of anthraquinone in cooking process	Low cost
15	Installation of automated control for paper moisture content [1]	Low cost
16	Addition of one extra cylinder on one paper machine[1]	Low cost
17	Increase white water recycling rate by the addition of a new pump	Low cost
18	Fibre recovery at the inlet of the primary clarifier using rotating four screens[1]	Low cost
19	Fibre recovery from the primary clarifier[1]	Low cost
20	Cardboard pulping and straw pulp using white water	Low cost
21	Recovery of condensate from the paper machine[1]	Low cost
22	Installation of a dust collecting system on the straw conveyor	Low cost
23	Installation of a new vacuum pulp washing line[1]	Low cost
24	Recovery of waste steam from the cooking process[1]	Medium cost

25	Construction of a white water flotation basin	High cost
26	Improvement of the black liquor extractors under the blow tanks	High cost

1. CP solutions that were implemented at the mill following the Ma An Shan workshop.

Among the twenty-six solutions, CP solutions number 10, 14, 16, 17, 18, 19, 20, 21, 23, and 25 were audited. Photos illustrating some of these solutions are presented in Appendix C.

CP solutions #10 & #14

An anthraquinone system has been put in place at a cost of 20 000 Renminbi. Anthraquinone is a cooking aid, which in this case has allowed the mill to reduce the cooking time from six hours to five hours (16% reduction) and the Kappa number has been increased accordingly (from 24 up to 31).

Last year straw pulp production was of 21 000 tons. The implementation of this CP solution gave the mill an extra cooking hour for every six hours. Therefore using this extra hour, the mill is now able to produce an additional 3500 tons. This can be demonstrated as follows:

*Additional production : (21 000 tons * 1 hr / 6 hrs) = 3500 tons*

The retailed price of paper is of 2200 Renminbi per ton with a total manufacturing cost of 1700 Renminbi for a net benefit of 500 Renminbi. Thus, the overall benefit resulting from this solution is of 1.75 million Renminbi or (3500 tons of paper per year * 500 Renminbi per ton).

From an environmental point of view this CP solution allowed to save energy (steam produced by the coal boilers) since the cooking time is reduced. However, the savings cannot be estimated since there is no steam meter at the site.

CP solution #16

On one of their paper machines one extra cylinder was added to the two existing ones, for quality control reasons. Prior to this addition, for a basis weight of 120 g/m^2, pulp was spread over the two existing cylinders at a rate of 60 g/m^2 per cylinder. With the new cylinder added, each cylinder receives 40 g/m^2. This will enhance the paper quality. Last year 70 tons of corrugated cardboard did not meet the customer's specifications. At a selling price of 2200 Renminbi per ton the saving is 154 000 Renminbi per year.

From an environmental point of view it represents an energy saving (steam) since this amount of pulp does not need to be reprocessed.

CP solution #18

Before entering the primary treatment, the wastewater goes into four rotating screens which recover fibre. Fibre is recovered at a rate of one ton per day or 330 tons per year. This amount is estimated based on the weight of the cart in which fibre are accumulated. This recovered fibre is used to replace cardboard. The purchasing cost of waste cardboard is of 1375 Renminbi per ton for a benefit of 453 750 Renminbi per year. It should be mentioned that the purchasing cost of waste cardboard is high since most of it is imported from North America.

Prior to the implementation of this solution the wastewater containing fibre was directly directed to the wastewater treatment plant implying that most of it was lost as sludge generated from the primary clarifier.

CP solution #19

The underflow of the primary clarifier contains a great amount of fibre which is recovered to be used on number five paper machine. This paper machine also uses waste recycled paper cardboard. The quantity produced by this machine is measured and the amount of waste cardboard is also measured. By difference, it is calculated that 1440 tons of fibre per year are recovered. The investment cost related to this solution is of 500 000 Renminbi and the saving is estimated at 1980 000 Renminbi (1440 tons per year * 1375 Renminbi per ton of waste cardboard).

This implies that the amount of sludge, mainly fibre, produced by the primary clarifier is now completely recycled instead of being landfilled.

