Research Paper

A Model for Control the Paraffin Deposition in producing Oil Wells: An Oilfield in Libya.

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Abstarct: Based on the characteristics of Amal oilfield, a detailed analysis of production problems, as well as the latest literature findings has defined a model to achieve optimal oil production. It has been found that major problems at Amal oilfield are paraffin's deposition, sand production, inefficient operations of gas lift system, inefficient oil desalination and environmental issues. Production problems, individually or together at some oil wells, caused a decrease in oil production of *40%* up to *75%.* This model deals with solving production problems relates to the deposition of paraffins. It was necessary to take additional measures and actions in order to solve the production problems so that they could not become worse and cause further decrease in oil production. Regarding more efficient solution of the paraffin's deposition problems, it has defined a set of new actions that must be taken. It is necessary to optimise the quantity of additives used, together with the regular monitoring and control of the injection process. For that reason, analysis of the efficiency of injection of chemical inhibitors such as acid-trichlorethylene *(TEKS),* ethylene copolymers and combined polymers, are recommended. Also, the thermal method is proposed.

Keywords: Oilfield, control, paraffin deposition, Amal, a model, chemical inhibitors.

1. Introduction

1.1. Oil Field Description

Amal oilfield, or block NC12 is located 50 km north of Augila oasis in the eastern part of the Sirte Basin. Latitude and longitude are *29 ° 25 '0 N* and *21 ° 10' 0 E*. Oilfield consists of eight different reservoirs, which are located at a depth of about 3600 meters and it covers an area of more than *100,000* hectares. Amal oilfield was the leading oil producing field in Libya with an extensive production capacity. It was discovered in *1959*, with daily oil production was about *200 M bbl/d*. Up to date, about *226* oil wells have been drilled of which *122* oil wells were in production, while 58 wells occasionally do not work due to compressor downtime or for workover. Around 104 wells, which are not in function for a longer period of time because of low oil production, are shut off. At present, the average oil production now is about *19000 bbl/d*, consequently, this has also had a negative impact on the country's economy, since the product forms the organization of the country's export value **[1 - 3].** There has been an intensive development of oilfield over the past decades, when a large number of new wells were drilled. New collecting stations *8, 9,* and *10* have also been constructed. Production of oil is carried out mainly by means of Gas Lift.

Oil production in the Amal oilfield has been declining over the past *40* years. Experts have argued that various surface as well as subsurface problems that can be attributed to this decline. Action must be taken to mitigate or to completely stamp out these problems to avoid the risk of the decrease in the production of oil from Amal oil field. Wire line jobs as well as literatures, daily production reports and well test, all show the oil production decline in the field. Subsurface operations are not well treated as surface operations, did not find enough care and most of the work over programs were about *ESP* wells and formations collapse are not satisfied. The development programs over the past four decades have seen numerous wells drilled, but the field has not been improved in oil production. The life of the field after redevelopment *(2007)* was expected to be around *10-11* years with complete abandonment by *2017* **[4 - 5].**

Comparisons made for Amal oil wells test records indicate that the productivity of about thirty nine oil wells in the Amal oilfield declined by forty percent to eighty percent. Oil produced by Amal Wells has an *API* of between *36°* and *39°* and contains high wax, sulphur composition, salt and there are some wells producing with sour gas **[6]**. Amal oilfield is owned by a Harouge Oil Operations company, previously (Veba Oil Operations), **[7 - 8].**

1.2. Exploitation methods

At Amal oilfield, oil production is carried out predominantly by using mechanical methods of exploitation:

- Gas lift (continuous) and
- Electric Centrifugal pumps.
- Natural flow

Gas Lift Exploitation Method was applied at *88* wells, while Electric Centrifugal pumps are used for production at 27 wells *(Figure -1)* shows the representation of exploitation methods at Amal oilfield.

