Siamese Dual Pumping Unit for Multiple Completions

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ABSTRACT

A new approach to pumping multiple completion oil wells with minimum surface equipment is by the use of a Siamese Dual pumping unit. Torque factor analysis, unit operation, and economic factors will be discussed.

HISTORY OF MULTIPLE COMPLETION WELLS

Since the mid 1930's interest has been focused on multiple completion of wells. Development of the necessary new down-hole equipment was a prerequisite to the acceptance of completing wells in this manner, because many operators felt, at that time, the complications involved in completing and servicing this type of installation would be more costly than the benefits obtained from initial savings.

As in all new endeavors to advance the industry, pioneering, which is characteristic of American petroleum industry, was forthcoming. The result of what was then considered a novelty, is now an accomplished fact: multiple completions are now a routine part of the industry's production practice.

As multiple completions became a more and more important factor in the economical production of oil, attention was focused on the surface equipment required to produce the two or more fluid zones. Conventionally, a pumping unit was sized to each producing zone, and each zone produced as though it were an independent well.

Characteristically, to economically accomplish the desired production rates, diameter limitations on multiple completion wells usually dictate the use of small pumps and relatively long strokes. In many cases the pumping unit structure satisfying the stroke length requirement was equipped with a reducer capacity in excess of that required for the zone to be pumped.

METHODS OF PUMPING MULTIPLE COMPLETION WELLS

The first accepted method of pumping multiple completion wells was to equip each zone with a separate pumping unit installation. This method proved itself satisfactory in many respects except for high initial investment and operating costs. These factors have possibly caused low potential or marginal zones to be bypassed in many cases.

Another method of producing multiple wells was to use a single unit to lift the rod strings by means of a stacked mulehead or a special polished rod hanger. This type of installation had the serious drawbacks of polished rod loads, reducer torques, and horsepower requirements of the individual zones being directly additive. In some cases this single unit method, as compared to the multiple separate unit method, resulted in lower initial investment and operating costs. However, because of inflexibility of the single unit method, it has not been used to any great extent.

It was obvious that a more economical, but still flexible, method to pump multiple completion of wells was highly desirable.

THEORY OF SIAMESE DUAL PUMPING UNIT

An examination of the peak torque loads imposed on the pumping unit reducer reveals the fact that there are two areas where there is available a considerable amount of torque that is not being utilized. It only requires an examination of a well worn low speed gear to show that the wear pattern follows a rather consistant configuration, for there are two quadrants directly opposed to each other on the gear where maximum wear occurs. On the other hand, in the quadrants intermediate to these, the wear is relatively slight.

Investigation of a means to utilize this idle torque capacity indicated that the phasing of a secondary mechanism operating at approximately 90° to a primary unit would result in a much higher utilization of the reducer capacity. With this indication in mind, an investigation was initiated: hypothetical dynamometer cards applied to a mechanism operating two rod strings (with approximately ninety degree stroke sequence phasing) were used, and the torque loads imposed on a single reducer powering both mechanisms were algebraically added. The torque curve generated was of four peak loads with much less overall torque variation than is that of a conventional unit pumping one rod string.

As a starting point a conventional API pumping unit was modified to accept the bearings and connecting pitmans of a secondary or slave unit. The modified adjustable crank counterbalanced unit is designated the primary unit, while the beam conterbalanced slave unit is designated the secondary unit and has no cranks or reducer but derives its power from the primary unit. The secondary unit is connected to the primary unit in such a manner that it operates 90° out of stroke sequence to the primary unit. By beam counterbalancing the secondary unit, substantially equal tension and compression loads are applied to the secondary pitmans and allow the beam counterbalanced secondary unit to be disconnected at any time from the primary unit. Thus, the primary unit is left to continue in operation without readjustment of the rotary counterweights.

The design of the wrist pin connection is such that one man can easily disconnect or connect the secondary unit.

