ANNALS of the ORADEA UNIVERSITY.

Fascicle of Management and Technological Engineering, Volume VI (XVI), 2007

THE LOGISTICS OF OIL PLANTS' RELIABILITY

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KEY WORDS: logistics, structural analysis, logistic function, operating system

Oil plants for drilling and drawing destined to ground and off-shore oil recovery are structured according to the appropriate technological processes. Their logistic analysis focuses on finding new ways of enhancing their energy and reliability performances and of preventing technical risks that may occur during oil recovery.

PRELIMINARY NOTES

The drilling plant's strucure depends on the drilling method used and on the operating systems which perform the functions necessary for the technological process.

From this point of view, the structural analysis is aimed at identifying the way a plant works. This shows the way in which main and auxiliary operating systems are grouped.

A main operating system performs the functions necessary for the drilling technological process and consists of the driving system and the producer. The driving system consists of the engine or engine group (M) and gearing. The latter can be of various types (according to its complexity and performance features).

In order to identify some models destined to the simulation of various working conditions there are used the methods of analysing system structure and plant compunds. Due to these methods there can be carried out the logistic analysis of a relevant number of situations encountered in practice.

LOGISTIC MODELS

Determining reliability as a logistic parameter of broad interest is very important especially in the designing phase because the designer must solve not only the problems related to the system's functions but also those related to its safe operation. In the calculation of every system, the system's structure is shown by the logistic model (MS), which may not differ from the block diagram of the system's functioning.

The core problem of the logistic model's analysis is to determine the extent to which the characteristic parameters can remain within the limits set for the system's working condition.

The logistic model is elaborated by using the configuration symbols of system structure. If we refer to the power supply (SE), the initial effort variable is defined as fuel intake pressure in the case of heat engines, and as potential difference in the case of electromotors, and the velocity variable is defined as fuel yield in the case of heat engines, and as amperage in the case of electromotors. Starting from these aspects, the structural analysis only presents the drilling plant as a complex system consisting of interconnected subsystems in order to identify some networks whose analysis can become operational.

As regards the driving system, the quadripole scheme is presented in (*Chart 1*), where the producer is the draw works (TF), and the actuator is the swivel hook (C). In the chart the mechanical power input and output parameters of every subsystem reflect the physical nature of the actual size, namely: the rotative moment (M) or force (F), and the velocity (ω) or (v), respectively. A main operating system (SM) carries out the functions necessary for the technological drilling process and consists of the driving system (SA) and the producer. SA consists of the engine (M), the gearing (T) and the gear box (CV). The latter can be of various types (with power take off from draw works or from gearing T), according to its complexity and performance features.

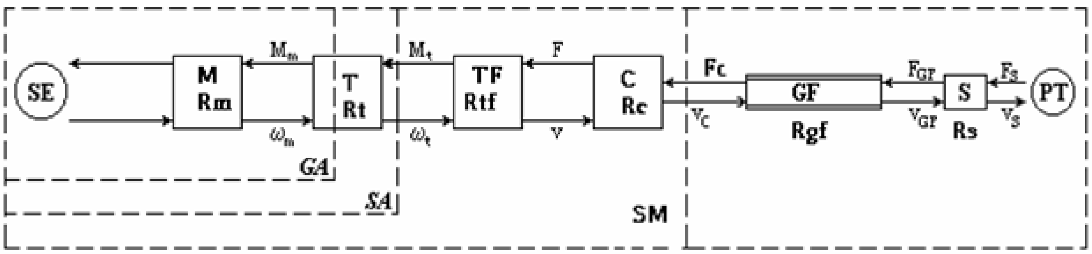

***Chart 1. Logistic model of driving system* (SM)**

The reliability functions of the comprising subsystems are:
Rm – for engine; Rt – for gearing; Rtf – for draw works; Rc – for assembly crown-block cable – hook crane, Rgf – for drill column and Rs – for drill rod.

For the centralised or group operating mode the main operating systems (SM, SR and SC) are operated by the same engine or group of engines. The systems are equipped with the same gearing, and the table – with a mechanical power take off and a gear box (CV) for MR. Below we will note the structural schemes for the rotating system (SR) and for the circulation system (SC), respectively.