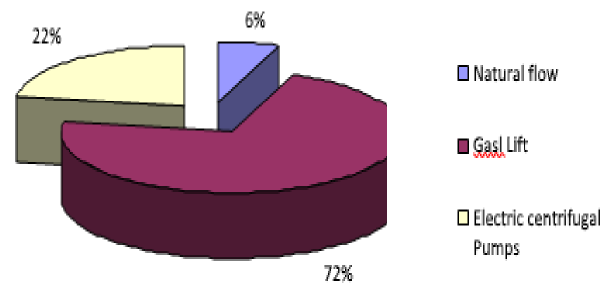

Figure - 1: Representation of exploitation methods at Amal oilfield

2. The method

Production problems require taking every day appropriate actions in order to solve them. Undertaken activities at the subsurface and surface equipment, as well as collection system at Amal oilfield with the aim of removing production problems are continually carried out, but they are insufficient and inadequate. The intensity of production problem is such that it requires the use of additional methods and activities, which will be defined in this paper. According to the analysis of oil production, it was specified that *39* wells had reduced oil production of *40-75 %.* Up to know, production problems become far worse and even cause a greater reduction in oil production. Key problems accompanying production process at Amal oilfield are:

- Deposition of paraffin.
- Accumulation of formation sand.
- Gas Lift System Operations.
- Deposition of salt and oil desalination
- Environmental problems.

On the other hand, this paper deals with the problem of parafffins deposition in the oilfield and how to control it.

2.1 Deposition of paraffin

Deposition of paraffin occurs in wells, especially in the upper part, also precipitates in pipelines. Problem of paraffin deposition in the down-hole can be solved by mechanical removal or application of chemical methods. Deposits of paraffin are very large and require a very fast action to remove it. The application of mechanical removal is inefficient and is reflected in a reduction in oil productivity. Also, because of the high intensity of the deposition the problems occur that require shutting off the wells or damage production equipment. The average pour temperature is *21,6^{o} C*. *Figure-2* Shows the temperature profile for two typical wells at Amal oilfield **[8].** Based on the pour point temperature, it can be seen that the precipitation begins at a depth between *500* and *530 m*, after which it intensifies with a further fall in temperature.

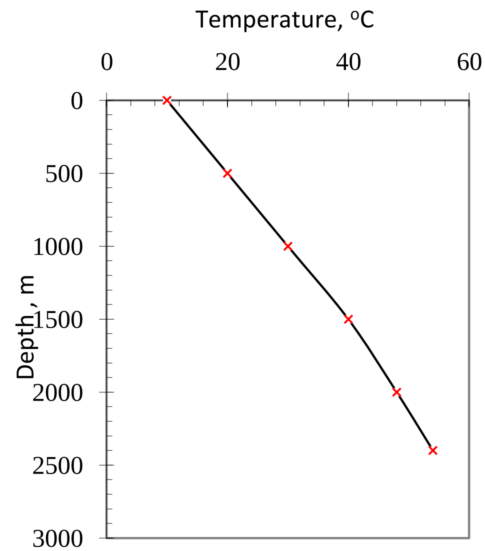

Figure-2 : Temperature profile of typical wells at oilfield Amal

Laboratory chemical analysis of paraffin layers, confirmed with a literary works **[9 - 13**], and found the following:

- Molecular diffusion occurs when the temperature of the crude oil flowing through the tubing and pipeline drops below the to the concentration gradient.
- Dispersion shear occurs when each paraffin molecule reacts with the surrounding paraffin molecules. Numerous impacts of molecules lead to the dispersion of paraffin particles in the flowing fluid.
- Thermally "agitated" molecules of crude oil continuously hit ("bombard") small and solid particles of the precipitated paraffin, which leads to the so called Braun's motion.

