Nest Lab

THE FIRST LABORATORY FOR ROBOTIZED
OIL FIELD DEVELOPMENT

CHALLENGE

Nest Lab

1. HOW MANY PRODUCTION LOSSES ARE THERE NOW?

REDUCED PUMP RATE

PLAN

Q_{oil}
WELL 1

NEW PLAN
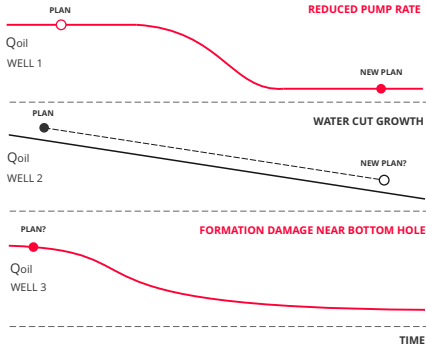
AT THE STAGE OF GENERATING PRODUCTION
PLAN VALUES, LOSSES CAN BE ASSUMED
AS NORMAL WELL OPERATING CONDITIONS.

WATER CUT GROWTH

PLAN

Q_{oil}
WELL 2

NEW PLAN?

THERE IS NO SYSTEMATIC APPROACH
TO PLANNING PRODUCTION PARAMETERS
FOR BASE PRODUCTION WELLS.

FORMATION DAMAGE NEAR BOTTOM HOLE

PLAN?

Q_{oil}
WELL 3

HOW TO ESTABLISH PLAN VALUES
CORRECTLY FOR ADDITIONAL
PRODUCTION AFTER APPLYING
WELL INTERVENTION TECHNIQUES?

TIME

CHALLENGE

2. COMMON ALGORITHMS AND ANALYSES FOR ALL WELLS

Normal and abnormal well operation is defined by the same percent of deviation for any parameter.

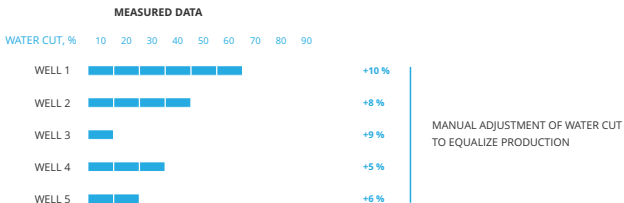| MAIN PARAMETERS	FACTORS INDIVIDUALIZING WELL DEVIATIONS		
LIQUID RATE	GAS IMPACT	TENDENCY TOWARDS PROCESS LOSSES	
WATER CUT	TENDENCY TOWARDS EMULSIFICATION	KIND OF FLOODING	
BOTTOM HOLE PRESSURE	ANNULAR PRESSURE	RESERVOIR PRESSURE MAINTENANCE SYSTEM	TENDENCY TOWARDS SKIN LAYER GENERATION

The same percent of deviation for all wells?

CHALLENGE

3. TIME-CONSUMING PROCESS OF INPUT DATA VERIFICATION AND APPROVAL, WITH AVERAGE METER FACTORS* OF 0.85-0.9

MEASURED DATA

WATER CUT, %   10 20 30 40 50 60 70 80 90

WELL 1		+10 %
WELL 2		+8 %
WELL 3		+9 %
WELL 4		+5 %
WELL 5		+6 %

MANUAL ADJUSTMENT OF WATER CUT
TO EQUALIZE PRODUCTION

As a result, input data for the subsequent development analysis are distorted.

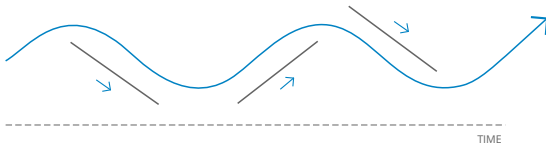How accurate will be analyses applied?

*METER FACTOR IS A RATIO OF ACTUALLY PRODUCED OIL TO MEASURED OIL

:: Nest Lab

4. CONTINUOUS VARIATION OF PARAMETERS

Local and systematic variations in well operation can be hard to differentiate from amplitude fluctuation of parameters typical for this well.

WATER CUT DYNAMICS, %

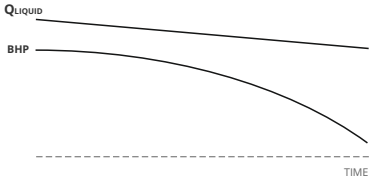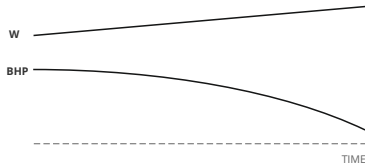Is there water cut growth?