CP solutions #17 & #20

White water recycling occurs at many places in the mill. Using white water means that less fresh water is used and also that there is less wastewater to be treated. As an example, if the mill uses 1000 tons of waste cardboard per month (white water being presently used as dilution water) diluting the pulp at 3.5% means a white water usage of 25 571 tons per month or 330 852 tons per year. Hence, the same quantity of fresh water is saved at a cost of 66 170 Renminbi (0.2 Renminbi per ton of fresh water * 330 852 tons of fresh water).

It implies that 330 852 tons of wastewater per year does not have to be treated at a cost of 0.24 Renminbi per ton for a saving is of 79 404 Renminbi per year. Therefore, the total saving is 145 574 Renminbi per year.

CP solution #21

The condensate produced by the paper machines is now recycled to the coal boilers. The cost of the piping involved is of 70 000 Renminbi. The plant used to operate nine boilers, each one operating at one ton of steam per hour. With this solution the mill now uses eight boilers. With a typical coal usage of 80 tons per day when operating nine boilers, only 71 tons of coal are now

used per day with 8 boilers representing a saving of 490 050 Renminbi per year. This saving can be calculated as follow:

*9 tons of coal per day * 330 days per year * 165 Renminbi per ton of coal*
The environmental benefit resulting from this solution is that there will be less particulates emitted at the atmosphere.

CP solution #23

A new vacuum straw pulp washing line replaces the existing pulp washer. The investment cost related to this equipment is of 100 000 Renminbi. The pulp washing process is used to increase pulp consistency. The old washer was thickening the pulp from 0.5% to 6% whereas the new vacuum washing line thickens the pulp from 2% to 10%. The water which is removed from this process is sent to the wastewater treatment system. Compared to the old washer which was producing 184 tons of water per ton of washed pulp to be treated the new vacuum washing line produces only 40 tons for a difference of 144 tons.

If the mill produces 21 000 tons of straw pulp per year and if for each ton produced 144 tons of water is not directed to the wastewater treatment plant it represents a saving of 3 024 000 tons of wastewater to be treated per year. In order to treat 1 ton of wastewater it costs 0.24 Renminbi. The total saving generated by this solution is of 725 760 Renminbi per year.

CP solution #25

A white water flotation basin having a capacity of 3 600 000 tons per year was constructed at a cost of 2 150 000 Renminbi. The total fibre recovered from this basin allows to increase the annual production of paper by 1080 tons implying a financial saving of 2 376 000 Renminbi per year.

White water entering the flotation basin has a COD content of 1200 mg/L whereas treated white water has a content of 400 mg/L for a net saving of 800 mg/L and 2880 tons of COD per year.

Table 6.3 presents further CP solutions that the mill is planning to implement in a near future.

Table 5.3 Future CP Solutions

CP Solution	Category of Solution
Regularization of the pulp injection by stabilizing the pulp level in the storage tank	Low cost
Installation of a straw compactor to increase the amount of straw in each digester	Low cost

Installation of a new high speed line	Medium cost
Construction of black liquor evaporation lines	High cost

5.4 Comments

The mill implemented several environmental solutions prior to the Ma An Shan workshop without formally calling them CP solutions. However, the workshop allowed the mill to redesign their existing environmental program based on CP principles. The mill is presently evaluating each CP solution in terms of financial and environmental benefits.

The savings resulting from the audited CP solutions are presented in Appendix D.

6 Lu An Paper Mill

6.1 General Information

Lu An paper mill is located in the city of Lu An which is approximately 70 km to the west of Hefei. The mill is a state owned enterprise which was established in 1958. It presently has a workforce of 2218 workers including 200 persons having a technical background. The mill possesses 10 paper machines but at the moment the mill operates only three or four of them. These paper machines are operated using purchased straw pulp and wood pulp as raw materials. Fresh water used in the process comes from Pi He river. In the past, the mill used to operate three straw pulping lines but in December 1997 the mill had to stop producing pulp due to the enforcement of more stringent environmental regulations. Its annual production capacity is of 55 000 tons but in year 2000, it produced only 17 000 tons. The finished product consists of printing paper, cups stock, and cardboard. The mill sells its products to customers based all over China and it also exports to Cuba, Japan, and Middle east.