If the temperature of crude oil decreases below the wax appearance temperature *(WAT),* or sometimes called cloud point, the precipitation of the wax molecules occurs. *WAT* is the temperature where the first wax crystal begins to precipitate out from the crude oil. Deposition of heavy organics from crude oil has been studied in [**14 - 23].** If sufficient wax is deposited over time, portions of the production system, such as wellbores and flow lines, can become partially or totally blocked, thus having a significant impact on production efficiency. Paraffin deposits vary from pure white paraffin to one that is entirely consisting of asphaltenes. Molecules of paraffin deposits are present in the form of real and branched chain alkanes from $C_{18}H_{38}$ to $C_{38}H_{78}$ where branching depends on the hydrocarbon composition of the crude oil. Paraffins wax tend to precipitate in the crude oil due to decrease of the temperature and pressure in the wells and pipeline during the production process. During the deposition process, the paraffin molecules of low molecular weight at a given temperature and pressure become insoluble in the crude oil and are separated in the form of paraffin crystals. The precipitated paraffin molecules act as nucleating agents (crystallization) to paraffin molecules of greater molecular weight . These nucleation agents remain on the walls of tubing and pipeline or remain in crude oil in the form of dispersed paraffin crystals. When the temperature and pressure decrease, they lead to the additional precipitation of paraffin molecules of greater molecular weight in the crude oil and the formation and precipitation of the previously deposited layers of paraffin molecules, i.e. of the additional “sticking” to the walls of the tubing and the pipeline.Paraffin wax deposits are, by nature, chemically unreactive and insoluble in crude oil at the production conditions. The molecular weight of paraffinic compounds vary from *250* to about *550*. Paraffin deposits can also contain aromatic hydrocarbons, naphthenes, resins, asphaltenes, oils, water, sand and silt.

2.2 Paraffins deposition model for Amal Oilfield

Paraffin deposition problem at Amal oilfield has so far been partially successfully solved. For that reason the model is defined (Figure -3), which includes a set of actions that must be taken for its effective solution. Left side of the sub model (Figture -3) includes existing actions that are used in the oilfield and that is measuring the content of paraffin and the temperature of pour point. For the successful monitoring and solving these problems, these actions are insufficient as past practice has so far shown. For successful solving the problems of paraffin deposition effectively at Amal oilfield, it is necessary to undertake a whole range of new actions, as shown on the right side of the submodel (Figure-3). The necessary actions include determination of:

- Intensity of deposition,
- Temperature profile of the well
- The speed of the deposition.

Action related to the intensity of the precipitation of paraffin will enable the determined mass of precipitated paraffin to construct the curve of precipitated paraffin **[24].** The curve of precipitated paraffin is obtained by measuring the mass of paraffin deposition at different temperatures. At the diagram shown in (Figure -4). It can be seen that the process of crystallization of paraffin starts at a temperature of about *55 ℃*, followed by slow separation of paraffin, or its deposition. Intensive paraffin deposition begins at a temperature of *40* ^{o}C. Actions related to well temperature profile should provide the determination of values of the temperature along the well's column based on the temperature measurements in wells or calculating by some of simulation software.