TIME

5. PRODUCTION CAN DECREASE DUE TO A NUMBER OF REASONS. DIFFERENTIATING THESE PRODUCTION LOSSES AND FINDING A COMPREHENSIVE SOLUTION IS A CHALLENGE

REDUCED PUMP FLOW RATE AND LOWER RESERVOIR PRESSURE.

FORMATION DAMAGE NEAR THE BOTTOMHOLE AND INCREASED WATER CUT.

Which production losses are the most significant?

What shall be applied to the well?

CHALLENGE

6. THERE IS A CHANGE OF VOIDAGE REPLACEMENT RATIOS TODAY, AND TOMORROW YOU HAVE PRODUCTION LOSSES. POTENTIAL LOSSES.

SURROUNDING PRODUCTION WELLS REACT TO VOIDAGE REPLACEMENT RATIO MODIFICAITON IN DIFFERENT WAYS.

VOIDAGE REPLACEMENT DYNAMICS FOR A CELL, %

TIME
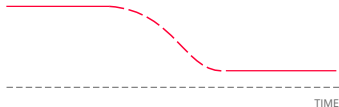
ABSENCE OF DAILY ANALYSES OF VOIDAGE REPLACEMENT LEADS TO LATE REGISTRATION OF PRODUCITON LOSSES

IMPACT OF WELLS ON ONE ANOTHER IS NOT ESTIMATED EMPIRICALLY IN EACH CASE.

BOTTOM HOLE PRESSURE, mpa   **WELL 1**

TIME

BOTTOM HOLE PRESSURE, mpa   **WELL 2**
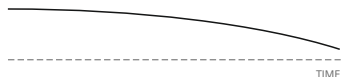
TIME

WATER CUT, %   **WELL 3**

TIME

7. NOT ACCURATE AND NOT TIMELY MPR (MONTHLY PRODUCTION REPORT)

You have to wait for the monthly closing to define geological losses which are underway now, and to select the relevant well intervention techniques.
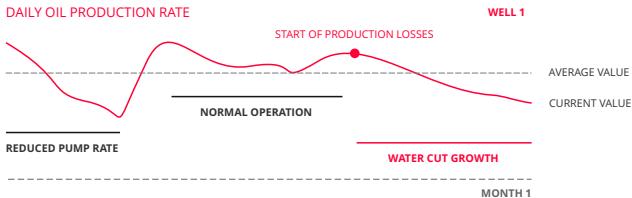
During MPR calculation, mean values may be distorted due to the impact of stabilization intervals and intervals with process losses.

SOLUTION

ROBOTIZED OILFIELD DEVELOPMENT (BIG DATA)

Nest provides a solution for geologists and oil field operating companies. In a few clicks
and seconds it finds wells with production losses, defines their amounts, time and reasons
of appearance, and, most importantly, it proposes ready solutions: what is required
to do and which wells shall be involved in order to increase
or maintain oil production rates. All Nest solutions
are customized for individual well parameters.

Nest has been tested on 3 real fields. The result is the following:

70%	105	63
OIL PRODUCTION INCREASE	KTONS OF EXTRA OIL PRODUCED	WELL INTERVENTIONS

SOLUTION

THE ESSENCE OF INNOVATION

DIFFERENCES OF **"360 DEGREES"**

Nest*

Analogues

ARTIFICIAL INTELLIGENCE

Nest Lab

CUSTOMIZED APPROACH TO WELLS

PROCESSES ROBOTIZATION

DEVELOPMENT AUTOMATION

RESULT

PROCESS

ROBOTIC DEVELOPMENT

100% HUMAN FACTOR

COMMON FILTERS AND ALGORITHMS
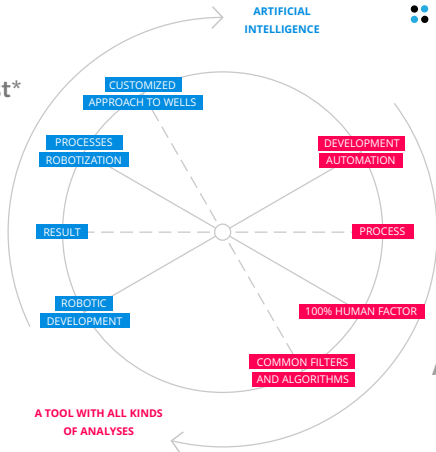
A TOOL WITH ALL KINDS OF ANALYSES

SOLUTION

Nest provides recommendations using rationale logic.

Robotic customized approach includes using algorithms capable of returning to the software source code when new experience (BIG DATA) is accumulated, and tailor the approaches to meet the requirements of the exact wells.