6.2 Wastewater Treatment Facility

The mill is not equipped with a conventional wastewater treatment plant. White water generated by each paper machine is directed to a common settling system having a total capacity of 250 m^3 per hour. The underflow in the settling tanks is mainly composed of suspended fibres which are directed toward a screening system. The overflow is discharged to the Huai He river. The treated effluent is monitored for COD, SS, and pH by the local Environmental Protection Bureau (EPB) since the mill does not possess its own environmental monitoring laboratory.

Table 7.1 presents the results of the analyses performed on the treated effluent of the mill in March 2001.

Table 6.1 Lu An Mill Environmental Results

Month	**pH** ***Standard[1] = 6-9***	**SS (mg/L)** ***Standard[1] = 100***	**COD (mg/L)** ***Standard[1] = 100***
March 2001	7.8	60	44

1. Source: Chinese regulation GWPB2-1999 (Paper making without pulping)

The results indicate that the mill is well below the national standards for the month of March. However, a trend cannot be established since the results covering a longer period of time were not provided.

6.3 Cleaner Production Solutions

So far, sixteen CP solutions were implemented at the mill. Out of these sixteen CP solutions, three are no cost solutions, twelve are low cost, and one is a medium cost solution. It should be mentioned that most of these solutions were implemented following the workshop that was held in Ma An Shan last July.

These CP solutions are presented in table 7.2.

Table 6.2 CP Solutions Implemented at the Lu An Mill

CP Solution Number	Implemented CP solution	Category of Solution
1	Awareness training session on CP given to the mill employees[1]	No cost
2	Establishment of operational procedures[1]	No cost
3	Establishment of a preventive maintenance program[1]	No cost
4	Improve raw material procurement and storage[1]	Low cost
5	Technical training sessions given to the employees[1]	Low cost
6	Installation of a suitable motor on a cardboard machine vacuum pump[1]	Low cost
7	Installation of a third headbox on the cardboard machine for the addition of low grade pulp in the mid-ply cardboard[1]	Low cost
8	Adjustment of the reject nozzle on the centrifugal cleaners[1]	Low cost
9	Replacement of the grate in the boiler[1]	Low cost
10	Reduction of washing water	Low cost
11	Fibre recovery from the flotation basins[1]	Low cost
12	Condensate recovery from the paper machines[1]	Low cost
13	Installation of an additional white water pump[1]	Low cost
14	Ashes from boilers are sold to brick manufacturers	Low cost
15	Installation of a wet scrubber on the coal boiler	Low cost
16	Installation of a new coal feeder on the boiler	Medium cost

1. CP solutions that were implemented at the mill following the Ma An Shan workshop.

Among the sixteen solutions, CP solutions number 6, 7, 8, 10, 11, 12, 13, and 14 were audited. Photos illustrating some of these solutions are presented in Appendix C.

CP solution #6

By changing the 110 kW motor of one of the cardboard machine vacuum pumps for a 90 kW motor, it allowed the mill to save 153 000 kWh representing a saving of 15 300 Renminbi per year. It is calculated as follow:

*20kWh * 22.5 operational hour per day * 340 days per year * 0.1 Renminbi per kWh*

CP solution #7

On the cardboard machine the mill used to produce two plies cardboard. The top ply consisted of 1/3 of the thickness and the bottom ply of 2/3. Each ply being visible, high grade pulp was required. By the addition of a third headbox the mill can now produce a three ply cardboard with each ply consisting of 1/3 of the thickness. The mid-ply can now contain low grade pulp without visually affecting the cardboard quality since high grade pulp is still used on the outer plies.

The price of low grade pulp is of 3400 Renminbi per ton compared to the price of high grade pulp which is 3800 Renminbi per ton. The price to produce two plies cardboard was of 3800 Renminbi per ton of cardboard produced. The price for the new cardboard machine configuration is of (2/3 * 3 800 + 1/3 * 3 400) or 3666 Renminbi per ton of cardboard produced. The saving resulting from this new arrangement is therefore of 134 Renminbi per ton of three ply cardboard produced. For an annual production of 13 600 tons of cardboard the saving is 1 822 400 Renminbi per year.