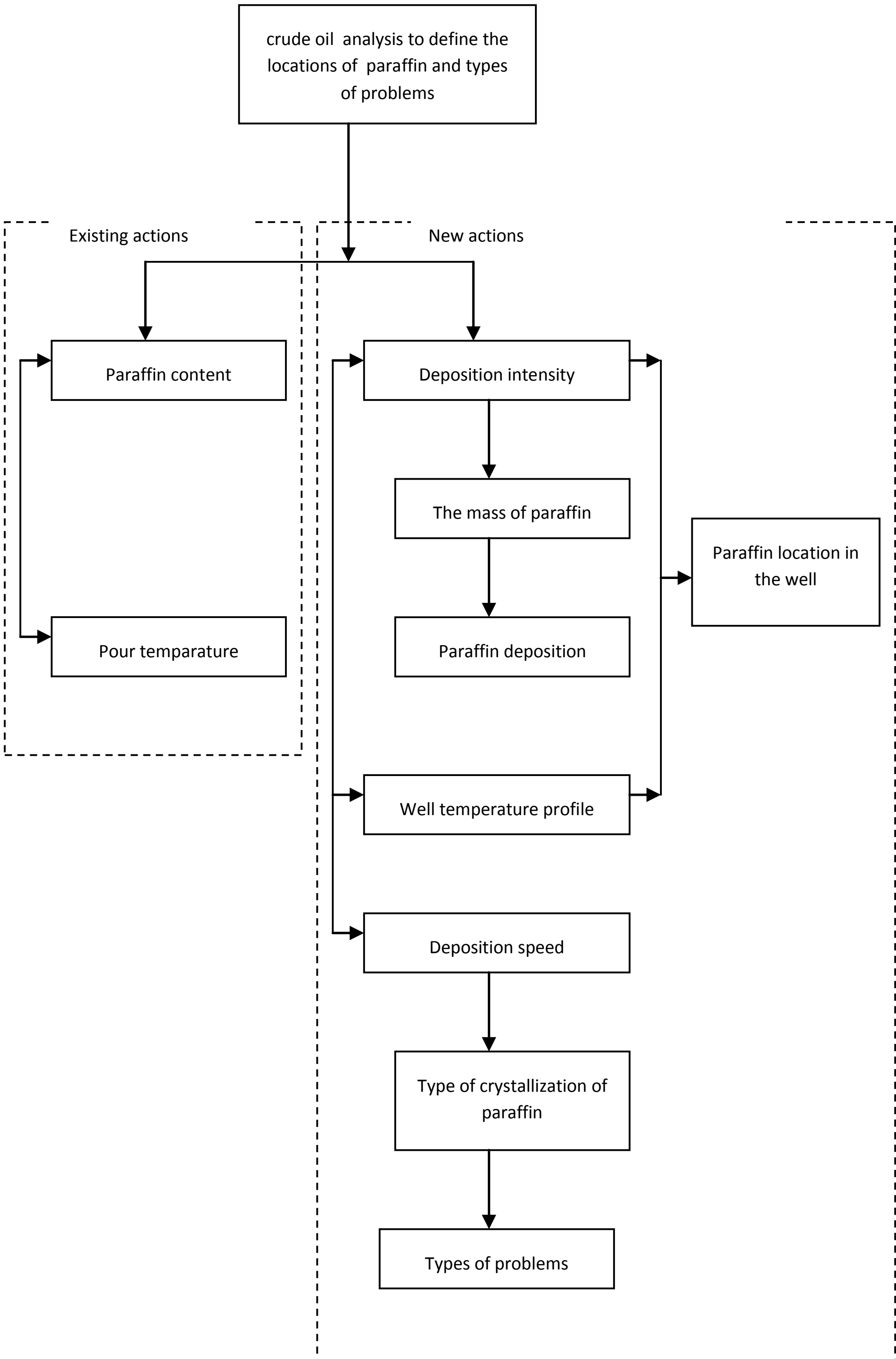

Figure- 3 : Analysis of the crude oil content in order to define the locations of paraffin deposition in the production system and the type of problem

