# Multi-Field Analysis of the Systems Sociotechnic in the Industrial Developing Countries: Case of the Industry of Cotton in Algeria

Marref A. Souad, Bahmed B. Lylia, and Benoudjit C. Azzedine

***Abstract*—In accordance with the general principles of prevention, developed within the legislative framework of the protection of workers, a risk analysis must be carried out in the whole of the industrial facilities. Inside the enterprise COTITEX of Batna, this principle of prevention is very little applied and one can partly allot this absence of application to the fact that the methods of analysis suggested are not well adapted to this factory.**

**To this end, a comparative study of several risk analysis methods issued from the "reliability" movement is undertaken, in order to choose the one whose field of application would answer better to our criterion of engagement, namely the triptych: Man-Installation-Environment. The risk analysis method retained is: MADS-MOSAR which presents a framework basing its approach on the concept of "system". We also carried out an ergonomic analysis of the difficult conditions induced by the technology transfer making use of the RENAULT method. We analysed these blockings of disparate appearance then and could allot mainly their causes to a conflict of values between the COTITEX and the institutions of prevention.**

***Index Terms*—Systems sociotechnic, RENAULT method, industry of cotton.**

## I. Introduction

Among the developing countries Algeria is characterized by some major features: importance of contracts with strong technological contents, volume of requested equipment. Consequently the country became quickly a very large importer of technology and thus a significant and interesting market for the goods industries of the developed economies [1].

In spite of the existence of technical and scientific human resources integrated into the control of imported technologies, the history and the practice showed that the diffusion of applied know-how can be the source of considerable negative effects [2].

Among the Algerian industrial companies confronted with these problems, textile cotton complex COTITEX Batna is a factory "turn-key" which began its production in 1966, from where it employs now a growing old population, of limited school and life levels, exposed to difficult working conditions. These conditions can affect the mental and physical health of workers and modify their behavior inducing a high rate of errors. This unsuitable situation during technology transfer increases the risks occurrence and gravity. Within the framework of setting up the prevention and rules of hygiene and safety of the companies (the law n °1414 of December 31, 1991: article L 230-2.), the development and the installation of a total step of prevention by the head of the company implies a thorough analysis of the risks (Scherrer 1981, SONALGAZ 1988). In COTITEX Batna company these principles were little applied due to the lack of a safety and prevention service. On the basis of this report, we started a study including a risk analysis in particular for electric risks, followed by a "anthropo-technological" analysis and a critical study of the working conditions using the RENAULT analysis method [3] [4]. This work is structured as follows.

### *A. Application of the RENAULT Method*

We build a collection of ergonomic information deepened by a total analysis taking into account: the working station, the physical environment, the physical load, the mental effects and finally the psychosociological aspect governing the adaptation of the operator to the difficult conditions of the techno-logy transfer, [5].

### *B. Thorough and Rigorous Study of Risk Analysis*

We choose one of the risk analysis methods adaptable to the reliability. The retained approach is the "MADS-MOSAR" methodology developed by the CEA (French atomic energy authority). It makes it possible to model our industrial field by a "Man-Installation-Environment" system, [6].

### *C. Application of the MADS-MOSAR Methodology*

The analyze is centered on the electric installations of the company and their characteristics (neutral modes, tensions and rated currents, fault tensions and currents, insulation defects, wiring, means of cut, protection, state of the legislation…) [7].

### *D. Presentation of the Results*

During this experimental phase, the advantages and drawbacks observed at the time of the implementa-tion of the analysis are underlined and presented.

### *E. Comparative Analysis of the Results Obtained and the Problems Encountered in the Preceding Stages*

In the light of the cindynic approach suggested by the model of Kervern [8], proposals of improvement and a

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correction for some safety barriers can be proposed towards the electric risks. This will be the matter for a future publication.

## II. "Anthropotechnological" Analysis by the RENAULT Method

In this part of the work, we present the anthropo-technological analysis carried out at the level of the weaving workshop of COTITEX Batna.

