

PRODUCTIVITY IMPROVEMENT IN CONSTRUCTION OF ONSHORE OIL & GAS PIPELINE TIE IN JOINTS EXECUTION

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ABSTRACT: One of the economical ways of transporting crude oil or gas over long distances is through onshore pipelines. Construction of onshore pipelines, involves considerable repetitive activities at various stages of the project. Cost incurred in the construction of pipelines depends on the length of the pipeline, the route and the timely completion of the project. One of the difficult areas in the execution of onshore pipeline construction is “tie in” joints on either side of crossings like roads, rail tracks etc. The aim of this research work is to improve the productivity of execution of “tie in” joints in onshore oil transporting pipelines so that more number of “tie-in” joints can be executed in a day. Improvements are proposed by suggesting alternatives like advanced tools and equipments or by suggesting alternative work methods to the existing conditions. Suggestion of alternative tools is achieved by using end caps to cover the ends of the pipeline sections, ring type cutting and beveling machines and semi automatic welding for “tie-in” joints. Also, an alternative work sequence has been suggested that has the potential to reduce the operational cost of equipments to a certain extent.

The outcome after incorporating these alternatives to the existing as well as the proposed alternative work method is assessed by developing a simulation model. Comparison based on percentage reduction between the alternative work method and the existing work method revealed a 50% reduction in time and 46% reduction in cost.

Keywords: Productivity Improvement-pipeline-“Tie in” Joint, Simulation

1. INTRODUCTION TO “TIE IN”

Onshore oil and gas pipeline is primarily a transmission line for continuous transportation of bulk quantity of oil or gas over long distances over land. It involves repetitive construction of activities at all stages till the completion of the project (Halpin, 1990). Hence, productivity of repetitive activities plays an important role in the timely completion of the project at minimal cost.

The term “tie in” is generally used to describe the connection of a pipeline to a facility, to other pipeline systems or the connecting together of different sections of a single pipeline (Fig 1). In the construction of pipeline, “tie in” joint is one of the areas where it is difficult to maintain the productivity at higher level (Fig.2). The reasons are (1) manual execution and hence skill level of

the labour (2) constraints related to work area – working inside the trench (3) sequential execution of activities (4) work method and work procedures.

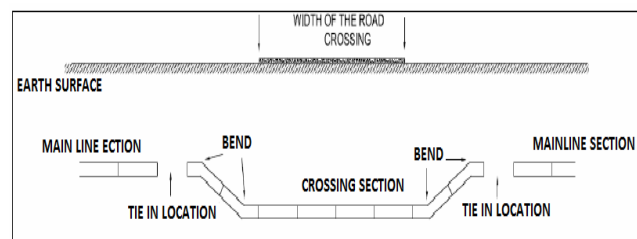


Fig. 1 Cross sectional view of a typical “tie in” joint



Fig. 2. A typical “tie in” joint between a river crossing and mainline section of a pipeline

Also it is very difficult to automate many of the individual activities of a “tie in” joint when compared to the welding of mainline joints. This is because “tie-in” welds are normally performed with the pipe already inside the trench. As the joint has to be made between two ends of completed pipeline sections (crossing and mainline) there is no technology available for introducing internal equipments like internal alignment clamp, automatic internal welding or radiographic machines into the pipe. All operations are therefore to be carried out manually and the accuracy of cutting, preparation and alignment of the pipe ends prior to welding becomes critical.

2. SIMULATION

Simulation is defined as the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding behaviour of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system. Discrete event simulation is widely used in modelling and in simulating construction operations due to its ease of use and its ability to model varied resources. Simulation analyses normally consist of the time and cost of construction, rates for the use of resources, waiting period, and other technical details. Comprehensive details can be made available regarding the construction project without the actual commencement of the work. Due to the availability of adequate details before the real construction, the plans are flexible, and can be modified for improvements in cost and techniques. STROBOSCOPE, discrete event simulation software has been used to analyse the outcomes of alternate work method and the utilization of advanced equipments.