Evolution of oilfield development software

AUTOMATION, ANALYSIS TOOLS	>	ANALYSIS ROBOTIZATION	>	ROBOTIZATION WITH A CUSTOMIZED APPROACH	=	ARTIFICIAL INTELLIGENCE
		Nest 2014		Nest 2015		Machine learning

Examples of software solutions: Avocet, Avocet Surveillance, Avocet IAM, OFM (all SLB), DecisionSpace Production Monitoring (Landmark)

Many tasks of reservoir and production engineers are replaced with robotization

The software makes assumptions customized for each well, based on empirical data (BIG DATA). Reservoir and production engineers do not have enough time for such detailed analysis even for not too many wells.

Examples of customized approach:
Customized % to determine well performance anomalies, calculated impact of each well on other wells for each cell of the field during flooding.

SOLUTION

Nest Lab

Nest answers the question "**What to do?**", but it doesn't answer the question "**How to do it**?". That's why Nest in no way influences well operations. Nest is a support tool for reservoir and production engineers. It saves a significant amount of time both for real-time solutions in case of unexpected production anomalies, and for long-term solutions.

Production Lifecycle Management

A reply to the question "What to do for a well?"

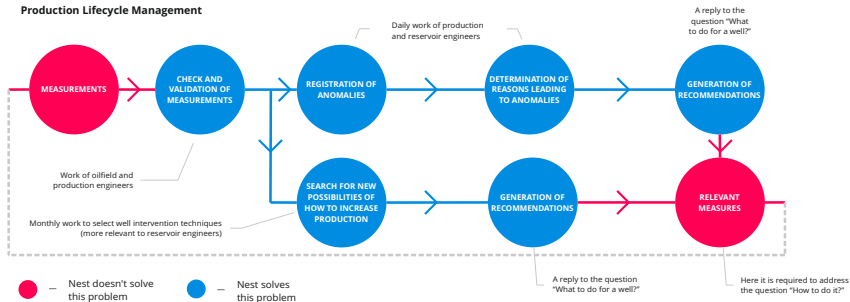Daily work of production and reservoir engineers

MEASUREMENTS → **CHECK AND VALIDATION OF MEASUREMENTS** → **REGISTRATION OF ANOMALIES** → **DETERMINATION OF REASONS LEADING TO ANOMALIES** → **GENERATION OF RECOMMENDATIONS**

Work of oilfield and production engineers

SEARCH FOR NEW POSSIBILITIES OF HOW TO INCREASE PRODUCTION → **GENERATION OF RECOMMENDATIONS** → **RELEVANT MEASURES**

Monthly work to select well intervention techniques (more relevant to reservoir engineers)

A reply to the question "What to do for a well?"

Here it is required to address the question "How to do it?"

● — Nest doesn't solve this problem   ● — Nest solves this problem

SOLUTION

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INPUT DATA

WELL TESTS

MPRs*

GLR**

CONTOUR LINES COORDINATES

RESERVOIR CHARACTERISTICS

LAYER INTERSECTION COORDINATES

DAILY MEASUREMENTS

WELL DESIGN

WELL REPAIRS

PERFORATED INTERVALS

*MPRs - MONTHLY PRODUCTION REPORTS

**GLR - GEOPHYSICAL LOGS RESULTS

SOLUTION

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Data loading diagram

Downhole telemetry systems

I. DAILY MEASUREMENTS
(AUTOMATIC LOADING)

Database administrator

→ Wells
→ Well development areas
→ Formations

Interrelation tables

→ Liquid production / Water injection
→ Bottom hole pressure
→ Operation time
→ Water cut

Daily measurements of production /
injection wells operating parameters

Chemical analysis laboratory

Flow test company

→ Operation parameters of well pumps
→ Injected agents properties
→ Inflow profile, intake profile studies
→ Flow tests results

Data per field development

Dynamic data

Service company

Well log company

II. RESEARCH AND INTERVENTIONS
(ENTERED BY PARTNER COMPANIES)

→ Underground and capital well repairs
→ Study of condition and quality of well cementing
→ Well perforation intervals

Technical data per wells

Drilling company

→ Layers intersection coordinates
→ Results of well logging interpretation
→ Well construction
→ Contour coordinates

Geological data per wells

Technical data per wells

Data per pay zones

Static data

III. MODELS
(EXPORTED BY RESERVOIR ENGINEERS)

Geological model

Hydrodynamic model

→ Maps of porosity, thickness, oil content
→ Geological and physical characteristics of developed areas
→ Monthly operating reports of production / injection wells
→ Production / injection wells operating mode
→ Maps of current "kh"