### A. Definition

The ergonomics of the technology transfer was called "anthropo-technology"[9] to underline the fact that the useful knowledge to treat the technology transfer call for social sciences and is interested in the individual as it is also the case for ergonomics. This science makes it possible to conclude there are specific problems to each country. One can observe that the countries which acquire foreign technologies and try to implement them encounter diverse successes; it is thus essential to use suitable means to be able to manage such situations [10]. Among these means we chose the RENAULT analysis method.

### B. Ground of Application

The use of the Renault method, to analyze the working conditions in the technology hall of COTITEX Batna, requires to carry out a certain number of measurements relating to the activity of the operator and to the environmental factors. These measurements correspond to six factors of working condition (design of the station, safety, physical environment, physical load, mental effects and psychological aspect), and each factor includes the evaluation of several parameters assessed either by a measuring apparatus, by a questionnaire, or by the direct observation. Each parameter is quantified in a scale of quotation which goes from 1 to 5, see Table I, [9]-[13].

### C. Evaluation and Analyzes

Our objective is the identification and the analyze of the risks related to the impact of the technology transfer on the Man-Installation-Environment system. Consequently, the method to be used must at the same time make it possible to evaluate the damage undergone by the operator, but also to provide indicators usable for a reliable and perennial analysis. The double objective imposes a slip compared to the analysis of the working conditions, the goal of which is the protection of the operator.

TABLE I: Evaluation Scale

| Level of quotation | Scale of quotation |
|---|---|
| **Very well** | **1** |
| **Well** | **2** |
| **Rather well** | **3** |
| **Passable** | **4** |
| **Badly** | **5** |

Table I presents the evaluation scale of the analysis carried out in the workshops of the COTITEX. This analysis related to 3 working stations, 12 machines corresponding to a technology transfer.

Detailed tables for each station were drawn up and table 2 synthesizes all the results by showing the average notes of each observed factor.

The curves of prescribed and observed work were obtained by evaluating the factors starting from documents, questionnaires, investigations and observations according to case's

The graph of Fig. 1 represents the variations of the two curves of real work (—) and of prescribed work (…..) according to the factors of quotation between 1 and 5.

It comes out from this analysis that there is a difference between the two curves (prescribed, reality), which means that the affected work at the weaving workshop would require more favorable conditions to be done in accordance with the posted requirements.

Among the factors which block the achievement of work (according to the graph), one can evoke:

1) The very high noise level (see 5.1.5) which causes a nervous tiredness.
2) The repetitiveness of the work which involves a loss of attention or a troublesome feeling.
3) The conditions of atmospheric hygiene (see 5.1.5).
4) The unsuitable height of the work surface (the quasi totality of the workmen finds it painful to carry out their task).

### D. Results

All these excesses involve a gap between what the operator must do (which is defined by the organization: work prescribed) and what the operator really makes (real work). That is illustrated by the station of the finishing workshop which presents adverse conditions at the achievement of the task (we have a parameter reaching value 5 of quotation "badly " for sound environment and several other "passable" values 4 of quotation for height and distance, thermal environment, atmospheric hygiene… etc.)

The application of the RENAULT method was difficult to achieve, because we did not find antecedents on our subject, neither forms being able to answer some of our questions, nor statistics carrying our purpose. We collected information by our own observations, talks and questionnaires

## III. Methodology of the Risk Analysis

The risk analysis of an industrial facility is a complex step because the company is itself a complex structure made up of machines, storages, in interaction between them and with the operators and the environment. To highlight the majority of the risks of an installation, several methods of the current of the reliability are proposed. To cope with the purpose of our study that results in the following stages:

### A. Definition

It consists in setting up the definitions and concepts connected to the risk and the risk analysis (and its fundamental components) such as they are seen and recognized by the institutions of prevention.