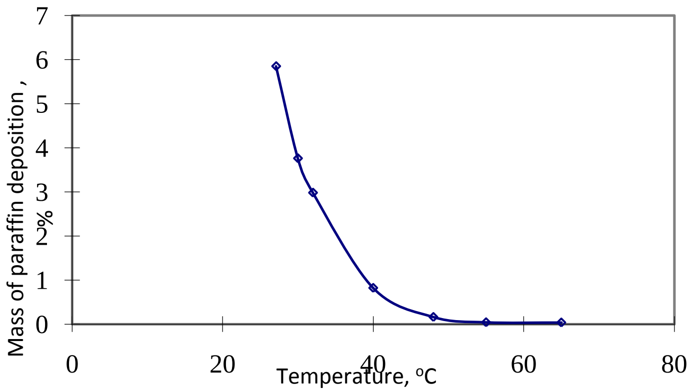

Figure - 4 : Paraffin deposition curve

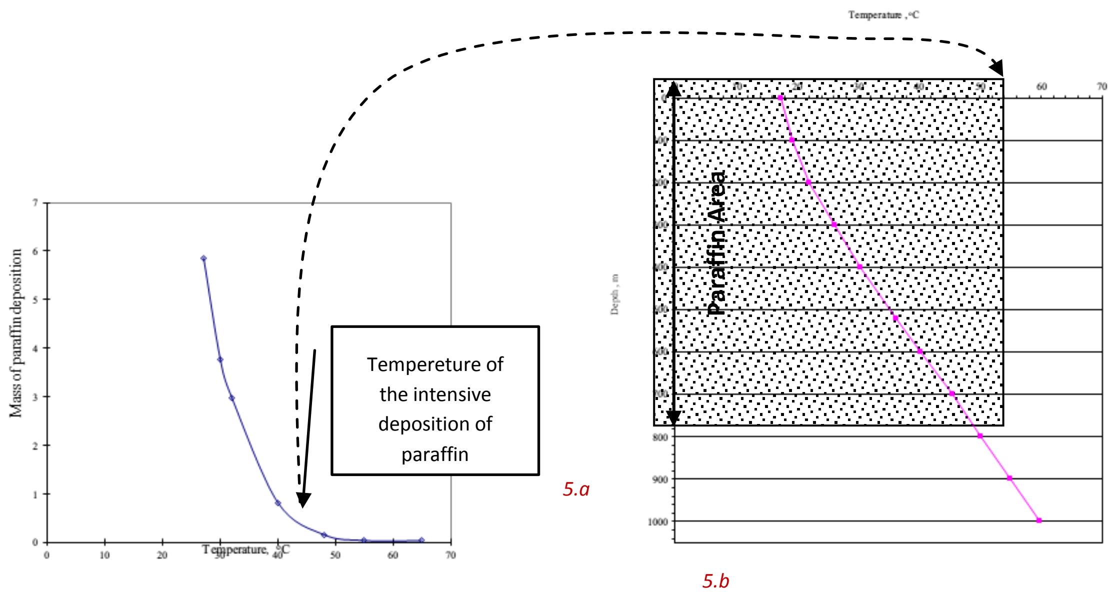

Figure- 5: The model for determination of the paraffin deposition location in the well ***[26].***

The previous two actions, the intensity of precipitation and temperature profile of the well, enable determination of the location of paraffin deposition in the well **[25 - 26**]. The method is illustrated in *(Figure -5).* First, the temperature of intensive paraffin deposition is determined (*Figure-5.a*). Then, the paraffin deposition locations are defined (*Figure- 5.b*) based on that value and the calculated decrease of temperature in the well. Action related to the speed of crystallization, allows the determination of the type of crystallization and the type of the problem **[27 - 33].** Crystallization speed directly affects the shape or type of paraffin crystals **[34 - 37].** Paraffins can crystallize in the form of needle-like, irregular, plate-like and microcrystals, (Figure -6), **[38 - 42].** Needle-shaped crystals have the ability of agglomeration unlike the microcrystals that do not express this characteristic. Therefore, microcrystals cause the least problems during the process. The shape of the crystals and their presence depend on the conditions under which they were formed: the degree of cooling, characteristics of the flow (laminar, turbulent) and the presence of other chemical elements.

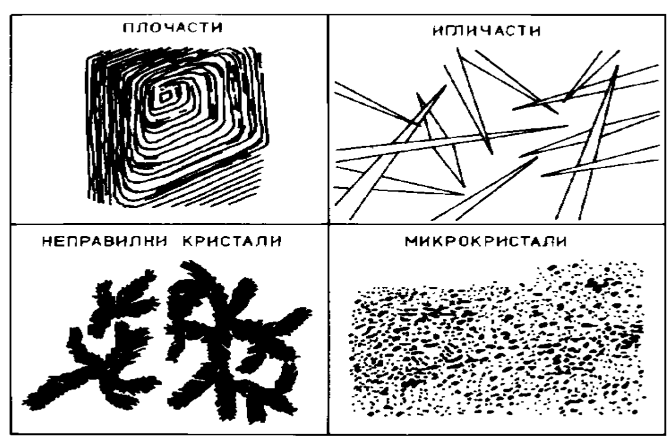

Figure- 6 : Types of paraffin crystals

The paraffin deposition problem was considered depending on the location of deposition within the production system (Figure -7).