Data per pay zones

Data per developed areas

Data per field development

Calculated data

Nest Database

SOLUTION

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Missing data. Nest target values and data to be loaded
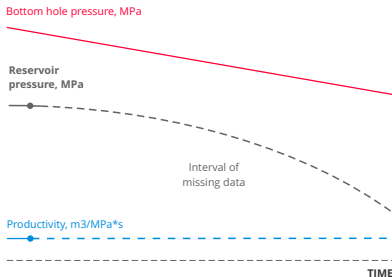
	1 LEVEL	2 LEVEL	3 LEVEL	4LEVEL
PRODUCTION / INJECTION DISTRIBUTION PER FORMATIONS	INFLOW / INJECTIVITY PROFILES	WELL LOG INTERPRETATION DATA	SURROUNDING WELLS	
IMPACT OF INJECTION WELLS	TRACER INVESTIGATIONS	DETERMINATION OF CORRELATION	COMPARATIVE ANALYSIS	
UP-TO-DATE MAPS OF CURRENT RESERVES	HYDRODYNAMIC MODEL	DISPLACEMENT AND COVERAGE MAPS		
RESERVOIR PRESSURE AND SKIN FACTOR DYNAMICS	FLOW TESTS	OPERATIONAL DATA AND INFLOW FORMULAE *	ANALYSIS OF VOIDAGE REPLACEMENT VARIATION	
RESERVOIR PROPERTIES	WELL LOG INTERPRETATION DATA	FLOW TESTS	OPERATIONAL DATA AND INFLOW FORMULAE	SURROUNDING WELLS

IF DURING DATA LOADING IT TURNS OUT THAT SOME FIRST-ORDER (FIRST-LEVEL) DATA ARE MISSING, THE NEST ALGORITHM WILL REFER TO THE SECOND-ORDER (SECOND-LEVEL) DATA AND DATA OF SUBSEQUENT ORDERS (LEVELS).

* - IN SOME CASES, NEST CAN COMPENSATE FOR THE MISSING DATA OF A LEVEL (**SEE AN EXAMPLE ON THE NEXT SLIDE**)

SOLUTION

Definition of reservoir pressure dynamics

IF DATA OF ONE OF THE LEVELS ARE MISSING, VALUES CAN BE DETERMINED BY NEST FROM THE DYNAMICS OF SECONDARY AFFECTING FACTORS.
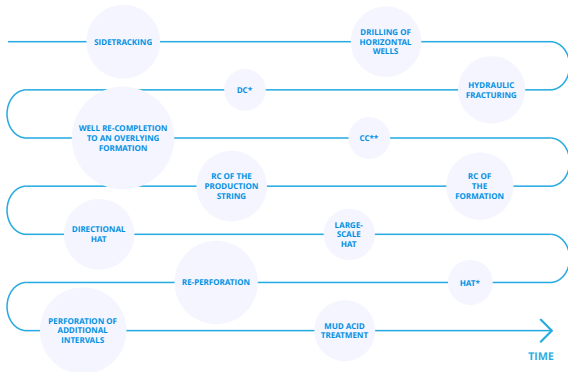
E.G. IF THERE ARE NO FLOW TESTS, AND ONLY PART OF OPERATIONAL DATA (PRODUCTIVITY), NEST WILL FIRST DETERMINE THE MISSING OPERATIONAL DATA USING A SPECIAL ALGORITHM, AND THEN WITH THE OBTAINED DATA AND WITH DUE REGARD TO ACCUMULATED HISTORY OF VOIDAGE REPLACEMENT VARIATION (THIRD LEVEL) IT WILL CALCULATE THE VARIATION OF RESERVOIR PRESSURE.

Bottom hole pressure, MPa

Reservoir pressure, MPa

Interval of missing data

Productivity, m3/MPa*s

TIME

SOLUTION

OUTPUT DATA

SIDETRACKING

DRILLING OF HORIZONTAL WELLS

DC*

HYDRAULIC FRACTURING

WELL RE-COMPLETION TO AN OVERLYING FORMATION

CC**

RC OF THE PRODUCTION STRING

RC OF THE FORMATION

DIRECTIONAL HAT

LARGE-SCALE HAT

RE-PERFORATION

HAT*

PERFORATION OF ADDITIONAL INTERVALS

MUD ACID TREATMENT

TIME

FOR MAXIMUM EFFICIENCY, NEST WILL DISTRIBUTE THE SELECTED WELL INTERVENTION TECHNIQUES THROUGH TIME, BASED ON THE CURRENT STATE OF WELL DEVELOPMENT.
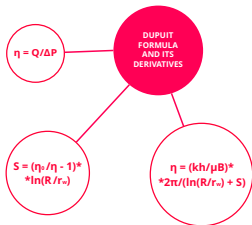
*DC - DUAL COMPLETION