To adjust production rates between the primary and secondary units, there are positions that allow for three stroke lengths on the secondary unit for each stroke length provided on the primary unit. This allowance is accomplished by moving the secondary equalizer bearing along the A-Frame member of the secondary unit.

DYNAMOMETER CARD ANALYSIS

To determine the torque loads imposed on the primary unit reducer, an analysis of the primary and secondary unit dynamometer cards is made by using torque factors in the conventional manner. The net reducer torque is calculated for both the primary and secondary units and then added algebraically at each crank position. Inertia effect of both rotary and beam counterweights can be neglected and thereby considerably simplify calculations.

However, it is necessary that a careful analysis of the secondary unit net well load be made to determine the direction of torque so that it may be properly added algebraically to the primary unit net torque at each crank position.

To analyze the Siamese Dual under heavy pumping conditions, an installation was placed in operation on a waterflood well which had exceeded the capacity of a long stroke unit initially installed on the well. The dynamometer cards from the Siamese Dual installation are shown in Figure 1. The torque tabulation at each 15° of crank angle is shown in Figure 2. The reducer torques are graphically shown in Figure 3. The secondary unit is a slightly heavier pumper than is the primary unit, probably because a new pump was installed in the well a few days prior to the dynamometer survey.

The peak torque from the primary unit was 80,500 in.-lb and the peak torque from the secondary unit was 96,580 in.-lb; and the total net reducer torque was 105,760 in-lbs. It appears from the above analysis that a 114,000 in-lb reducer would be required either to pump the wells with separate units or to pump both wells with a Siamese Dual unit.

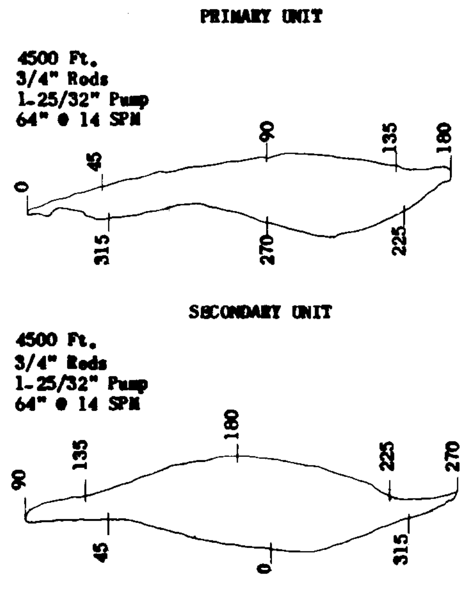


FIG. 1

CRANK ANGLE	PRIMARY UNIT NET REDUCER TORQUE	SECONDARY UNIT NET REDUCER TORQUE	TOTAL NET REDUCER TORQUE
0	9610	91470	101080
15	1130	81380	82510
30	15860	48580	64440
45	54020	32070	86090
60	77990	27770	105760
75	80500	21190	101690
90	67130	5620	72750
105	45110	1270	43840
120	15020	1650	16670
135	- 1130	10400	9270
150	-4000	37750	33750
165	3930	86650	90580
180	8940	96580	105520
195	15290	80200	95490
210	24700	49770	74470
225	46800	10740	57540
240	68300	5420	73720
255	80490	7240	87730
270	47370	4330	51700
285	7350	880	6470
300	10670	3410	14080
315	7430	17960	25390
330	15510	44300	59810
345	-13410	82400	68990
0	9610	91470	101080