3. OBJECTIVE AND SCOPE: Considering the importance of execution of “tie-in” joints and the timely completion of construction of oil and gas pipelines, the main emphasis is given to the individual activities involved in execution of “tie-in” joint and the cycle as a whole. The objective of this work is to improve the productivity in “tie-in” joint execution in the construction of onshore oil pipelines

The scope of this project is limited to “tie-in” joint execution in the construction of onshore oil and gas pipelines of larger diameter (24” and above)

4. TIE IN JOINT ACTIVITIES

In order to understand the concepts involved in the execution of “tie in” joints (Chart 1) and to collect data for building the simulation model, a live pipeline project is selected which is India’s longest SEHMS (Skin Effect Heat Management System) pipeline to transport crude oil over a distance of around 600 kilometers, through a 24” diameter pipe with 10.2 mm wall thickness. It was observed that the crew was capable of completing one tie in per day. This Sequence is shown in Fig 3 to Fig 6.

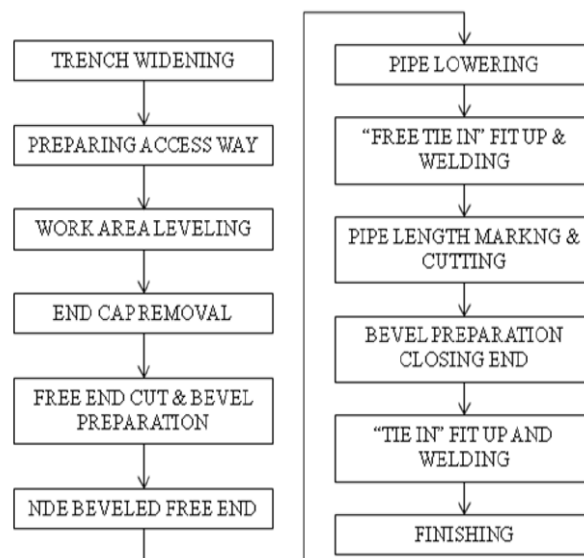


Chart 1 Sequence of activities involved in a “tie in” joint

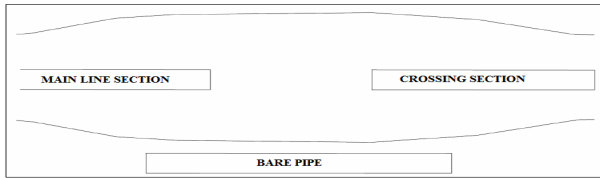


Fig. 3 “Tie in” location before bare pipe lowering

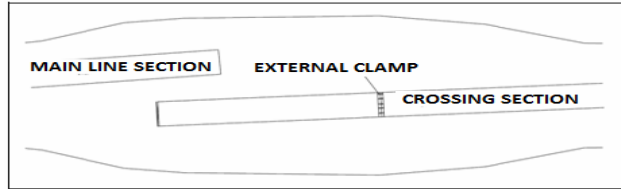


Fig. 4 “Tie in” location after bare pipe into trench

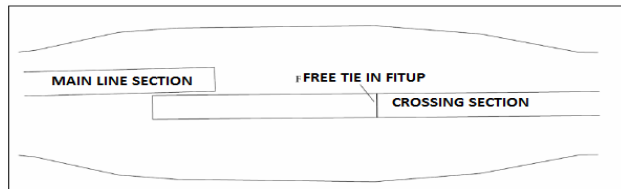


Fig. 5 “Tie in” location after “free tie in” fitup

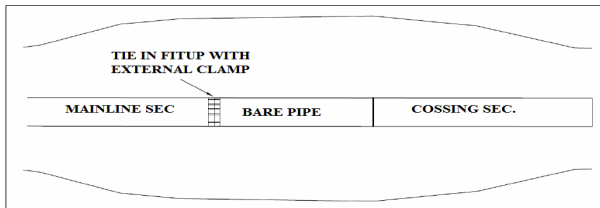


Fig. 6 “Tie in” location after “tie in” fitup

4. DURATION OF ACTIVITIES

The duration of activities involved in a “tie in” joint based on the above breakup is shown below (Fig.7). These durations does not include the time lost due to equipment breakdown and idle time of labours and equipment. Probability distributions were then framed from the recorded durations to incorporate in the simulation model to evaluate the duration of activities during simulation run. the information about the percentage duration of “tie in” activities. It is clear that the removal of end cap, pipe cutting, edge preparation, fitup and weding consumes about 82% of the total time.