**CC - CONFORMANCE CONTROL

***HAT – HYDROCHLORIC ACID TREATMENT
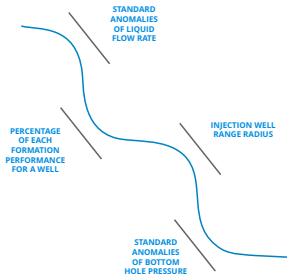
SOLUTION

Nest Lab

ASSUMPTIONS

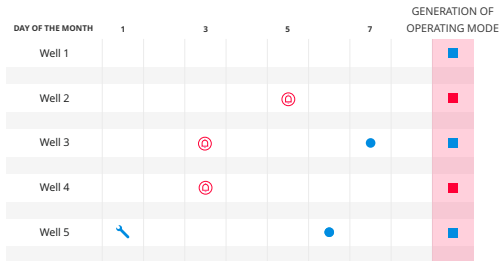Nest uses all main types of algorithms: linear, branching, cyclic ones, combined.

Some assumptions made by Nest remain unchanged:

Examples of assumptions subject to continuous adjustments depending on the peculiarities of each well:

$\eta = Q/\Delta P$

DUPUIT FORMULA AND ITS DERIVATIVES

$S = (\eta_2/\eta - 1)* *\ln(R/r_w)$

$\eta = (kh/\mu B)* *2\pi/(\ln(R/r_w) + S)$

STANDARD ANOMALIES OF LIQUID FLOW RATE

INJECTION WELL RANGE RADIUS

PERCENTAGE OF EACH FORMATION PERFORMANCE FOR A WELL

STANDARD ANOMALIES OF BOTTOM HOLE PRESSURE

SOLUTION

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1. FLEXIBLE PLANNING WITH DUE REGARD TO THE STATE OF WELLS AND PRODUCTION LOSSES

DAY OF THE MONTH	1		3		5		7	GENERATION OF OPERATING MODE
Well 1								■
Well 2					◎			■
Well 3			◎				●	■
Well 4			◎					■
Well 5	🔧					●		■

1. NEST WILL DEFINE THE STATE OF WELLS

2. FIND THE CAUSES OF WELL PARAMETERS VARIATION: PROCESS OR GEOLOGICAL ONES

3. PREPARE AND UPDATE NEW PLAN PARAMETERS FOR WELLS WITH PROCESS VARIATIONS

4. UPDATE PLAN PARAMETERS FOR WELLS WITH GEOLOGICAL VARIATIONS IN A FLEXIBLE WAY (UPON THE END OF THE VARIATION CYCLE OF WELL OPERATING PARAMETERS)

● UPDATING PARAMETERS AS PER GEOLOGICAL PLAN   ■ UPDATING PARAMETERS AS PER PROCESS PLAN   🔧 WELL INTERVENTIONS
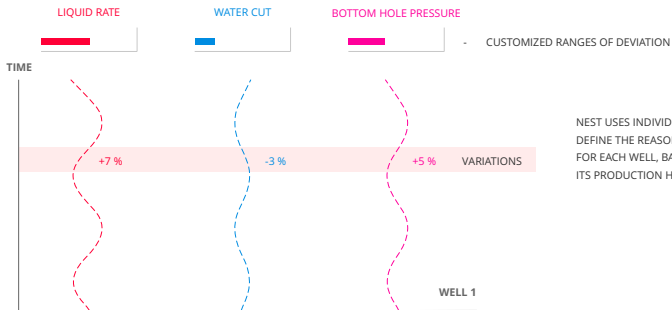
◎ START OF PRODUCTION LOSSES   ■ PREVIOUS PLAN OPERATING PARAMETERS REMAIN

SOLUTION

2. CUSTOMIZED APPROACH TO EACH WELL

Based on production history, Nest assigns custom ranges of each parameter deviation for each well.

LIQUID RATE   WATER CUT   BOTTOM HOLE PRESSURE

- CUSTOMIZED RANGES OF DEVIATION

TIME

+7 %   -3 %   +5 %   VARIATIONS

NEST USES INDIVIDUAL CRITERIA TO DEFINE THE REASONS OF LOSSES FOR EACH WELL, BASED ON ITS PRODUCTION HISTORY.
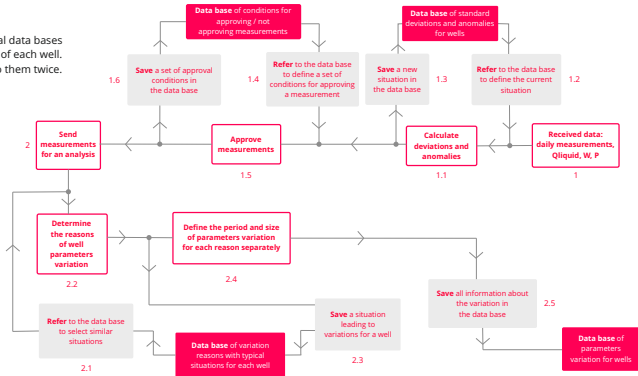
WELL 1

SOLUTION

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A fragment of algorithms customization diagram for wells

Nest algorithm creates special data bases
for individual peculiarities of each well.
It refers to them twice.