FIG. 2

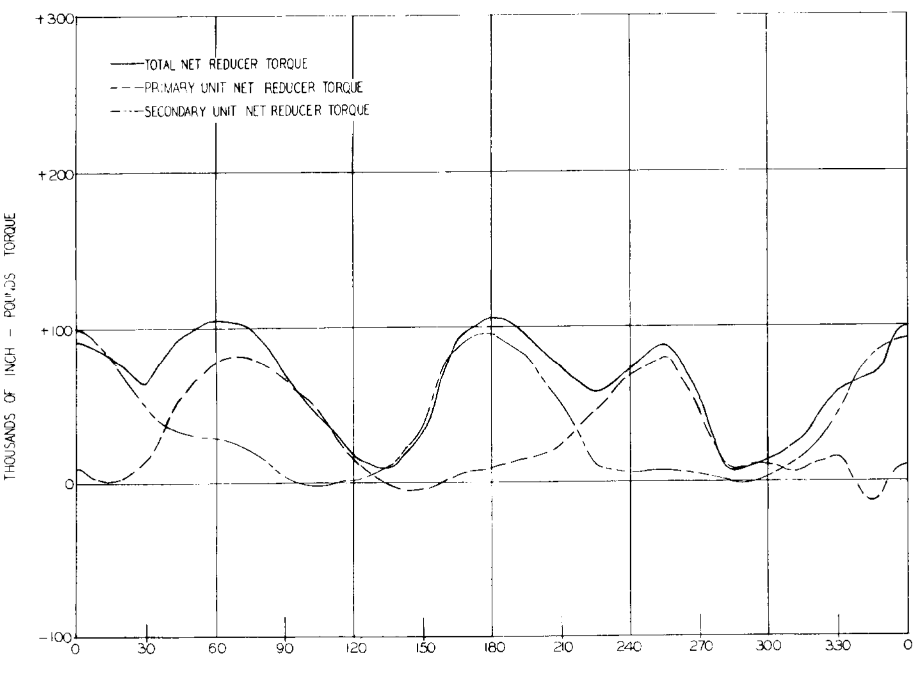


FIG. 3

A dynamometer card from a waterflood well in the same field as the above Siamese Dual unit is shown in Figure 4. The torque tabulation at each 15° of crank angle is shown in Figure 5, and the reducer torque is shown graphically in Figure 6.

Also in Figure 6 is shown the total net reducer torque of the Siamese Dual unit previously discussed. This is not a direct comparison since the units have different stroke lengths and operating speeds, but it serves the purpose of illustrating the four peak loads and the more uniform torque loading of the Siamese Dual unit as compared to a conventional unit.

The dynamometer cards from a deep well Siamese Dual installation are shown in Figure 7. The primary unit is on a zone with a 1-1/16 in. pump set at 10,200 ft with a tapered string of 7/8 in., 3/4 in. and 5/8 in. rods. The secondary unit is on a semi-flowing zone with a 1-3/4 in. pump set at 5,485 ft with a tapered string of 7/8 in. and 3/4 in. rods. Both units of the Siamese Dual are operating with a 74 in. stroke at 10 SPM.

The torque tabulation in Figure 8 shows that the primary unit peak torque is 114,566 in-lb, the secondary unit peak torque is 47,500 in.-lb, and the total net reducer torque is 113,340 in.-lb. It is to be noted that the total net reducer peak torque is slightly lower than is the peak torque of the primary unit. This difference is the result of a clockwise torque that is imposed by the secondary unit and that occurs at the point of peak counter-clockwise torque of the primary unit. Ammeter readings of this installation have confirmed this fact. The reducer torques are shown graphically in Figure 9.

The dynamometer cards from a slim-hole Siamese Dual installation are shown in Figure 10. The torque tabulation and torque graphs are shown in Figures 11 and 12, respectively. The well is typical of many slim-hole dual wells on which Siamese Dual units have been installed. The use of these units has proven to be an extremely economical method of pumping these wells.

