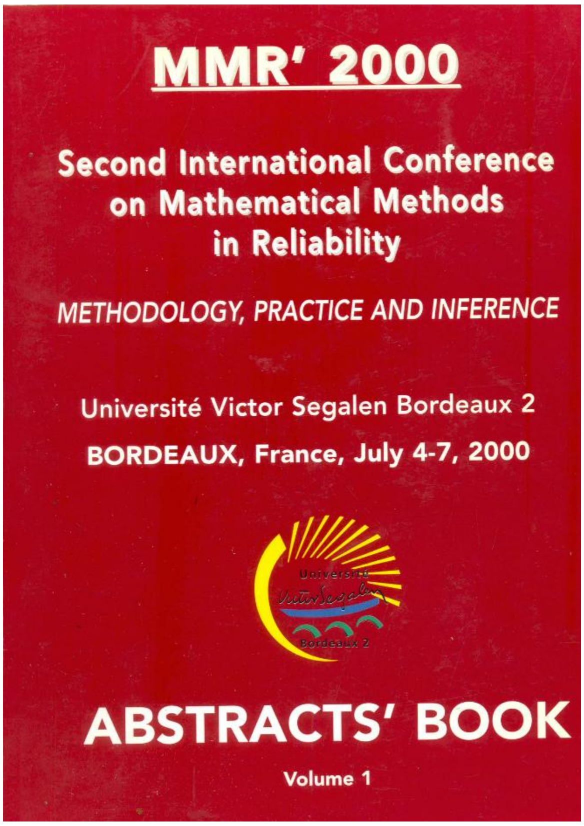

Reliability Analysis of Hydrocarbon Transshipment Optimization for the Algerian Pipelines

Smail Adjabi, Djamil Aissani, Assia Rabahi, Soraya Mendil
E-mail : adjabi@hotmail.com

LAMOS
Laboratory of Modelisation and Optimisation of Systems
University of Bejaia, 06000 Algeria

Abstract

In this work we propose a methodology aimed to evaluate the optimal amount of oil that should transit the Algerian pipelines. This evaluation is based on the reliability and availability of the pump stations. As a first step, we conducted a statistical analysis related to the mean time to failure of the pump stations equipment. This study has settled the reliability properties of the system s' components. In addition to fitting by classical distributions, we have used non parametric distributions fitting. The model was validated by the test of Prochan Pyke and the graphical method. The second step of this work is modeling the different variants of the system from a reliability point of view. A calculation of reliability and availability, based on the reliability and availability of its components, was performed on each variant. The result established by the linear program yields the best way for assigning the line busy periods and the optimal amount of oil to be shipped under a certain rate of production. An application was performed on the Hassi-Messaoud – Bejaia pipeline.

MMR' 2000

Second International Conference on Mathematical Methods in Reliability

METHODOLOGY, PRACTICE AND INFERENCE

Université Victor Segalen Bordeaux 2

BORDEAUX, France, July 4-7, 2000

ABSTRACTS' BOOK

Volume 1

Reliability Analysis of Hydrocarbon Transshipment Optimization for the Algerian Pipelines

Smail Adjabi, Djamil Aissani, Assia Rabahi, Soraya Mendil
E-mail : adjabi@hotmail.com

LAMOS
Laboratory of Modelisation and Optimisation of Systems
University of Bejaia, 06000 Algeria

Abstract

In this work we propose a methodology aimed to evaluate the optimal amount of oil that should transit the Algerian pipelines. This evaluation is based on the reliability and availability of the pump stations. As a first step, we conducted a statistical analysis related to the mean time to failure of the pump stations equipment. This study has settled the reliability properties of the system s' components. In addition to fitting by classical distributions, we have used non parametric distributions fitting. The model was validated by the test of Prochan Pyke and the graphical method. The second step of this work is modeling the different variants of the system from a reliability point of view. A calculation of reliability and availability, based on the reliability and availability of its components, was performed on each variant. The result established by the linear program yields the best way for assigning the line busy periods and the optimal amount of oil to be shipped under a certain rate of production. An application was performed on the Hassi-Messaoud – Bejaia pipeline.

Introduction

Following the numerous discoveries of oil-fields and the market reorganization due to the will of expansion and the development of foreign companies partnership, the Algerian oil company, Sonatrach, is intending an extensive increase of its exportation rate. Up to the year 2000, the enhancement should reach 33% of the current production level. To perform this design, the Sonatrach company is facing the following question: are the current production frames able to deal with the 2001'horizon management objectives ?

1. Reliability model for H.E.H Bejaia line

The reliability analysis will be carried out on the infrastructure of the stations located on H.E.H Bejaia line. The global structure of the system, constituted of the different stations, is depicted here.