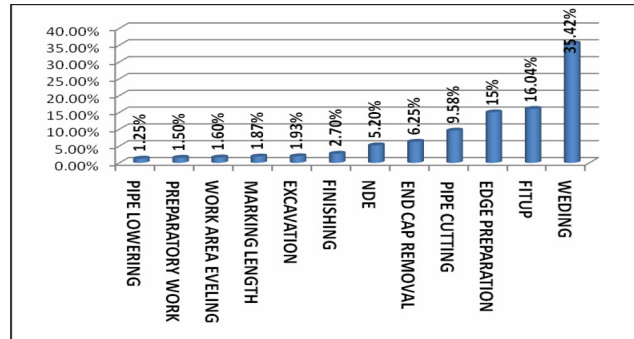


Fig. 7 Percentage duration of “tie in” activities

5. ALTERNATE WORK SEQUENCE

Productivity can be improved by following an alternate work sequence which is depicted in the following chart 2. and the procedure is explained in Fig 8 and Fig.9.

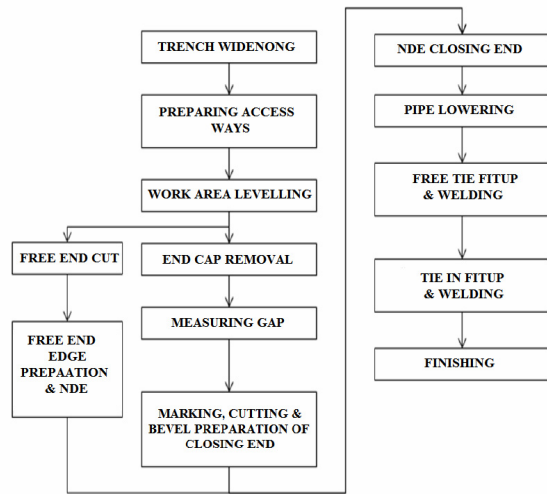


Chart 2. Alternate sequence of activities proposed

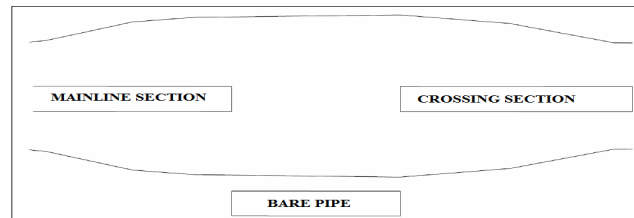


Fig. 8 Pipe cut to required length before lowering into the trench

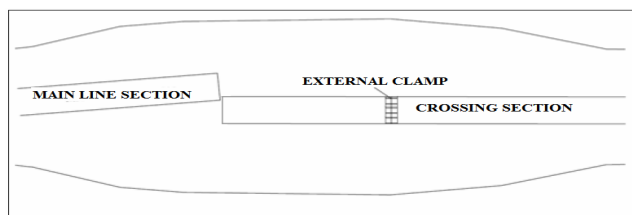


Fig. 9 “Free tie in” fitup without excess length of the pipe

Advantages of alternate work sequence:

1. Reduced waiting time of NDE team since both the ends of the pipe can be tested simultaneously
2. Possible reduction in the duration of “tie in” fit up since the pipe is cut to the required length before lowering into the trench
3. Reduced working duration of diesel generator
4. Overall reduction in “tie in” duration
5. Improved productivity and increased utilization rate of resources.

5.1 REPLACEMENT OF END CAPS:

The main aim of fixing end cap at the ends, as shown in Fig.10, is to prevent the entry of foreign materials in to the pipe. During the start up of “tie in” joint, the welded end caps are to be removed and the edges of the pipe has to grinded to make edge of the pipe free from the weld metal deposit and spatter during the welding of end cap. Also resources like welders and DG are required during fixing and grinders and diesel generator during the removal.



Fig. 10 Metal Plate welded at the edges of pipe

If the metal end caps are replaced by easy to remove coupling like end caps, both time and cost incurred on resources can be saved. Also end caps can be reused in different locations.