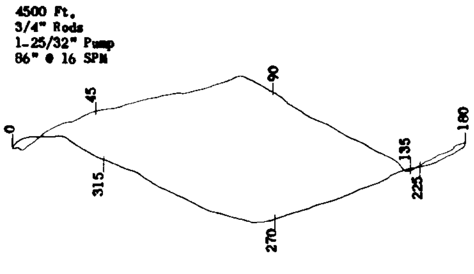


FIG. 4

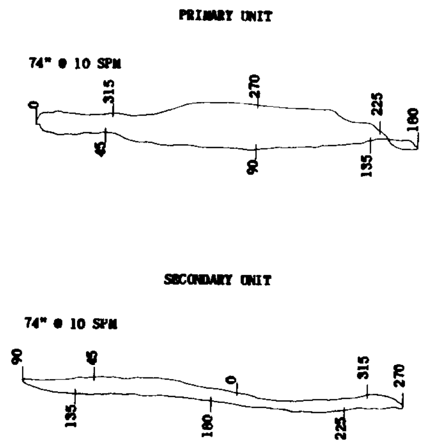


FIG. 7

CRANK ANGLE	TOTAL NET REDUCER TORQUE
0	19470
15	8500
30	76270
45	170230
60	221970
75	247400
90	175340
105	30820
120	- 57730
135	- 95050
150	- 44770
165	- 7060
180	17320
195	37500
210	57820
225	83800
240	124100
255	187110
270	247390
285	211170
300	99720
315	- 10050
330	- 68730
345	- 52690