TABLE II: PRESENTATION OF RESULTS OF THE GRID OF EVALUATION

| Factors of quotation | Level of quotation | Scale of quotation |
|---|---|---|
| *I Design of the station* | | |
| 1 Height and distance | Passable | 4 |
| 2 Alignment, evacuation | Rather well | 3 |
| 3 Obstruction, accessibility | Rather well | 3 |
| 4 Order, signals | Well | 2 |
| *II Safety* | | |
| 1 Safety | Passable | 4 |
| *III Physical environment* | | |
| 1 Thermal environment | Passable | 4 |
| 2 Sound environment | Badly | 5 |
| 3 Illumination | Well | 2 |
| 4 Noise and vibration | Badly | 5 |
| 5 Atmospheric hygiene | Passable | 4 |
| 6 Aspect of the station | Rather well | 3 |
| *IV Physical load* | | |
| 1 Principal posture | Passable | 4 |
| 2 Most unfavourable posture | Rather well | 4 |
| 3 Effort of work | Passable | 3 |
| 4 Posture of work | Rather well | 3 |
| 5 Effort of handling | Rather well | 3 |
| *V Mental effects* | | |
| 1 Mental operation | Rather well | 3 |
| 2 Level of attention | Rather well | 3 |
| *VI Psychosociological aspect* | | |
| 1 Individual autonomy | Rather well | 3 |
| 2 Autonomy of group | Rather well | 3 |
| 3 Relation independent of work | Rather well | 3 |
| 4 Relation dependent on work | Well | 2 |
| 5 Repetitiveness | Passable | 4 |
| 6 Necessary potential | Passable | 4 |
| 7 Responsibility | Rather well | 3 |
| 8 Interest of work | Passable | 4 |

### B. Presentation

It specifies the field of action, the constraints taken into account and the criteria selected to choose the method being able to prove as the best tool to detect blockings of the action field against the risk analysis.

### C. Formalization

It presents the three principal methodological currents of risk analysis through examples of methods considered as representative of each one of these currents, then it justifies the choice of one of these currents according to the criteria of the study and the description of the principal methods which are connected to it.

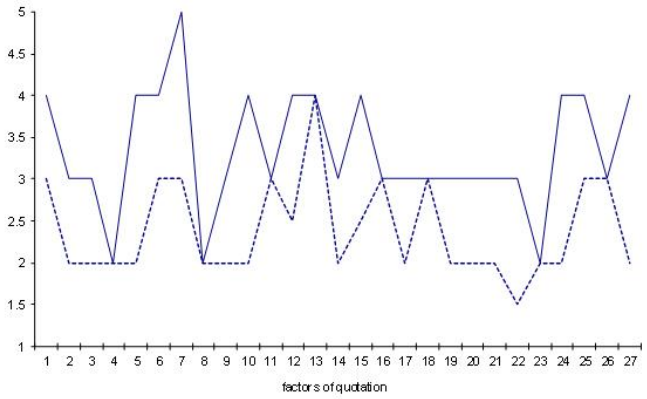


Fig. 1. Evaluation by the Renault method.

### D. Identification and Analyzes

This stage aims at identifying the risks and their mechanisms by counting dreaded events shown by the questions asked during the investigation near the operators. For example, in a thought aiming at foreseeing the consequences of the components failures of a product (possibility of accident), one listed the components and the mode of failures which can affect them. In other terms, one is interested not in the failure itself, but in its demonstration in the studied system.

### E. Prioritization

The purpose is to classify the risks by associating to each dreaded event studied a frequency of occurrence (a probability if one can consider the event as random) and a gravity (a cost in currency, time, image, in sight, moral)
The method that we seek must fill a certain number of conditions to enable us to study the blockings observed in the company of textile. These conditions consist in satisfying the following criteria:

1) A good level of formalization of the steps of the risk analysis: knowing that a traditional analysis always comprises the same standard stages, the degree of formalization makes it possible to ensure a more complete and easily reproducible analysis that is an essential quality to carry out the same experimentation in various companies.
2) The use and the formalization of a model of accident: A model of the process of danger with a systemic vision make it possible to have a coherent and complete approach of the phenomenon taking into account the initiating mechanisms, their causes and the consequences of the accident.
3) The consideration of "victims" from different kinds.

## IV. SELECTION CRITERIA TO CHOOSE A RISK ANALYSIS METHOD

The majority of the methods of analysis of the risk gather mainly the five stages presented in table 3. Table 4 proposes a comparison of the principal risk analysis methods employed in reliability against the selection criteria which is adopted.