CP solution #8

The adjustment of the nozzle on the centrifugal cleaner allowed the mill to save 40 kg of pulp per ton of cardboard produced which were otherwise transferred to make low quality grade cardboard. This pulp is put into bags and weighted. 40 kg of pulp per ton of cardboard produced at a rate of 13 600 tons per year which implies that the mill saves 544 tons of cardboard per year. The quantity of cardboard saved is calculated as follows:

*(40 kg of pulp per ton of cardboard produced * 13 600 tons of cardboard produced per year) / 1000 kg of pulp per ton*

The selling price of the high quality cardboard is 6800 Renminbi per ton and that of the low grade is 2000 Renminbi per ton. It means that producing 544 more tons of high quality cardboard gives a benefit of 2 611 200 Renminbi per year. The calculation is as follows:

*544 tons of high quality cardboard produced per year * (6800 Renminbi per ton of high grade cardboard – 2000 Renminbi per ton of low quality cardboard)*

CP solution #10 & #13

The installation of a new white water pump allowed the mill to use white water in the cardboard pulper instead of fresh water. The annual production being of 13 600 tons of cardboard per year and the consistency being maintained at 4% in the pulper 326 400 m^3 of fresh water are saved annually. The fresh water cost being 0.15 Renminbi per ton the financial benefit is of 48 960 Renminbi per year. Through a better maintenance of the valves and by using recycled water to clean the paper machine felts as well as the floors an additional amount of approximately 200 000 m^3 of fresh water is saved per year for a benefit of 30 000 Renminbi. These values are based on the readings of the inlet flowmeter.

CP solution #11

Fibres are recovered from the underflow of the white water flotation basins. The underflow containing the fibre is thickened using an inclined screen. The recovered fibres are bagged, weighed and sold to an internal company at a price of 500 Renminbi per ton. The financial benefit is of 340 000 Renminbi which is calculated as follows:

*50 kg of recovered fibre per ton of cardboard * 13 600 tons of cardboard produced annually * 500 Renminbi per ton*

By recycling these fibres the organic content of the treated effluent discharged to the Pi He river (a tributary of the Huai He river) will be greatly reduced.

CP solution #12

Steam from the paper machines is now recovered using a series of flash tanks. The investment cost for this system is of 38 000 Renminbi. The steam saving is estimated to be 1.5 ton of steam per ton of cardboard produced as measured at the steam meters. Knowing that one ton of coal bought at 270 Renminbi per ton produces 4.9 tons of steam it gives a saving of 1 124 000 Renminbi per year.

The main environmental benefit related to this solution is a reduction of the amount of ash generated.

CP solution #14

Ashes generated from the boiler are sold as a filler in construction material. Knowing that 16 000 tons of coal are used on a yearly basis having a 25% ash content 4 000 tons of ash are therefore generated. At a selling price of 66 Renminbi per ton of ash the benefit is of 264 000 Renminbi per year.
Putting ashes in bricks as a filler implies that ashes will not be landfilled.

Table 7.3 presents further CP solutions that the mill is planning to implement.

Table 6.3 Future CP Solutions

CP Solution	Category of Solution
Installation of automatic consistency control	Medium cost
Switch from direct current to alternative current on one paper machine	Medium cost
Redesign the steam supply for all paper machines	Medium cost
Implement a de-inking process	High cost

6.4 Comments

Following the Ma An Shan workshop, two CP teams were set up at the mill. One focused on management and the other one on production.

At the beginning of December, the CP program was only starting at the Lu An mill. The CP program that was put in place by the management team reflects a good understanding of the CP principles. Most of the solutions identified are either no or low cost solutions. The results generated by the implementation of the CP solutions, even if many of them are very simple and easy to implement, are financially and environmentally attractive.

The safety aspect is interesting to observe in this mill. Motors couplings are covered by well adjusted covers, hoses are rolled up if not in use; even the surroundings of the coal boiler are clean. In most cases when safety issues are taken care of, it indicates that a special attention is also paid to other management aspects such as environment.