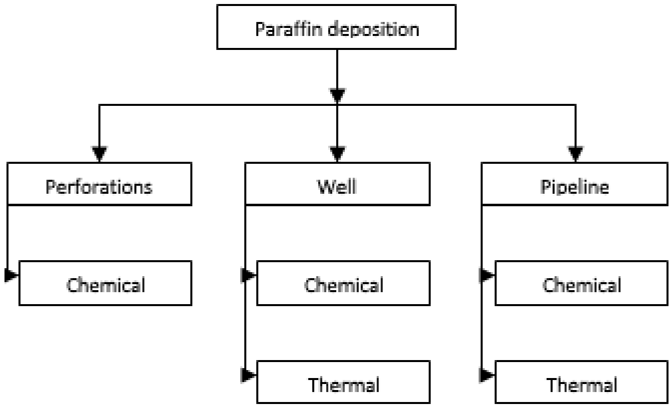

Figure- 7: Methods for solving the deposition of paraffin

3. Results and discussion

The application of only chemical methods is proposed for paraffin deposition in the perforations. The application of appropriate additives for removal of paraffin deposition is recommended. The preventive dosage of additives is not necessary because the deposition of paraffin in the perforations is very rare.The analysis of modern methods which are applied for solving the problem of paraffin deposition **[43 - 55],** have shown that the application of chemical methods can be continued at Amal oilfield and the application of the thermal method is proposed as well. So far, the chemical method for solving the problem of paraffin deposition proved to be successful, both in the wells and in the pipelines. Further, it is necessary to optimize the amount of additives that are added **[56 - 63].** Dosing the additives in the well preventivly solves the problem of paraffin deposition **[64].** Application of chemical methods at this oilfield is simpler, since it does not require electrical installations.

Besides applying chemical methods, the use of thermal method is also proposed, or the heating of wells and pipelines by heating cable or electric induction heating of pipeline **[65].** Thermal methods can easily and quickly be applied to a group of wells with high temperature pour point. Their application is recommended, and it depends on the management whether it will be applied. In support of this is the possibility of installing a gas engine generator that will use gas, which is now being flared, to produce electricity and thus additional sources of electricity will be provided for the application of thermal methods.

The results may be explained as follows: The chemical inhibitor *TEX* reacts with paraffin deposits when forming and prevents their growth, keeping the tubing clean. Ethylene copolymers and chemically combined polymers have a primary role in preventing gelling and/or paraffin deposition in pipelines. This is because they alter the paraffin crystals in order to prevent them from agglomerating, and thus keeping the tubing clean. The results show that injecting chemical inhibitors down the casing together with the gas offer potential solutions to the problem of paraffin deposition in oil wells employing the gas-lift technique **[64].** The production of well *B-99* dropped from *1000 BOPD* to only *50 BOPD*. The first analysis of its oil showed a high wax, and sediments but no water, and during last survey a high level of sand fill was covering the top perforation.

The wells soft concerns are;
B7,13,16,19,25,28,30,34,35,38,40,50,51,53,54,55,56,58,61,62,64,76, 84,88,90,92,93,99 And N-3,6,9,10,13,21,32,39,50,56 and 57.

4. Conclusion

Production problems, individually and taken together, have caused *40-75%* lowering of production in some wells. It was therefore necessery to take additional measures and actions to solve production problems so that they would not worsen and cause an even greater drop in oil production. Based on the characteristics of Amal oilfield, a detailed analysis of production problems, as well as the latest literature findings has defined the new model. The model deals with solving production problems relates to the deposition of paraffin.

A set of new actions to be taken is defined for more efficient troubleshooting of paraffin deposition at Amal oilfield. Necessary actions include determining the intensity of deposition, temperature profile of the borehole and the rate of deposition. New activities allow precise identification of areas of paraffin deposition in the well in order to determine the exact location for injection of additives. It was found that the use of chemical methods can continue where it is necessary to optimize the quantity of additives used, together with the regular monitoring and control of the injection process. For that reason, analysis of the efficiency of injection of chemical inhibitors such as acid-trichlorethylene *(TEKS),* ethylene copolymers and combined polymers, are recommended.

In addition to chemical methods, the thermal method is proposed for solving the problem of paraffin depositions, that is, heating wells and pipeline with heating cable in order to increase the production of wells. Thermal methods can easily and quickly be applied to a group of wells with high oil pour temperature. Their application is recommended, and it depends on management whether thery will be applied. This proposal also includes the installation of gas engine generators, which will use gas that is now flared to produce electricity. This will provide additional sources of electricity for the application of thermal methods. If sufficient wax is deposited over time, portions of the production system, such as wellbores and flow lines, can become partially or totally blocked, thus having a significant impact on production efficiency. The service operations are not efficient and effective as they ought to be culminating to this decline thus no optimization of the production activities.

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