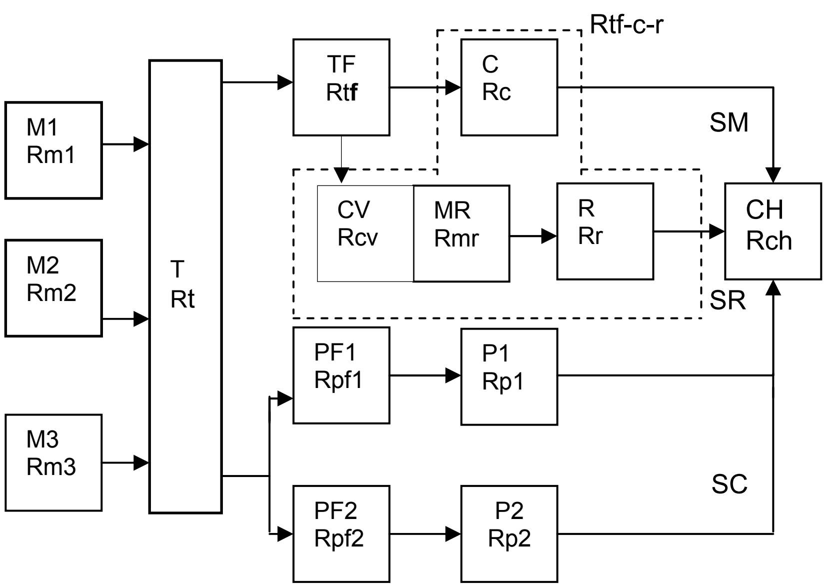

Chart 2. Logistic model of operation group1 (G1)

The total reliability function for this operating mode is calculated using the features of structural analysis methods, as follows:

$$R_{G1} = Rm \cdot Rt \cdot [1-(1-Rtf\text{-}c\text{-}r)(1-Rpf\text{-}p)] \cdot Rch \qquad (2)$$

where:

$Rtf\text{-}c\text{-}r = Rtf \cdot [1-(1-Rc)(1-Rcv \cdot Rmr \cdot Rr)]$

$Rpf\text{-}p = [1-(1-Rpf1 \cdot Rp1)(1-Rpf2 \cdot Rp2)]$

$Rm = 1-\prod_{i=1}^{n}(1-Rmi)$, the reliability function of the group of n engines

Rch – the reliability function of swivel casing

There is also a second variant for the group operating mode, G2, where one of the pumps has its own group of engines and gearing, and for MR the power take off is connected either to TF or directly to T1, as shown in the chart below:

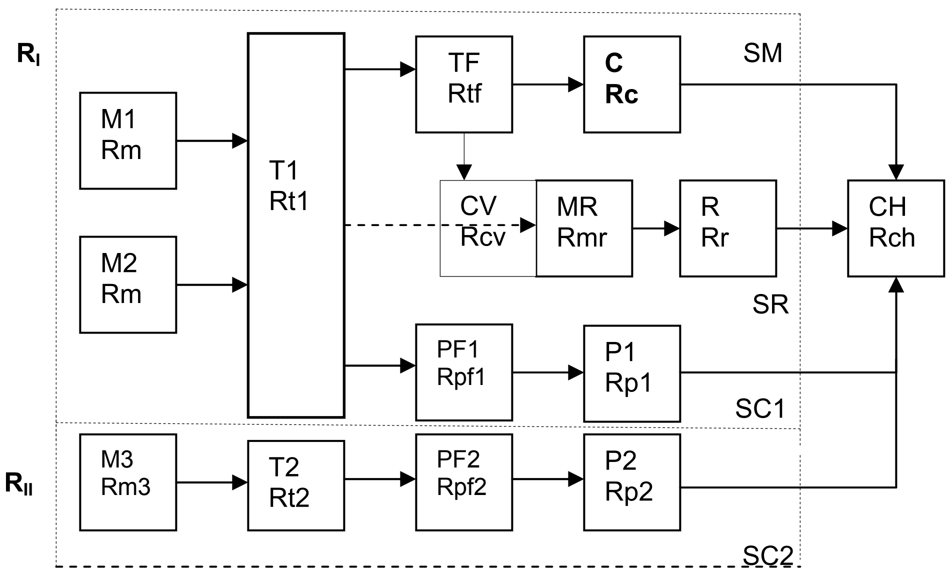

Chart 3. Logistic model of operation group2 (G2)

The total reliability function in this case is:

$$R_{G2} = [1-(1-R_I) \cdot (1- R_{II})] \cdot Rch \qquad (3)$$

Where:

$R_I = Rm_{1,2} \cdot Rt \cdot [1-(1-Rtf\text{-}\ c-r) \cdot (1-Rpf1 \cdot Rp1)]$

$R_{II} = Rm_3 \cdot Rt2 \cdot Rpf2 \cdot Rp2$

the values of variables are known.

Another operating mode would be the one for which SM and SR receive the energy flux from a common group of engines by means of common gearing, and SC works independently. This operating mode is called mixed1 (M1) because it refers to the logistic configuration 1 of subsystem connecting.

We notice that M1 differs from G1 and G2 by the complete separation of SC (*CHART 4*), which has major implications on the whole IF project. These are to be found in the analysis of the whole system's reliability and in that of its technical security due to the physical separation of working areas.