5.2 USE OF BAND OR RING TYPE CUTTING MACHINE

Cutting a pipe at a specific plane is an important activity in a “tie in” process since the degree to which the cut is performed leads to varying degrees of edge preparation. In most of the “tie in” processes, pipe cutting is done manually with the help of oxy-acetylene cutting torch or with the help of ring type cutting machine which is then followed by manual edge preparation. The duration and quality of the bevel depends on the skill level of the rigger. During manual edge preparation, one can expect the diesel generator to run at less than 1/3 of its rated load since no other activity will be ongoing and all other crews remain idle. It is found that combined percentage duration of both the pipe cutting (9.5%) and edge preparation (15%) in a “tie in” process is nearly 25% of the total duration. If the required bevel angle is obtained during the pipe cutting stage itself, then the time required to dress the edge can be reduced to very a negligible time or even brought down to zero. This results in 15% reduction in the total duration of the “tie in” process. One more advantage is that the running time of diesel generator during this time can be reduced by 15%. A band or ring type cutting and bevelling machine can be used as an alternative since it has the ability to cut the pipe at greater speed with lesser manual interruption at exact location along with a maximum bevel angle of 45°. The mere use of band or ring type cutting and bevelling machine alone cannot eliminate the process of edge preparation. It is the proper use and maintenance of the cutting torch and rolling setup which rolls over the band, setting the torch at accurate angle and the use of right proportion of oxy-acetylene mixture which aids in greatly reducing the need for edge preparation.



Fig. 11 Band type cutting machine used to cut pipes

5.3 USE OF SEMI AUTOMATIC WELDING MACHINES

In general, “tie in” joint welding is done by manual metal arc welding because of the presence of external clamp. It involves welding the joint with successive weld passes and the removal of slag deposited over successive weld passes. It is found that welding constitutes about 36% of the total duration in a “tie in” process. So, reducing the duration of welding can provide the crew adequate time to complete an additional joint in a day and also to reduce the cost incurred in the resource deployment.

Tsuboi et al., (1975) proposed automatic and semi automatic continuous welding method for welding of pipe line which can weld continuously from the root pass to the cap pass. They state that it can reduce the welding time to half the time required for the conventional manual metal arc welding method. From the experiments performed, they have come up with a short arc welding process which was proved effective for automatic welding of pipeline. He also found that the continuous weld from the root to the cover pass minimizes the inter pass welding suspension and grinding work, so that the welding time can be reduced by 20 to 50%. He also showed that the level of defects in the welds welded by semi automatic welding is very less when compared to manual welding. The advantages of using automatic welding machine are: high quality continuous weld, higher metal deposition rate and hence greater weld speed, wastage of filler metal in the form electrode stick out can be eliminated, consistent higher quality of welds and no need for slag removal in between the hot, filler and cap passes which results in reduction in duration and resource requirements like grinders, grinding machines etc and less stress to welders which helps in occupational benefit to welders and grinders.

6. SIMULATION MODEL

Two separate simulation models have been developed representing the existing and the proposed work sequence with the help of STROBOSCOPE and Microsoft Visio graphical user interface for STROBOSCOPE (Fig.12). The

models were provided with options to change the number of resources working, total number of “tie in” joints to be completed, timing of shifts and moreover to understand the % utilization of all resources, with a customized outputs. The developed model has been simulated with 12 scenarios and the output from the experiments is shown in Fig.13, and compared to select the suitable alternative.

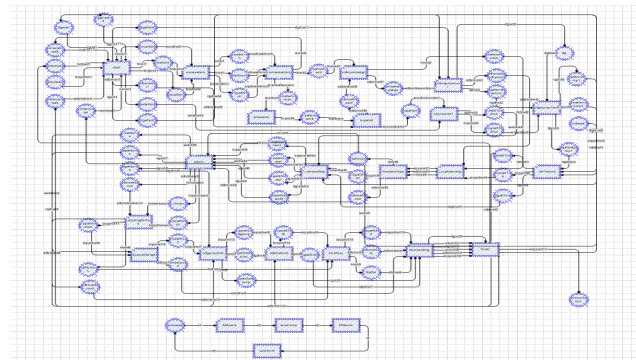


Fig. 12 Developed simulation model in Visio (Graphical User Interface)

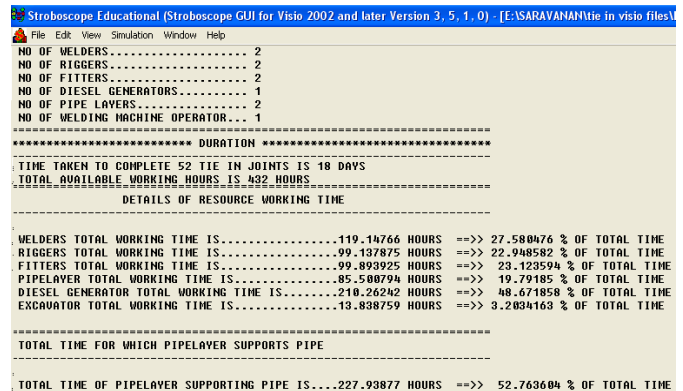


Fig.13 Customized output showing percentage working time of resources, cost incurred, duration etc.