The savings resulting from the audited CP solutions are presented in Appendix D.

7 Gao Sen Paper Mill

7.1 General Information

Gao Sen pulp and paper mill is located along the Yangtze river in Gao Sen city, Anhui province. The mill is a state owned enterprise which was established in 1958. It presently has a workforce of 950 workers, including 180 persons having a technical background. Its annual production capacity is of 20 000 tons. The mill presently operates three paper machines producing respectively white cigarette paper, yellow cigarette tipping paper and insulation paper. It should be noted that the unit producing insulation paper is operated under a Japanese joint venture (Anhui Mikitoku Paper Company Limited). The raw materials used for cigarette and tipping paper production consist of seventy percent purchased wood pulp and thirty percent purchased straw pulp while purchased unbleached wood pulp is used for the production of insulation paper. The fresh water used by the mill is taken from the Gao He river. The total yearly production of the mill is of 10 200 tons (5100 tons/year for cigarette and tipping papers and 5100 tons for insulation paper).The mill sells its products to customers based all over China and exports to Japan, Hong Kong, and South-East Asia.

7.2 Wastewater Treatment Facility

The mill is not equipped with a conventional wastewater treatment plant. White water generated by both cigarette paper machines is combined. The combined white water is directed to a screening system followed by a flotation system. The treated effluent from the flotation system is then directed to a final screening system before being discharged to the Gao He river. A quantity of three tons per month is recovered and is sold to external companies manufacturing cardboard.

The treated effluent is monitored for COD, SS, and pH every three months by local the Environmental Protection Bureau (EPB) since the mill does not possess its own environmental monitoring laboratory. The environmental results from the EPB are not available at the mill.

7.3 Cleaner Production Solutions

So far, nine CP solutions were implemented at the mill. Out of these nine CP solutions, four are low cost, two are medium cost, and three are high cost solutions. It should be mentioned that among these nine solutions four were implemented following the workshop that was held in Ma An Shan last July.

These CP solutions are presented in table 8.1.

Table 7.1 CP Solutions Implemented at the Gao Sen Mill

CP Solution Number	CP Solution	Category of Solution
1	White water recycling[1]	Low cost
2	Modification of sand removal system[1]	Low cost
3	Steam pipe insulation	Low cost
4	Pulp consistency control	Low cost
5	Steam pressure control	Medium cost
6	Modification of the coal feeder system	Medium cost
7	Idled straw pulping[1]	High cost
8	Development of high benefit products	High cost
9	White water recovery[1]	High cost

1. CP solutions that were implemented at the mill following the Ma An Shan workshop.

The Gao Sen mill has identified solutions which are mainly process oriented and not management system based. Consequently, they have identified fewer solutions than other selected mills. Solutions 1, 2, 3, 5, 6, 7, and 9 are analysed in details in the following paragraphs. Photos illustrating some of these solutions are presented in Appendix C"

CP Solutions #1 and #9

Forty percent of the white water generated from the paper machines forming sections is directly recycled to pulp dilution. The white water portion (60%) that is not recycled to pulp dilution is directed towards a series of inclined screens where the coarse fibres are removed. Then the screened white water is pumped to two flotation units in order to recover the short fibre. The total amount of recovered pulp has been evaluated to be in the order of seven tons per month.

Knowing that the cigarette and tipping paper production generates 100 meter cube of wastewater per ton produced and since this 100 m^3/ton corresponds to the 60% white water discharged it therefore implies that 66 m^3/ton ((100 / 0.6) – 100) of white water is recovered through this CP solution. From an environmental stand point, it means that the same amount of fresh water is saved.

This CP solution led to three main financial benefits:

1. Pulp saving: *Seven tons of recovered pulp per months * 12 months per year * 5285[1] Renminbi per ton = 443 940 Renminbi per year.*

[1] 70% straw pulp at 4200 Renminbi + 30% wood pulp at 5750 Renminbi.