### A. Comment of Table IV

The safety analysis methods filling best with these

constraints are the APR, the AMDEC and MOSAR. Methods MOSAR and AMDEC offer the advantage of having a formalization step of prioritization whereas the APR does not propose tools.

The AMDEC gathers a great number of the criteria we set but, even if this method is able to integrate personal and organizational features, it does not define the tools which will allow this integration. That constitutes an additional difficulty.

The method MOSAR guarantees the presence of the four following principal criteria:

1) formalization of the different steps of risk analysis: MOSAR is an organized method.
2) simultaneous consideration of the installation, the workers and the environment like potential victims of the risk: MOSAR is a systemic method.
3) formal use of a model of accident: MOSAR is based on the model MADS which describes the process of danger.
4) taking into account of the technological, human and organizational risk factors: MOSAR includes lists of source of danger systems of the three above mentioned kinds.

Moreover MOSAR integrates tools that one finds in the APR, the AMDEC or in logical trees. By considering and validating safety barriers installation at the step of acceptability determination and risks treatment, the methodology MOSAR appears to be a method apparently complete and general. Its application in the context of the COTITEX deserves to be tested. Method MOSAR is thus the method nearest of our waiting, it is thus that which we employ during this study.

## V. Application of Selected Methods

### A. Contribution of the RENAULT Method

The RENAULT method and the anthropo-technological analysis for the reduction of the human error in the system Man Machine Environment, named "Anthropo-technology" by A. Wisner, is a field of the ergonomics which answers the following definition:

1) the anthropo-technology is an "adaptation of the technology to the population which, like ergonomics, joins together knowledge issued from the social sciences to improve the design of technical device, … the scale being different, the necessary sources are different" [14] [15].
2) the anthropo-technology is thus a field of the ergonomics dealing with the difficult questions of the technology transfer belonging to the social sciences collective. It is carried out through the ergonomic analysis, taking into account the frequent degradation of technical devices and the heterogeneous features of the two cultures in the operator mind.

The RENAULT method, developed with the National Control of the Factories RENAULT (RNUR) in France, during the Seventies, allows to carry out an analysis of the working conditions starting from this particular ergonomic approach. The aim is to facilitate the adaptation of an operator and a technological device when the device designer comes from a different culture than that of the operator.

This method enabled us to evaluate the place of the ergonomics and of the anthropo-technology in the prevention of the negative effects of the technology transfer and their influence on the rates of probability and gravity of the risks in industry.

Our observations related to various features of the organization.

#### 1) The choice of the building

The workshops of the complex are buildings with light walls and of traditional design requiring means for heating and air-conditioning, but this mean does not function any more. The climatic conditions of the workshops became hateful and present a disastrous influence on the health of the workers and the productivity.

#### 2) The purchase of the machines

It does not take into account the anthropometrical standards. One announces a difference in height of 0.15m compared to the standards, which explains the painful postures of the workmen. One easily seizes the need for having machines designed for a real adaptation to the morphology of our workers.

#### 3) Selection and staff training

This aspect is of real interest for the too marginal candidates from the physical or mental point of view. One notes a higher absenteeism rate of the personnel presenting psychological difficulties, which explains the fast degradation of the capacities of the workers under the effect of the internal conditions, and even outside the company (housing, health…). The selection will have to be made from the dynamic point of view to provide good elements.

#### 4) Discussions with the persons in charge

It made it possible to find an escape of the personnel well trained towards other more attractive companies. One also noticed a teaching problem in the formation being attached to the system of industrials values: exactitude, precision, attention, vigilance, reliability… etc. The concepts taught do not correspond to the traditional culture of the workers; the formation should be made in Arab language with reference to the local cultural models.

#### 5) Physical aspect

*Sound environment:* one records in the majority of the workshops a noise level largely exceeding the level of alarm (85dB) and even of danger (90dB). Moreover the noise becomes definitely more significant during the operation of all the machines, causing several awkward effects (trouble in communication and perception of oral signals, headaches, nervous fatigue, stress, etc.)