FIG. 5

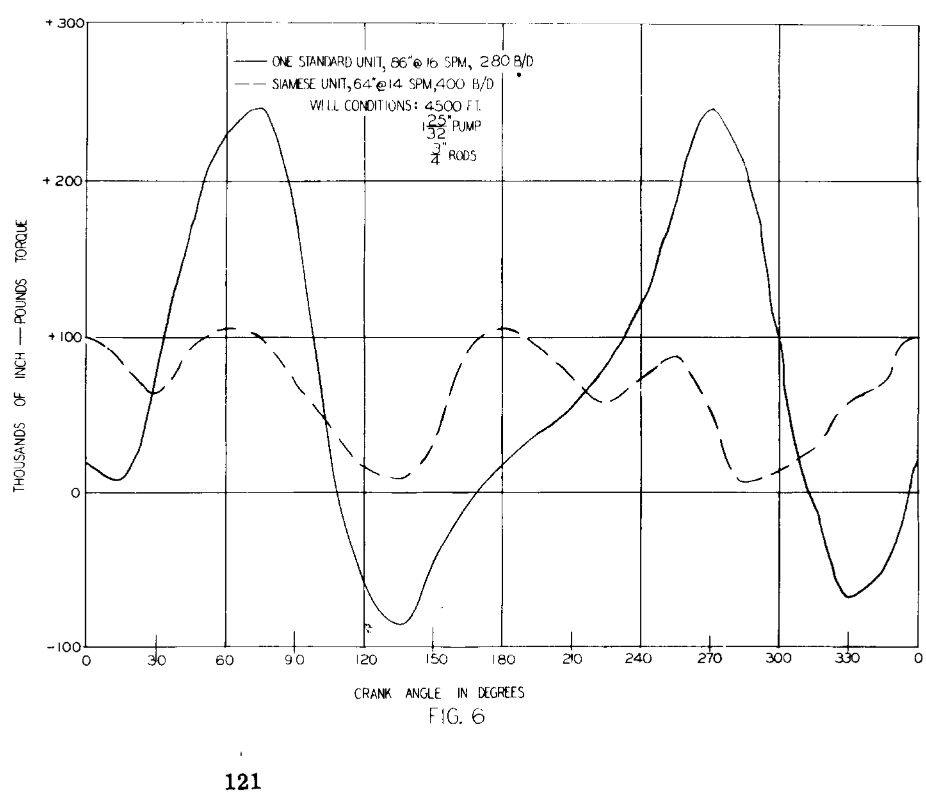


FIG. 6

CRANK ANGLE	PRIMARY UNIT NET REDUCER TORQUE	SECONDARY UNIT NET REDUCER TORQUE	TOTAL NET REDUCER TORQUE
0	-36250	- 770	-37020
345	-87330	18270	-69060
330	-107670	9700	-97970
315	-114560	1220	-113340
300	-101370	1080	-100290
285	-112570	1940	-110630
270	-75630	-4620	-80250
255	-34710	-13160	-47870
240	28270	-22910	536C
225	69560	-34920	34640
210	76160	-47080	29080
195	70560	-41530	29030
180	26280	-24380	1900
165	-21020	-10020	-31040
150	-67430	- 7530	-74960
135	-98420	- 5000	-103420
120	-114560	2050	-112510
105	-102180	2310	-99870
90	-66040	- 5660	-71700
75	- 990	-16700	-17690
60	55460	-27480	27980
45	92380	-40830	51560
30	65530	-47500	18030
15	25550	-29630	- 4080
0	-36250	- 770	-37020

FIG. 8

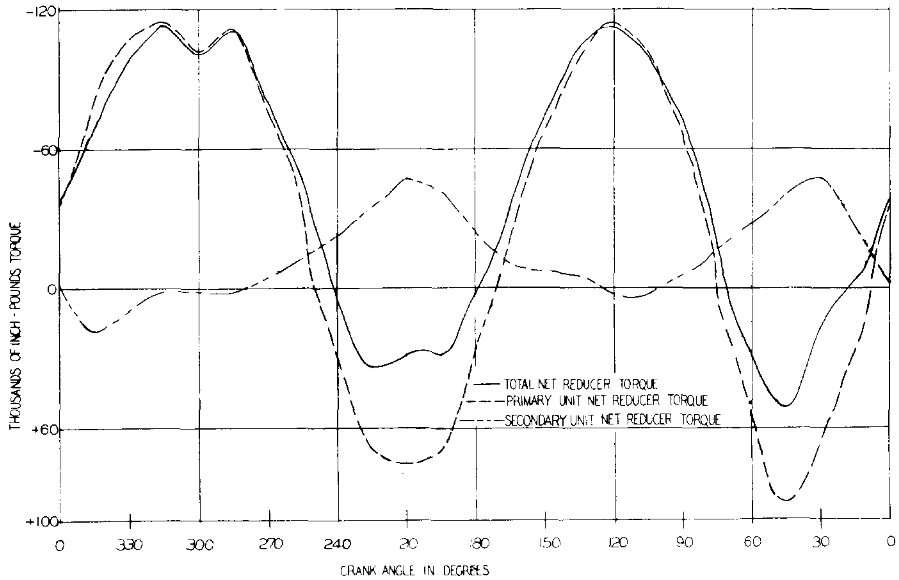


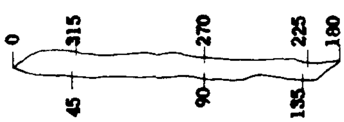
FIG. 9

ECONOMIC FACTORS

The Siamese Dual unit consists of only a primary unit and a beam counterbalanced secondary unit; thus is eliminated one complete prime mover package and one pumping unit reducer. The initial savings from the elimination of these expensive items, along with lower operating and maintenance costs, provide a flexible, but highly economical method of pumping multiple completion wells. It should be added that, by adding single units utilizing special wireline assemblies, this unit may also be used for triple and quadruple completions.