Data base of conditions for approving / not approving measurements

Data base of standard deviations and anomalies for wells

Save a set of approval conditions in the data base — 1.6

Refer to the data base to define a set of conditions for approving a measurement — 1.4

Save a new situation in the data base — 1.3

Refer to the data base to define the current situation — 1.2

Send measurements for an analysis — 2

Approve measurements — 1.5

Calculate deviations and anomalies — 1.1

Received data: daily measurements, Qliquid, W, P — 1

First, to define what is going on with
a well based on its historical data.

Determine the reasons of well parameters variation — 2.2

Define the period and size of parameters variation for each reason separately — 2.4

Then, to register a new situation.

Refer to the data base to select similar situations — 2.1

Save a situation leading to variations for a well — 2.3

Save all information about the variation in the data base — 2.5

Data base of variation reasons with typical situations for each well

Data base of parameters variation for wells

SOLUTION
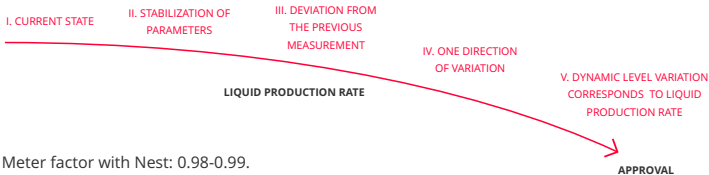
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3. ROBOTIZED CHECK AND APPROVAL OF INPUT DATA

Multi-stage process including over 10 steps to verify each parameter.
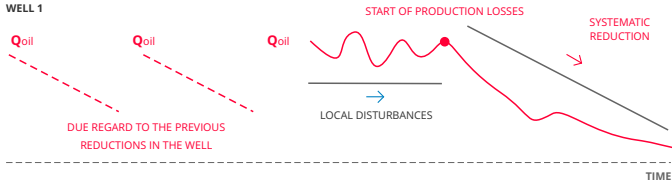
MAIN VERIFYING BLOCKS

I. CURRENT STATE

II. STABILIZATION OF PARAMETERS

III. DEVIATION FROM THE PREVIOUS MEASUREMENT

IV. ONE DIRECTION OF VARIATION

V. DYNAMIC LEVEL VARIATION CORRESPONDS TO LIQUID PRODUCTION RATE

LIQUID PRODUCTION RATE

Meter factor with Nest: 0.98-0.99.

APPROVAL

CUSTOMIZED ALGORITHMS APPLIED TO EACH WELL.

SOLUTION

4. ANY GRAPH BEHAVIOR WILL BE FOLLOWED BY AN IMMEDIATE EXPLANATION

Nest will define bending points (start of performance deterioration) in the graph.

WELL 1

Q_{oil}

Q_{oil}

Q_{oil}

START OF PRODUCTION LOSSES

SYSTEMATIC REDUCTION

DUE REGARD TO THE PREVIOUS REDUCTIONS IN THE WELL

LOCAL DISTURBANCES

TIME

Nest will define if there have been previous intervals of losses with the same cause.

☑ **CUSTOMIZED ALGORITHMS APPLIED TO EACH WELL.**

SOLUTION

5. ROBOTIZED DISTRIBUTION OF PRODUCTION LOSSES AS PER THEIR REASONS AND AS PER FORMATION LAYERS

Nest selects a comprehensive solution to eliminate simultaneously occurred losses.