### B. Control Level of Concentration of Dust

Here also, one find a high concentration of dust of cot-ton ($VM$ = 0.662 mg/m$^3$) compared to the interna-tional standards concerning the acceptable dust levels in the working rooms (0.2 mg/m$^3$) [19], [20]. But if we take into account the influence of moisture on the standard weight of fibres and cotton dust, one can assert that the results can decrease slightly; nevertheless that does not prevent the occurrence of respiratory difficulties, intoxications,

occupational diseases and bad smells, according to the statistics.

TABLE III: SUMMARY OF THE METHODOLOGY OF RISK ANALYSIS [16]

| Procedure Training courses | To define | To present | To formalize | To identify | To treat on a hierarchical basis |
|---|---|---|---|---|---|
| **Stage 1** | Risk, danger, accident, probability of occurrence. | Types of method: " To that "," Ergonomics (dangerous actions or Man-machine maladjustment)"and" reliability ". | Stages of the analysis of the risks (five stages) | Risks and generating mechanisms of risks. | Dangers. |
| **Stage 2** | "Victims" of the risk (formalization by the means of systemic, systems targets flows of danger) | The sphere of activity and its criteria. The amplifying environment and effects or reinforces cf model MADS | The direction of reasoning (inductive or deductive) at the time of the stage of research of the scenarios of accidents | The scenarios of realization of the risks while being based on a model of simple and intuitive accident. | Scenarios of realization of the risks |
| **Stage3** | System of application of the analysis (example: COTITEX of Batna) | Method of selected analysis | The acceptability criteria for which tools for negotiation are Grids G/P/A that can be imposed by the regulation. | Solutions | Potential accidents and their consequences in term of gravity and probability. |

TABLE IV: COMPARISON OF THE PRINCIPAL METHODS [17], [18]

| *CRITERIA* | | METHOD | | | | | |
|---|---|---|---|---|---|---|---|
| STEPS | | APR | AMDEC HAZOP | Tree of failures | Trees events | Diag. Causes-csq | MOSAR |
| **formalization** | Definition of the system | Not | Yes | Not | Not | Not | Yes |
| | Identification of the risks | Yes | Yes | Not | Not | Not | Yes |
| | Identification of the generating mechanisms of risks. | Yes | Yes | Yes | Yes | Yes | Yes |
| | ***Evaluation*** | Not | Yes | Yes | Yes/not | Not | Yes |
| | prioritization | Not | Yes | Not | Not | Not | Yes |
| | Identification of the solutions. | Yes | Yes | Not | Not | Not | Yes |
| **victims taken into account** | Installation | x | x | x | x | x | x |
| | Man with work | x | possible | x | | x | x |
| | Ecosystem | x | possible | x | | x | x |
| **type of factors of risks considered** | Technological | x | x | x | x | x | x |
| | Human | x | possible | x | | | x |
| | Organisational | possible | possible | | | | possible |
| ***Model of accident*** | | Yes | Yes (weak) | Yes (weak) | Not | Implicit | Yes |
| ***Feel investigation*** | | Inductive | Inductive | deductive | Inductive | Inductive and deductive | Inductive and deductive |

X: Indicate the type of victim taken into account, and the type of factors of risk under consideration for each one of the methods of analysis yes/no: to assert or to invalidate the presence of each step of formalization of the various methods of analysis.

In the same way, it is advisable to take into account the capacities of the workers of the Algerian populations, noting that the muscular force is not proportional to the size but that it is in close connection with the state of nutrition and health. One notes according to the talks and the questionnaire that the workmen are very badly fed within the unit (the meals prepared at the restaurant of the complex are of bad quality, the majority of the workers prefer to eat cold meals (of which the calorific contribution is insufficient).

It is noted, that the majority of the workmen are old and weak. Their average physical capacity is by far much lower than that of a European worker.

However, the anthropo-technology does not include only the working physical conditions or the effect of heat and the noise on the production but it is also interested in the mental activities: perception and comprehension of the signals, decision-making and relationship with the operation of the machines, realization of maintenance, the quality control of the products. One could show that the work considered as simple, like the mass production in the textile, requires complex mental activities in the absence of which breakdowns or errors occur implying frightening effects on the quality of the production and on its volume.