SCENARIO DESCRIPTION	SCENARIO											
	1	2	3	4	5	6	7	8	9	10	11	12
DO NOTHING	█											
REPLACE END PLATE WITH END CAP		█				█		█				█
BAND TYPE CUTTING MACHINE			█			█	█	█	█	█		
SEMI AUTOMATIC WELDING MACHINE				█		█					█	█
INCREASE IN DURATION OF SHIFT					█				█	█	█	█

Chart.3 Scenarios experimented in the developed simulation model

7. RESULTS AND DISCUSSIONS:

The results obtained for the existing and the alternate work sequence in terms of cost comparisons from the simulation model are shown in the Table 1 to Table 3. It indicates varying amount of cost can be saved by following different scenarios i.e. various combination of alternatives. Negative value on percentage indicates increase in cost. It can be seen from the Table-1 that scenario 9 and 12, use of band type cutting machine and semi automatic welding machine, increase in the working duration, will result in 46% savings in cost when compared to that of existing method without any alternates deployed.

8. CONCLUSIONS

Thus, by simply following the alternate work sequence will result in 0.50% reduction in the cost. In addition to the cost, the other tangible benefits are less stress to workers and reduced duration. If we want to complete more number of “tie ins” per day along with increased productivity, band type cutting machine, semi automatic welding machine could be deployed along with increase in working duration.

Table 1 Cost comparison for equipment cost

SCENARIO	EXISTING METHOD		ALTERNATE METHOD	
	TOTAL INR	% CHANGE	TOTAL INR	% CHANGE
1	1488844	0.00 %	1479952	0.60 %
2	1484284	0.30 %	1475392	0.90 %
3	1475620	0.88 %	1473112	1.05 %
4	1472428	1.10 %	1463764	1.70 %
5	1488844	0.00 %	1479952	0.60 %
6	1471060	1.19 %	1468552	1.40 %
7	1459660	1.96 %	1456924	2.10 %
8	1454644	2.29 %	1452364	2.40 %
9	792640	46.76 %	781924	47.00 %
10	1475392	0.90 %	1473113	1.05 %
11	1471972	1.13 %	1088263	26.90 %
12	781013	47.54 %	779188	47.60 %

Table 2 Cost comparison for labour cost

SCENARIO	EXISTING METHOD		ALTERNATE METHOD	
	TOTAL INR	% CHANGE	TOTAL INR	% CHANGE
1	263088	0.00 %	263088	0.00 %
2	263088	0.00 %	263088	0.00 %
3	263088	0.00 %	263088	0.00 %
4	263088	0.00 %	263088	0.00 %
5	312417	-18.75 %	312417	-18.75 %
6	226800	13.79 %	226800	13.79 %
7	226800	13.79 %	226800	13.79 %
8	226800	13.79 %	226800	13.79 %
9	156208	40.62 %	156208	40.62 %
10	312417	-18.75 %	312417	-18.75 %
11	312417	-18.75 %	225634	14.23 %
12	156208	40.62 %	156208	40.62 %

Table 3 Overall Cost comparisons among various scenarios

SCENARIO	EXISTING	% CHANGE	ALTERNATE	% CHANGE
1	1751932	0.00%	1743040	0.50%
2	1747372	0.30%	1738480	0.80%
3	1738708	0.80%	1736200	0.90%
4	1735516	0.90%	1726852	1.40%
5	1801261	-2.80%	1792369	-2.30%
6	1697860	3.10%	1695352	3.20%
7	1686460	3.70%	1683724	3.90%
8	1681444	4.00%	1679164	4.20%
9	948848	45.80%	938132	46.50%
10	1787809	-2.00%	1785530	-1.90%
11	1784389	-1.90%	1313897	25%
12	937221	46.50%	935396	46.60%

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