I. WATER CUT GROWTH

II. REDUCED PUMP RATE

CURRENT PRODUCTION LOSSES

PAST LOSSES FROM HISTORY

SQUARE DIAGRAM OF PRODUCTION LOSSES REASONS

WELL 1

III. FORMATION DAMAGE NEAR BOTTOM HOLE

IV. REDUCED FORMATION PRESSURE

CURRENT PRODUCTION LOSSES
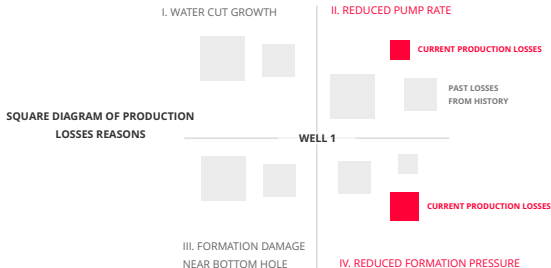
NEST:

1. DIFFERENTIATES PRODUCTION LOSSES

2. ANALYZES THE HISTORY OF LOSSES AND THEIR REMEDIES

3. DEFINES THE ORDER OF LOSSES REMEDIES

4. PROPOSES A SOLUTION

CUSTOMIZED ALGORITHMS APPLIED TO EACH WELL.

SOLUTION

6. ROBOTIZED MONITORING OF VOIDAGE REPLACEMENT RATIOS

Nest ensures continuous control of voidage replacement in field cells and recommends its more accurate distribution.

IMPACT OF WELLS ON ONE ANOTHER IS
DEFINED EMPIRICALLY, AND IT IS
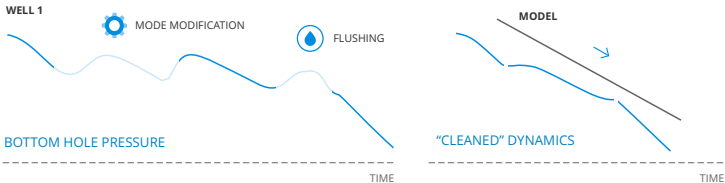A CUSTOMIZED VALUE FOR EACH
CELL OF THE COMPANY'S FIELDS
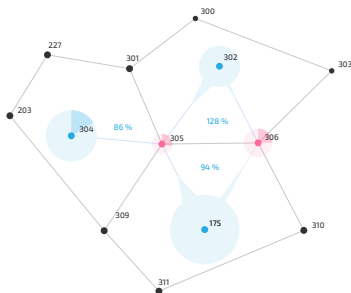
☑ **CUSTOMIZED ALGORITHMS APPLIED TO EACH WELL.**

SOLUTION

7. USE OF DAILY DATA

Nest ensures quick decision-making for geological production losses without letting them grow.

WELL 1

MODE MODIFICATION

FLUSHING

BOTTOM HOLE PRESSURE

TIME

MODEL

"CLEANED" DYNAMICS

TIME

Nest "cleans" the dynamics of parameters (liquid flow rate, water cut, bottom hole pressure, dynamic level) from process losses and stabilization phase of parameters.

SOLUTION

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PROBLEMS

1 GENERATING PRODUCTION PLAN VALUES.

2 COMMON ALGORITHMS AND ANALYSES FOR ALL WELLS.

3 VERIFICATION AND APPROVAL OF INPUT DATA.

4 CONTINUOUS VARIATION OF PARAMETERS.

5 LOWER PRODUCTION DUE TO A NUMBER OF REASONS.

6 POTENTIAL PRODUCTION LOSSES.

7 NOT ACCURATE AND NOT TIMELY MPR.

NEST SOLUTIONS

«FLEXIBLE PLANNING WITH DUE REGARD TO THE STATE OF WELLS AND PRODUCTION LOSSES»

«CUSTOM APPROACH TO WELLS»

«ROBOTIC VERIFICATION AND APPROVAL OF INPUT DATA»

«ANY GRAPH BEHAVIOR WILL BE FOLLOWED BY AN IMMEDIATE EXPLANATION»

«ROBOTIC DISTRIBUTION OF LOSSES AS PER REASONS AND FORMATION LAYERS»

«ROBOTIC MONITORING OF VOIDAGE REPLACEMENT RATIO»

«APPLICATION OF DAILY DATA»

VALUE PROPOSITION COMPETITORS

Nest Lab

1. SCOPE

Nest has not been developed to deal with single details, it embraces the whole picture. Due to this Nest is sensitive to the mutual impact of anomalies, and it understands complicated (and sometimes concealed) impact of new and previous measures on the surrounding wells.
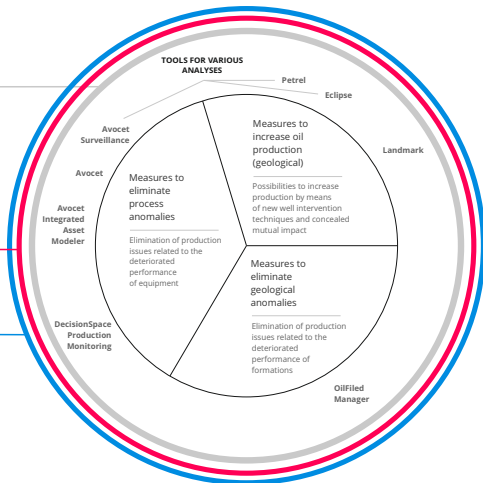
The software which partly (only as per process anomalies) deals with concealed mutual impact in production history: Avocet Workflow Manager