Thus the anthropo-technology leads to know better the features of the population of workers of each country, and it analyzes closely the processes really carried out by the

operators, particularly in the mental and physical field of their activity.

Moreover it is necessary to protect the health of the workers of the importing countries and not to admit the situations of work which one refuses rightly elsewhere. Only a thought on the clean conditions of the installation of the factory will make it possible to find solutions adapted and inexpensive with the real problems encountered during a technology transfer. This thought, by the involved consequences for design and organization of the equipment and procedures, must make it possible for the operator to adapt himself to his task, to make less errors, thus inducing a risk mitigation and a reduction of the sources of dangers.

### *C. Contribution of MOSAR Methodology for the Control of the Human Error in the System Man Machine Environment*

The methodology MOSAR enabled us to finalize all the steps necessary to an analysis of the electric risks and to carry out the assessment and the prioritization of these risks. The method associates also to the module of analysis itself, a research module to find solution for the treatment of these risks which appeared unacceptable.

These steps do not follow always perfectly the reference guide of method MOSAR and some modifications are progressively integrated during the application. These adaptations became necessary either to answer to the attempts of a MOSAR approach by another skew, or just to circumvent insuperable difficulties in the real time of the experimentation which was allocated to us.

Some difficulties appeared during our experimentation and concerned mainly:

1) the constitution and the stability of the working group.
2) the need for expertise in particular fields of electricity, safety and risk prevention.
3) already evoked deplorable working conditions, due to the negative effects of technology transfer.
4) the poverty of the industrial fabric which does not support the emergence of a safety culture and of an experience feedback sharing.
5) the absence of some specific knowledge on the risks, their models of occurrence and their models of representation for the COTITEX.
6) the assessment of the probabilities and the gravity of each scenario of accident (as well as risk acceptability).

These blockings did not seem coming inevitably from the same source, nor as being of the same order. Some appear intrinsic with the method whatever the context of application, others are related to the COTITEX whatever the method of analysis employed, while others occur rather at the interface COTITEX / method.

The results of our experimentation starting from the five concepts developed by Kerven (values, objectives, rules, models, data) show that the course of a risk analysis can be mainly compromised by the blockings connected to the concepts of *values* and *models.* The proposals and tracks for improvements that we will present in a further publication are primarily centered on these two concepts. The three other dimensions (objectives, rules and data) often ensue. The difficulties encountered during our analysis are mainly related to the *values* showing a gap between the rules used by company COTITEX and the rules imposed by the institutions. One also notice a lack of model of representation for the process of occurrence of an accident.

## VI. Recommendations

To mitigate the negative effects of technology transfer on workers' health and to make these imported technologies suitable for our Man-Machine-Environment system there are two complementary ways: to adapt man to technology and to adapt technology to man. The adaptation of man to technology induces personal selection and formation. This approach involves physiological, cognitive and emotional aspects and it implies a specific attention to the work organization. The adaptation of technology to man relies on four topics:

1) the physical environment and especially the noises: sound harmful effects are treated in different ways: classical equipments like ear plugs and noise limiter helmets that are often refused by the workmen for their discomfort, but also absorptive and dissipative devices like hoods, screens and sound insulating treatments that reduce the noise emission of industrial systems. We can also use reactive devices like acoustic ventilation grids, windows and doors to mitigate the sound nuisance propagation,
2) man-machine interface and operator assistance,
3) allocation of functions between man and machine
4) organization of work.

## VII. Conclusions and Prospects

We conclude that to succeed in setting up an effective risk analysis in company COTITEX Batna, it seems significant to propose tracks of evolution at the same time for the method and for the teaching step in order to minimize the conflicts and to fill the deficiencies due to the technology transfer.

These suggestions concern mainly:

1) the training and the awareness of the personnel of the company to the models of understanding and representation of the risks.
2) the dialogue between the institutions and the company for the joint definition of objectives.
3) the search for models of evaluation of the electric risks adapted to the data available in company COTITEX.
4) the promotion of a dialogue between the institutions and the company so that they can together deal with the problems arising from the technology transfer and its influence on the mainly electric risk management.
5) the integration of the two steps of safety management: RENAULT and MOSAR approaches.

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