Thus, there appears mechanical gearing T2 (only for SC), given the fact that T has been replaced by T1 whose complexity decreased due to the removal of chain PF1-P from G2 and its transfer to M1.

Similarly, from the logistic perspective of plant exploitation there can be organised an IF and an operating mode by means of which driving and rotating systems work together and circulation works independently.

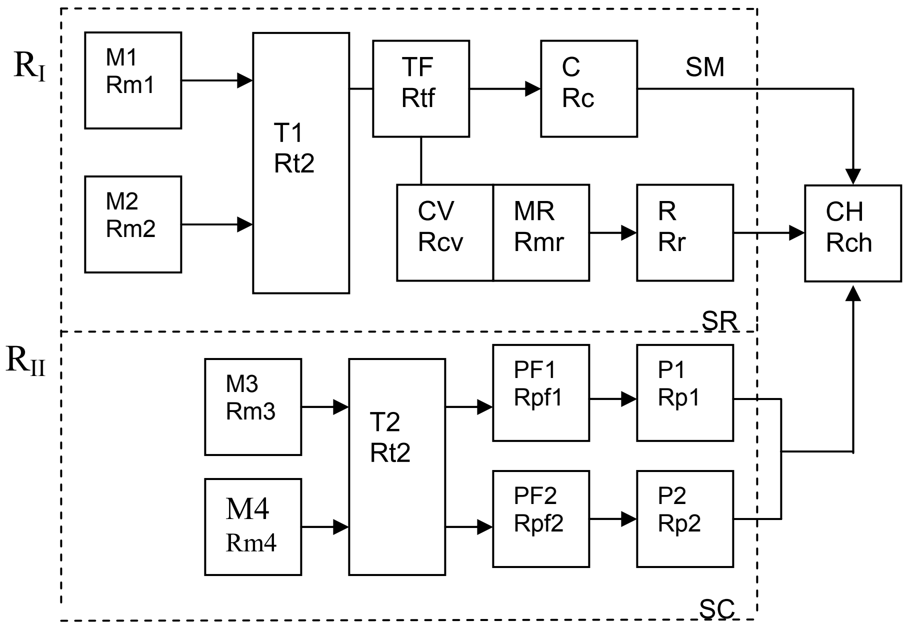

Chart 4. Logistic model of mixed operating mode1 (M1)

The total reliability function R_{M1} is calculated considering R_I and R_{II} shunted together, and the result concatenated with Rch is:

$$R_{M1} = [1-(1-R_I)(1-R_{II})] \cdot Rch \qquad (4)$$

where:

$R_I = Rm12 \cdot Rt \cdot Rtf\text{-}c\text{-}r$

$R_{II} = Rm3 \cdot Rt2 \cdot [1-(1-Rpf1 \cdot Rp1)(1-Rpf2 \cdot Rp2)]$

the variables' values are already known.

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Thus, there appears mechanical gearing T2 (only for SC), given the fact that T has been replaced by T1 whose complexity decreased due to the removal of chain PF1-P from G2 and its transfer to M1.

Similarly there can be analysed an alternative structure for the mixed operating mode, configuration 2, called mixed 2 (M2). Within this structure SR is completely separated from SM and SC, which operate on high power.

As regards the physical charateristics of the main operating systems, complete separation can be distinguished as a design variant, so that each main operating system should work autonomously. That leads to a general approach to each operating system in such a way that every system's module is analysed. (*Chart 5*).