2. ROBOTIZATION

Nest provides an independent analysis and generates properly justified recommendations.
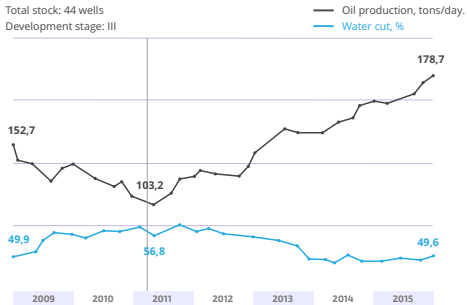
3. CUSTOMIZATION

Nest reveals individual properties of wells throughout all their history and modifies its own algorithm adjusting to the peculiarities of individual wells.

TOOLS FOR VARIOUS ANALYSES

Petrel

Eclipse

Landmark

OilFiled Manager

Avocet Surveillance

Avocet

Avocet Integrated Asset Modeler

DecisionSpace Production Monitoring

Measures to eliminate process anomalies

Elimination of production issues related to the deteriorated performance of equipment

Measures to increase oil production (geological)

Possibilities to increase production by means of new well intervention techniques and concealed mutual impact

Measures to eliminate geological anomalies

Elimination of production issues related to the deteriorated performance of formations

RESULT

NEST OPERATION RESULT

OILFIELD 1

Total stock: 44 wells
Development stage: III

— Oil production, tons/day.
— Water cut, %

152,7

178,7

103,2

49,9

56,8

49,6

2009   2010   2011   2012   2013   2014   2015

START OF APPLYING THE SELECTED WELL INTERVENTION TECHNIQUES

Nest lab has selected

53 WI

Daily oil production growth

▲ **73,1 %**

75,5 tons/day

91 440,3

Tons of extra oil produced

CUSTOMERS

Nest Lab

To use Nest, you need to purchase an annual license which includes:

DATA BASE CREATION*

*Information about fields is united to create an initial data base for Nest

CUSTOMER SUPPORT

UPDATES

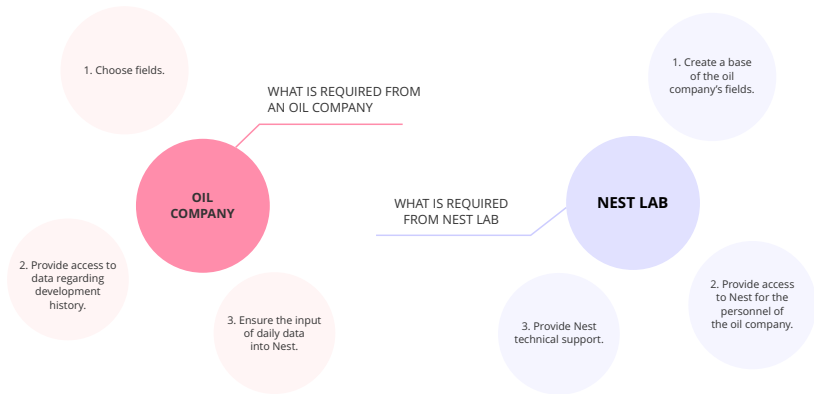Potential customers of Nest Lab:

OPERATORS

SERVICE PROVIDERS**

**Providing services for the selection of well intervention techniques and improvement of field development system

R&D CENTERS**

INTERFACE

1. Choose fields.

WHAT IS REQUIRED FROM
AN OIL COMPANY

**OIL
COMPANY**

2. Provide access to
data regarding
development
history.

3. Ensure the input
of daily data
into Nest.

WHAT IS REQUIRED
FROM NEST LAB

NEST LAB

1. Create a base
of the oil
company's fields.

2. Provide access
to Nest for the
personnel of
the oil company.

3. Provide Nest
technical support.

COMPANY

NEST LAB PROFILE

NEST LAB WAS FOUNDED IN 2013.
THE HEADQUARTERS ARE IN UFA, RUSSIA.

ABOUT 30 PROFESSIONALS HAVE BEEN INVOLVED
IN THE CREATION OF NEST. CURRENTLY
THE HEADCOUNT OF THE COMPANY
IS 6 PEOPLE, MOSTLY PROGRAMMING
ENGINEERS.

THE CORE OF THE COMPANY IS MIKHAIL FOKIN
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Contact us to test customized approach to each well (BIG DATA solution) in your oilfield

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