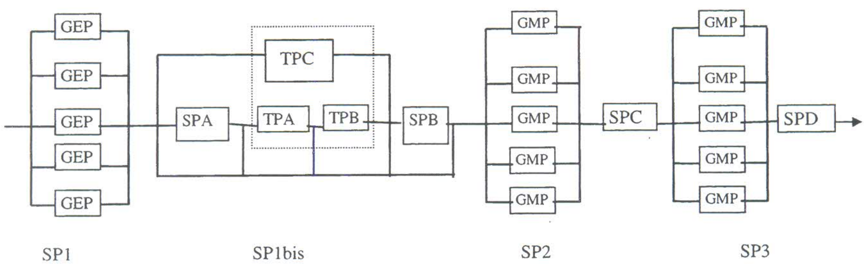

Fig 2.1: Line reliability diagram

1.1 Proposed reliability models for the system

The analysis consists of reducing the global system to obtain a variant set of operative systems. From reliability point of view, each variant is constituted with elements for which failure causes the failure of the whole variant. These elements are presented on a serial form with the other elements. Those elements which do not cause system failure, unless combined with other elements, are presented on parallel form (cf. figures 2 – 6 [6]).

2. Data reliability analysis

The first step that enables us to analyze the reliability of the equipment, is the study of the behavior of the variable representing the mean time to failure "MTTF" obtained from the data samples constructed from fastback experience.

We have achieved two kinds of fittings:

- parametric fitting, we have chosen the negative exponential distribution and the Weibull distribution, validated by Kolmogorov-Smirnov and Khi-2 tests when possible;
- non parametric fitting "IFR" and "DFR" validated by the two following tests: Prochan-Pyke and the TTT-plot test based on the TTT-statistic.

3. Debit optimization by reliability and availability analysis

3.1 Computation of the reliability

3.1.1 Components' reliability

In this section, we shall present some reliability characteristics of the most important equipment.

Variable	Parameters		MTTF
X1 : GMP engine	$\beta=0.63$	$\eta=21790$	30857.00
X2: GMP pumps	$\beta=0.69$	$\eta=19996$	25666.43
X3: GMP multipliers	$\lambda=0.000027$		36614.50
X4: S. satellites and TPC	$\lambda=0.000170$		5892.43
X5: TPA-TPB	$\beta=0.428$	$\eta=5344$	14894.99
X6: Boosters	$\lambda=0.000025$		40425.30
X7: Loading GEP	$\beta=0.48$	$\eta=2857.7$	6180.63

Table 3.1 Table of MTTF of reliability variables

3.1.2 System variants reliability

We have calculated the reliability factor for different variants of the system. The results are presented on the following graph

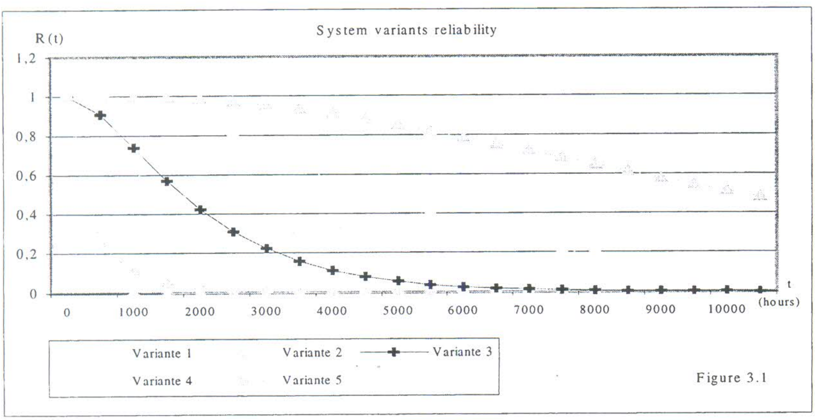

Figure 3.1

3.2 Interpretation of reliability curves of variants of the system :

As shown on figure 3.1, the fifth variant is the most reliable. It reaches 0.5 index of reliability after 10 000 hours of running. The fourth variant reaches half this performance, the other variants are far from this level. The only variant able to run without interruption during a year (8760 h), is the fifth one with an index of probability equal to 0.61. But it is practically impossible for the other variants to achieve this mission.

The statistical study had showed that the equipment s' MTTF is classified in two categories:

- The first , containing GMP pump's and engines, turbines and pumps of TPA and TPB as well as the pumps' engines of GEP, is characterized by decreasing rates of failure.
- The second, containing the GMP multipliers, the boosters, the turbines and the pumps of the satellite stations and those of TPC, is characterized by constant rates of failure.

4. Calculation of availability

An element can be in four (4) different situations : Available in state of running, available, but in state of rest; in state of reparation; in state of revision (RP, RG).

The following table summarizes the rates of availability as well as the availability of each variant during one year :

	Variant "1 "	Variant "2 "	Variant "3 "	Variant "4	Variant "5 "
Availability	0.05	0.32	0.90	0.99	0.999
Availability with t = 8760h	433.2	2833.44	7914.72	8681.16	8756.5

Table 4.1 Availability for variants of the system

5. Debit optimization

In order to determinate the maximum amount of crud oil that can be shipped through the line during one year in such a way that the availability of each variant is satisfied, we have formulated the problem as a linear program to be maximized. The presented model calculates the times for which the line can work in each mode, such that the calculated time does not exceed its availability. The objective function Z represents the amount that can be shipped through the line during one year such that the availability of each mode is satisfied.

$$\text{Max } Z = \text{dens} \times \sum_{i=1}^{5} d_i \ t_i$$

dens =density of the crud oil; d_i = hourly debit for mode i.