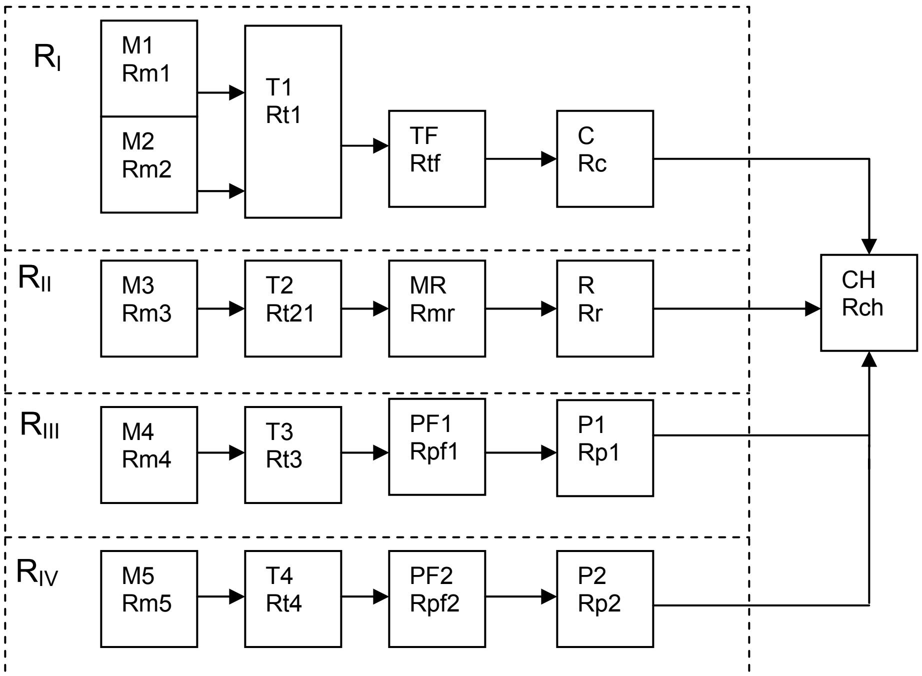

Chart 5. Logistic model of autonomous operating mode (IND)

The total reliability function R_{IND} is calculated considering R_I and R_{II} shunted together, and the result concatenated with Rch is:

$$R_{IND} = [1-(1-R_I)\cdot(1-R_{II})\cdot(1-R_{III})\cdot(1-R_{IV})]\cdot Rch \quad (5)$$

where:

$R_I = (1-(1-Rm1)\cdot(1-Rm2))\cdot Rt1\cdot Rtf\cdot Rc$

$R_{II} = Rm3\cdot Rt2\cdot Rm\cdot Rr$

$R_{III} = Rm4\cdot Rt3\cdot Rpf1\cdot Rp1$

$R_{IV} = Rm5\cdot Rt4\cdot Rpf2\cdot Rp2$

the variables' values are already known.

The logistic models thus obtained can allow us to carry out simulations useful to the design of safe and efficient systems, enhancing their performances. The system functions (R) contained by the models described above can be continuous or discrete or signal functions (known logistic functions or chance number generating functions following various distributions simulated by means of the programming mode (MathCad)) and will replace block functions (R) within computer-assisted simulation.

This software package provides the user with a complete series of probability distributions with continuous or discrete variation and the chance number generators distributed according to the corresponding partition law.

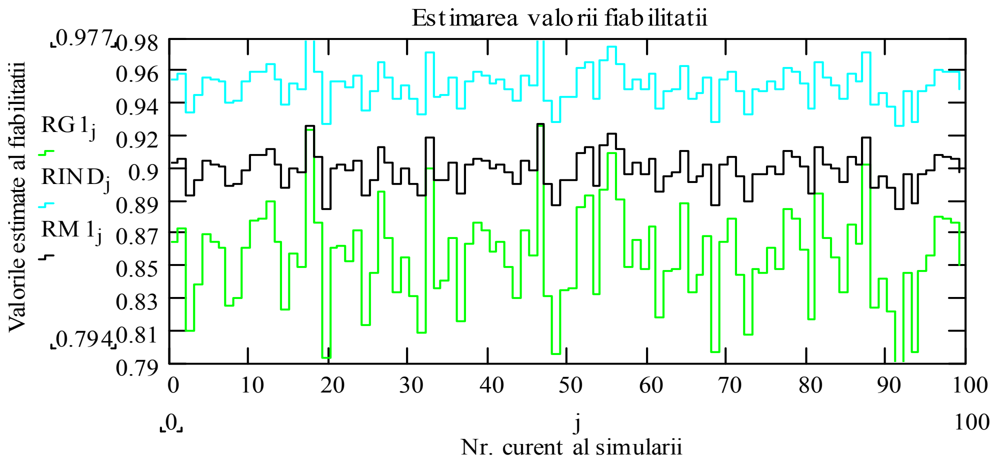

Chart 6. Types of probability distributions and the corresponding chance number gene

The partition law WEIBULL adapts to the reliability study of technological plants during their running, when failures occur mainly because of the plant's runout and/or ageing. The NORMAL partition law adapts to the various technical systems whose failures occur because of a great number of factors, which generally lead to materials' wear and breakage.

Conclusions

In (*Chart 6*) are presented three logistic models (G1, IND and M1, whose graphs are displayed in descending order) of reliability analysis and numerical simulation for a drilling plant. The average values of reliability indicators are displayed in ascending order (see the distribution of values on graphs).

The author proposes that the method should be also applied for the other operating modes of drilling plants which were mentioned taking into account their characteristics.

The main contribution this article makes is the introduction of logistic models in the calculation of complex systems' reliability (drilling plants or production installations).

In order to carry out some purely logistic comparative analyses of finding the optimal operating mode, the designer may choose his own values for simulation so that he could decide which of the operating modes leads to a convenient value of reliability according to the number of elements taken into account and their grouping mode.

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