2. Fresh water saving: *66 m^3/tons * 5100 tons per year * 0.02 Renminbi per cubic meter of water = 6732 Renminbi per year.*

3. Avoided wastewater treatment cost: *66 m^3 per ton * 5100 tons per year *0.5 yuan per meter cube = 168 300 Renminbi per year.*

Hence, the total saving is of 618 972 Renminbi per year.

Considering that the investment cost to implement this solution was of 5 000 000 Renminbi, it can be said that the main benefit is more environmental than financial.

CP Solutions #2

At the inlet of each paper machine (white cigarette and yellow tipping paper machines) new more efficient sand removal systems were installed. The investment cost for each unit was 40 000 Renminbi. These systems allowed to save approximately 2% (conservative estimation) of the fibre that otherwise were sent to the wastewater treatment unit.

It represents a financial saving of 539 070 Renminbi per year calculated as follow:

*5100 tons of cigarette and tipping paper produced per year * 2% of fibre saved * 5285 Renminbi per ton of fibre.*

By reducing the sand content of the paper produced, the quality of the finished paper has been enhanced.

CP solutions #3, #5, and #6

Throughout the mill several steam pipes were insulated at a cost of 40 000 Renminbi.

Steam pressure control valves were installed on white cigarette and yellow tipping paper machines at a total cost of 90 000 Renminbi. It allowed the mill to better control the finished product moisture content. Thus, it became possible to increase the moisture content by 0.5% without affecting the finished paper quality. An increase of 0.5% in moisture content means that 0.5% less fibre is used.

The coal feeder on the boiler was replaced at a cost of 50 000 Renminbi increasing the combustion efficiency.

For these CP solutions, the total investment is of 180 000 Renminbi. Financial savings are as follows:

1. Coal consumption reduction: The coal consumption is measured by the amount of coal purchased. Coal usage has been reduced from 1.3 down to 1.2 ton per ton of paper produced and that for all paper machines. This solution generated a saving of 255 000 Renminbi per year or *0.1 ton of coal per ton of paper * 10 200 tons of paper produced per year * 250 Renminbi per ton of coal.*

2. Fibre content reduction in the finished products (cigarette and tipping paper): Conservatively speaking, it represents a saving of 134 767 Renminbi per year or *5 100 tons of paper produced per year * 0.5% of saved fibre * 5 285 Renminbi per ton of fibre.*

Therefore the total saving for these CP solutions is of 389 767 Renminbi per year.

CP Solutions #4

Pulp consistency controllers have been installed throughout the mill essentially to control the basis weight of paper. The total investment cost is of 320 000 Renminbi. The basis weight required by the customers is 28 to 30 +/- 0.5 g/m^2. Before installing the pulp consistency controllers, the basis weight of finished products was occasionally off specifications. For example, one ton of paper which is usually sold at 12 000 Renminbi could only be sold at 8 500 Renminbi. Assuming that 5% of the production (5 100 tons of paper per year) did not meet the customers specifications this solution leads to an annual saving of 892 500 Renminbi or *5 100 tons * 5% * (12 000 – 8 500)*. This CP solution gives the customers a greater confidence in the manufactured products.

CP Solutions #7

The mill used to operate one straw pulping line. This process was idled in October 2000 due to environmental non-compliance; especially for COD. Since then, a new pulper was installed in order to use 70% purchased wood pulp and 30% purchased straw pulp. The investment cost for this pulper is of 2 000 000 Renminbi.

The production cost of the pulp that was manufactured on site was of 2800 Renminbi per ton whereas the average cost of purchased pulp is of 5285 Renminbi per ton. Thus, there is no financial saving related to this solution. However, from an environmental point of view, this CP solution allowed the mill to continue its operation while lowering its environmental impacts.

In terms of further CP solutions to be implemented, Gao Sen mill is planning to build a biological wastewater treatment plant which will allow them to restart their pulping line while complying to environmental standards.

The mill is also planning to produce high class white tipping paper instead of the medium class yellow tipping paper that is presently produced. In this case, the main environmental benefit will be the elimination of the yellow colouring agent that ends up in the discharged effluent.