PRIMARY UNIT

3260 Ft.
5/8" Rods
1-1/4" Pump
48" @ 8 SPM



SECONDARY UNIT

2700 Ft.
1/2" Rods
1" Pump
48" @ 8 SPM

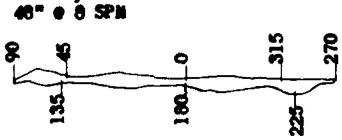


FIG. 10

CRANK ANGLE	PRIMARY UNIT NET REDUCER TORQUE	SECONDARY UNIT NET REDUCER TORQUE	TOTAL NET REDUCER TORQUE
0	- 4100	- 4940	- 9040
345	-11770	- 4350	-16120
330	-20020	- 2940	-22960
315	-19290	- 2640	-21930
300	-16180	- 1240	-17420
285	-15110	- 280	-15390
270	- 5080	510	- 4570
255	- 1330	760	- 570
240	3000	- 1780	1220
225	8820	- 8070	750
210	10810	- 2710	7600
195	8550	- 9150	- 600
180	4150	- 3080	1070
165	- 3050	- 6760	- 9810
150	-12340	- 2740	-15080
135	-18890	- 3260	-22150
120	-20320	- 2370	-22690
105	-20020	- 1240	-21260
90	-15010	40	-14970
75	- 6090	- 650	- 6740
60	- 230	- 6390	- 6620
45	- 5590	- 4350	- 9940
30	- 3880	- 6090	- 9970
15	- 500	- 6350	- 6850
0	- 4100	- 4940	- 9040

FIG. 11

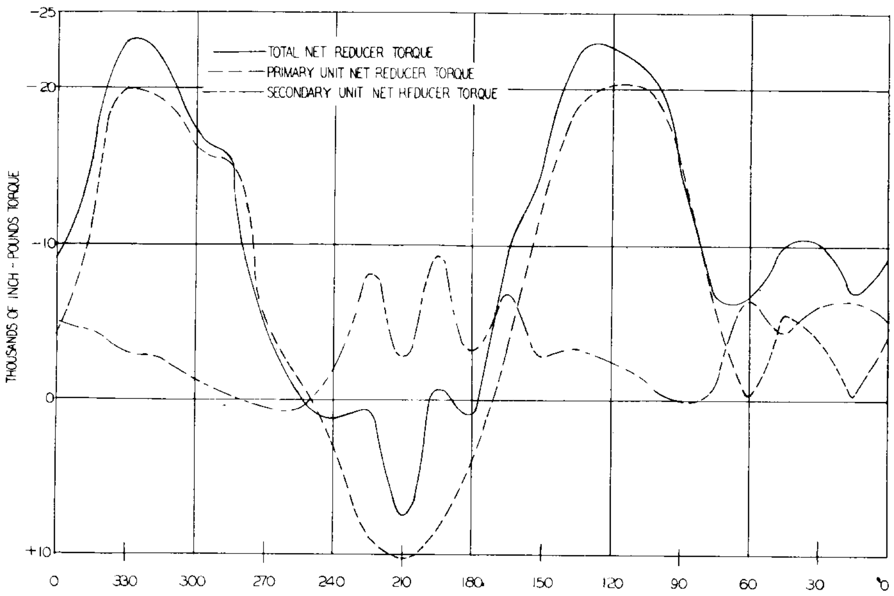
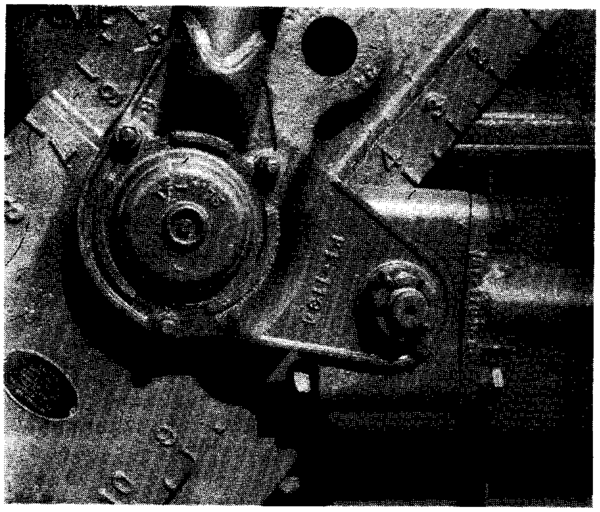


FIG. 12



CONCLUSION

There are numerous applications of the Siamese Dual pumping unit to produce multiple completion wells with substantial savings in initial investment and operational costs. The facts challenge those responsible for the economical production of oil to seriously investigate the Siamese Dual unit in their operations.