$\text{Max } Z = (2500\ t_1 + 2200\ t_2 + 1800\ t_3 + 1400\ t_4 + 800\ t_5) \times 0.779$, under the constraints:

$$\begin{cases} \sum_{i=1}^{5} t_i = 8760 & (1) \\ t_1 \leq 433.2 & (2) \\ t_2 \leq 2833.44 & (3) \\ t_3 \leq 7914.72 & (4) \\ t_4 \leq 8087.04 & (5) \\ t_5 \leq 8101.2 & (6) \\ \\ t_i \geq 0, \quad i = 1,...,5 & \end{cases}$$

- the first constraint (1) shows the limit on the total time of running, it should be equal to 1 year.
- the constraints (2) until (6) indicate the limits on availability of the line under each operative mode.

The obtained optimal solution indicates that the line can work during 433.2 hours with a debit of 2500 m^3/h, with a period of 2833.44 hours with the debit 2200 m^3/h and a period of 5493.36 hours with the mode 1800 m^3/h in order to ship a maximum amount which is 13.4 million tones per year.

6. Actions enhancing the availability

When observing the availability of variants of the system, we have noticed that the rate of unavailability, for variant of the system whose hourly debit is 2500m^3/h, is much more larger than 0.95. Many measures can be taken to enhance the availability of the system. Among those seeming to be realistic for us, we cite the following:

* Reducing length of revisions: The obtained results show that the system can work a period of 2 months and 24 days with an average debit of 2500m^3/h, and during approximately 8 months with a debit of 1100m^3/h. The remaining time of the year (about 1 month and 6 days), the company can keep the line with an average debit of 1800m^3/h in order to achieve a maximum amount of 15.13 million tones. This measure will not induce an increasing of the labor cost.
* Reinforcing stations SP2 and SP3: The second proposition deals with the reinforcement of the stations SP2 and SP3, by adding a GMP in each of them. The calculation of availability for this variant indicates that if the company adopts this proposition then the line will be able to transship 15.15 million tones per year. The line can work 114.6 days with a debit of 2500 m^3/h, or 182.3 days with a debit of 2000 m^3/h, or 1800 m^3/h during 68 days.
* Achieving the two propositions simultaneously.

References

[1] Aïssani D., Aïssani A., *Modèles de Fiabilité et Sciences de l'Ingénieur*, revue ***MATAPLI*** (Société française de Mathématiques Appliquées et Industrielles), Paris, Avril 1998, pp. 65-66.

[2] Aissani A., *Tests d'ajustement pour des distributions non paramétriques*, Actes des JSA'97 (Journées Nationales de Statistiques et Applications), USTHB, Alger, 1997, pp. 10-19.

[3] Chevalier C., Lannoy A., Evolution de la fiabilité d'un matériel et de ses composants.

[4] Lyonnet P., *La maintenance: mathématiques et méthodes*, Ed. Technique et documentation (Lavoisier), Paris, 1986.

[5] Documents internes de la Sonatrach, *Capacités réelles de transport des oléoducs RTC pour la période 1997-2001*, Ed. Sonatrach, 1998.

[6] Rabahi A. et Mendil S. , *Analyse de Fiabilité pour l'optimisation du transport des hydrocarbures au niveau de l'Oléoduc H.E.H-Béjaia*. Prépublication, Université de Béjaia, Juillet 1999

TABLE OF CONTENTS

VOLUME 1

Reliability Analysis of Hydrocarbon Transshipment Optimization for the Algerian Pipelines

Smail Adjabi, Djamil Aissani, Assia Rabahi, Soraya Mendil
E-mail : adjabi@hotmail.com

LAMOS
Laboratory of Modelisation and Optimisation of Systems
University of Bejaia, 06000 Algeria

Abstract

In this work we propose a methodology aimed to evaluate the optimal amount of oil that should transit the Algerian pipelines. This evaluation is based on the reliability and availability of the pump stations. As a first step, we conducted a statistical analysis related to the mean time to failure of the pump stations equipment. This study has settled the reliability properties of the system s' components. In addition to fitting by classical distributions, we have used non parametric distributions fitting. The model was validated by the test of Prochan Pyke and the graphical method. The second step of this work is modeling the different variants of the system from a reliability point of view. A calculation of reliability and availability, based on the reliability and availability of its components, was performed on each variant. The result established by the linear program yields the best way for assigning the line busy periods and the optimal amount of oil to be shipped under a certain rate of production. An application was performed on the Hassi-Messaoud – Bejaia pipeline.