7.4 Comments

The mill's managers clearly mentioned that the CP concept was completely unknown before the Ma An Shan workshop. In December 2000, the mill was still elaborating its CP program. One management representative clearly said that the mill was struggling for survival but the presence of this CP program helped developing a program that was not only directed to environmental protection but also to cost reduction.

The CP program the mill came up with does not contain any no cost solution. However, it seems that most items that usually fell in this category were already implemented.

The savings resulting from the audited CP solutions are presented in Appendix D.

8 Summary

With the implementation of CP solutions, the mills quickly realized the importance of the CP concept as well as the advantages it brings. The vast majority of the CP solutions identified corresponded to the CP solution definition that was presented at the Ma An Shan workshop. However, it should be noted that some CP solutions are not true CP solutions as such but the purpose of this report was not so much to analyze the nature of the CP solutions but rather to find out if the solutions that were implemented had a direct positive impact on environmental and financial (production/operational costs) aspects.

The total number of solutions does not necessarily reflect the degree of involvement of the mill management in the CP program. The number of CP solutions identified by each mill is essentially site specific. For example, if a mill has already implemented basic solutions such as piping insulation, white water recycling, etc., it will obviously have fewer no or low cost solutions than a mill where these solutions have not been implemented.

The following table presents a summary of the CP solutions that were implemented at each mill.

Table 8.1 Summary of the CP Solutions Implemented at each Mill

Mill	No cost	Low cost	Medium cost	High cost	Total
Ma An Shan					
Shan Ying	4	6	4	2	16
Tian Du	7	7	2	1	17
Jin Zhong	3	12	4	1	20
Chao Lun	13	10	1	2	26
Lu An	3	12	1	0	16
Gao Sen	0	4	2	3	9
Total	30	51	14	9	104

As mentioned previously, only the most representative CP solutions were audited. Table 9.2 presents the savings resulting from these solutions.

Table 8.2 Summary of the Savings Generated by the CP Solutions

Mill	Fibre saved (t/yr)	Coal saved (t/yr)	Water saved (t/yr)	Electricity saved (kW/yr)	Oil saved (L/yr)	Renminbi saved per year
Ma An Shan	1 450	***	870 552	----	960	4 824 110
Tian Du	1 224	***	822 936	----	----	1 836 302
Jin Zhong	5 000	3 120	----	----	----	11 525 200
Chao Lun	6 420	2 970	3 354 852	----	----	8 075 134
Lu An	4 843	77.5	526 400	153 000	----	6 255 860
Gao Sen	211	1 020	336 600	----	----	2 440 309
Total	19 148	7187.5	5 911 340	153 000	960	**34 956 915**

*** Probable savings achieved but not estimated

While this data is subject to a considerable margin of error, it should be remembered that only 28 of the 81 no/low cost solutions, seven of the fourteen medium cost solutions and four of the nine cost solutions were audited. Assuming that the solutions which were not audited also produced significant results, it indicates that the overall impact of this program is very significant for the participating mills.

Results are also very significant from a province-wide perspective, as the participating mills represent 47% of actual production in Anhui Province (see table 1 in chapter 1).

9 Conclusion

In order to build on the success of the demonstration projects in Fuyang and Huainan, and help ensure project sustainability, the Joint Project Steering Committee meeting of 2000 decided that it would be important to implement the CP process at additional plants in the pulp and paper and fertilizer sectors. The guiding principle behind this implementation was that as it proceeded, the roles of the Canadian experts would diminish and the roles of the local Chinese experts would increase. Additionally, both the Fuyang Chemical General Works and the Anhui Paper Mill would participate in these extension activities, to showcase their demonstration projects, to act as trainers for personnel from the newly participating mills and to give their managers and engineers additional practice in implementing CP.

The objectives of this exercise were:

- To field test the CP auditing manuals and guidelines ;
- To help insure project sustainability;
- To attempt to achieve a regional impact on the pulp and paper making industry.

All three objectives have been met through the project activities in FY2000-2001.

From the project activities to date, a certain number of conclusions can be drawn. Most notably, the methodology employed to implement CP in an industrial sector appears to work very well, at least with regard to the pulp and paper sector. This methodology is based on the following steps:

1. Inspection of a limited number of plants, in order to choose a representative plant for demonstration purposes.

2. Execution of a detailed pre-audit and audit at the plant, using local and international experts.

3. Production of detailed audit reports (likely more detailed than the mill itself might produce).

4. Identification and ranking of CP solutions for implementation.

5. Implementation of CP solutions and careful, accurate reporting of results (environmental and financial savings).

6. Based on the above, production and wide dissemination of a CP audit manual and CP guidelines and solutions for the sector.

7. Identification of a group of enterprises who are willing to participate in the program.

8. Training of the personnel of these participating enterprises, using the previously completed demonstration project as an example.

9. Inspection of the participating enterprises, to assess progress and provide further assistance as may be required.

The extension activities in the six mills provides ample evidence of "low-hanging fruit" to be picked, that is to say all mills, without exception, were able to quickly identify very important CP solutions which could be implemented quickly, at relatively low cost, and which provided an extremely high rate of return.

Furthermore, the emphasis given on financial benefits of implementing a CP program appears to be fully justified. The prospect of an improved bottom line has proven to be a very important driver and motivator for mills to implement CP.

Some of the solutions which were implemented and presented as CP solutions were not, strictly speaking, CP solutions. That is to say they did not necessarily eliminate pollutants at source. Indeed, in certain cases, it could be argued that the solutions had no impact on pollution at all. The audit team deliberately chose to ignore this issue, because all solutions, whether "Cleaner Production" solutions or not, showed evidence of CP thinking. In other words, even the solutions which did not meet the strict definitions of CP demonstrated that the mill was looking for ways to make its process more efficient. Thus, some solutions seemed to have only financial, not environmental benefits. Other solutions seemed to be more in the nature of end of pipe treatment. But all, without exception, made the mills more efficient and demonstrated that the participants had a good grasp of the basic principles involved.

The audit team discovered that some of the participating mills had already begun to implement CP, prior to the training program which they received in July 2000. Nevertheless, these mills were able to make very good use of the training. This is because the training gave them a methodology by which to implement CP. Not only were they able to go about their CP programs in a more systematic way, but they were also able to apply methods to rank various CP options and thus prioritize their interventions.

Finally, participation in the CP program undoubtedly gave the mills added incentive to achieve results and provided them with an opportunity to meet with their colleagues from other mills to discuss CP.

There is evidence that the mills are now better able to implement environmental management plans. For instance, the Ma An Shan and Jin Zhong mills have established specific, measurable objectives and targets. These would easily fit into an ISO 14001 management system.

Some of the CP solutions audited were assessed on the basis of theoretical calculations. In a few cases it was difficult to obtain before and after performance measurement data regarding the efficiency of the solutions implemented. This highlights a systemic problem in the Chinese pulp and paper industry. Few pulp and paper mills are able to measure on their own, their environmental performance. They do not have the personnel or equipment to take samples or the laboratories in which to analyse the samples. Most mills rely on the local Environmental Protection Bureau to tell them whether or not their effluent meets the regulated standard and most mills do not have the habit of tracking their environmental performance against production, over time.

Consequently, while the first phase of CP implementation is successful, one wonders about the ability of the mills to implement a sustained, continually improving CP program over a number of years. To do so efficiently and effectively would probably require that the mills have the capacity to measure accurately on a monthly basis its environmental performance. This would be difficult for the smaller mills.

In conclusion, mill management, without exception, are enthusiastic regarding the CP process and all agree to continue. Without exception, the mills see CP as a means to contribute not only to their well being but also, in some cases to their survival. In this regard, they may be right, as the short term financial benefits associated with implementing a CP program can be very large.

The information gathered from the participating mills gives a good indication that the CP program is well adapted to the need of the Chinese pulp and paper sector. Through continuous application of an integrated preventative environmental strategy to process, product and service the pulp and paper sector will have ability to improve eco-efficiency and reduce risks to humans and the environment.

Further efforts should be deployed by the project to insure that the mills are able to continue implementing CP. In particular, mills could use assistance in improving their capacity for performance measuring and monitoring.