

Development of Ultra-High Speed Roller Cone Bit

---International Workshop on Petroleum Equipment Standardization

Technology Center of Kingdream

Xu Hong

[Http://www.kingdream.com](http://www.kingdream.com)

Contents

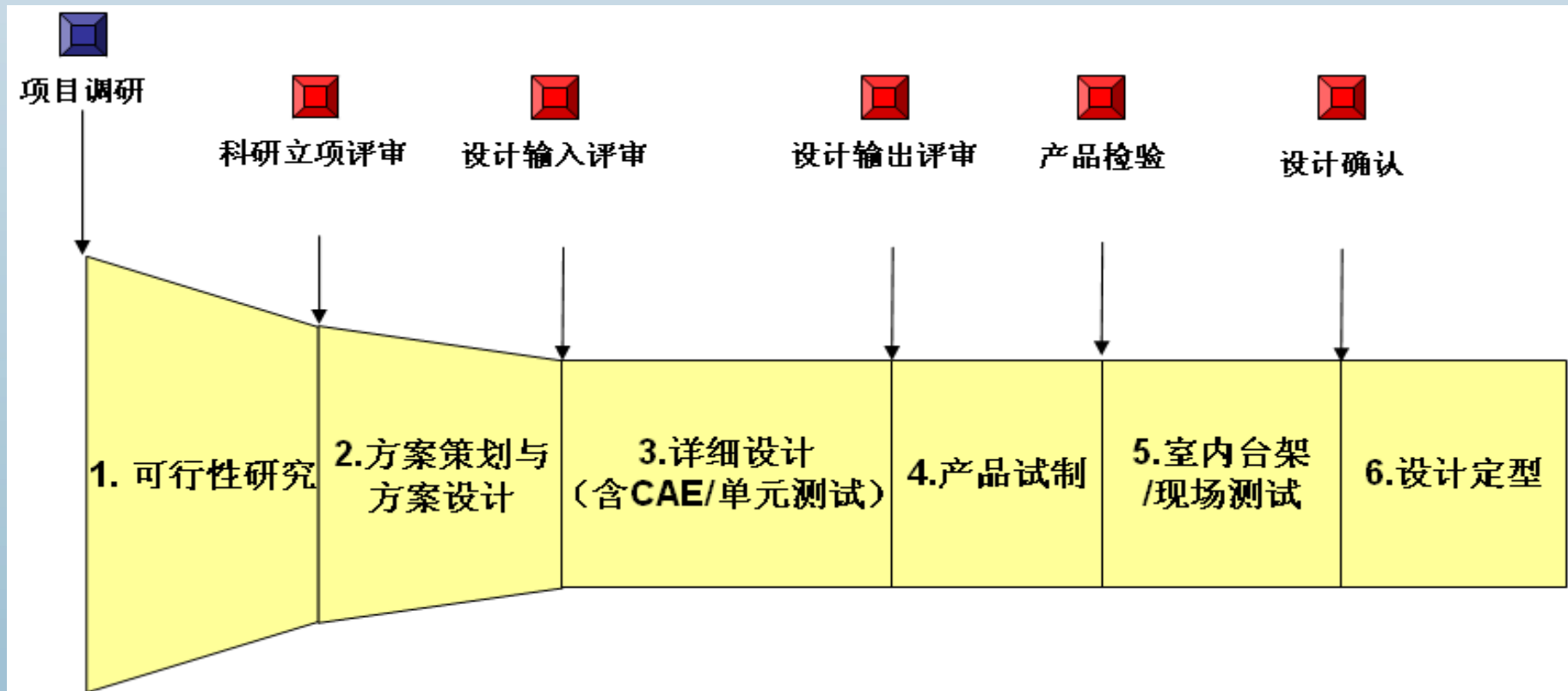
1. Background for developing the ultra-high speed roller cone bit
2. Main study contents for the development
3. Application cases of the new bit
4. Conclusions

Background of the development

As investments in oil and gas exploration and production have been obviously increased in recent years both domestically and internationally, the requirements for increase drilling speed have become popular and urgent. Among many technologies, horizontal drilling technology has been grown fast and down hole power drilling tools, e.g. screw drill and turbo drill, are largely used and RPM of the bits is obviously higher than that of rotary drilling and other drilling parameters are also becoming higher and higher. Turbo drills are widely used in Russia: RPM of the turbo drill for 11-5/8" bit can be 600r/min, and RPM of the turbo drill for 8-1/2" bit can also reach 400r/min. In medium soft to medium hard formations, drilling conditions combine high speed ($>200\text{r/min}$) and ultra-high speed ($>400\text{r/min}$) with higher WOB have brought higher requirements for bit performances including bit bearing life, cutting ability and cuttings removal efficiency, etc.

In a word, under high RPM and high WOB conditions, adaptability of roller cone bits have gradually become the bottleneck to higher drilling speed, and development of ultra-high speed roller cone bit has become the major direction of R & D of roller cone bits.

Control Procedure for R & D



Major problems need to be solved

- How to prevent premature bearing failure under high RPM conditions;
- How can make the cutting structure match with the high RPM, and solve the problems of cutter breakage and bit diameter shrinkage concerned with conventional bits;
- How can bit hydraulic system facilitate timely removal of drilling cuttings and help to avoid regrinding of the bit on bottom hole.

Main contents of the study

- **Development of the ultra-high speed bearing**
- **Study on bit grease for drilling under ultra-high RPM**
- **Study on bit cutting structure for drilling under ultra-high RPM**
- **Study on bit hydraulic system for drilling under ultra-high RPM**
- **Development of ultra-high speed roller cone drilling bit**

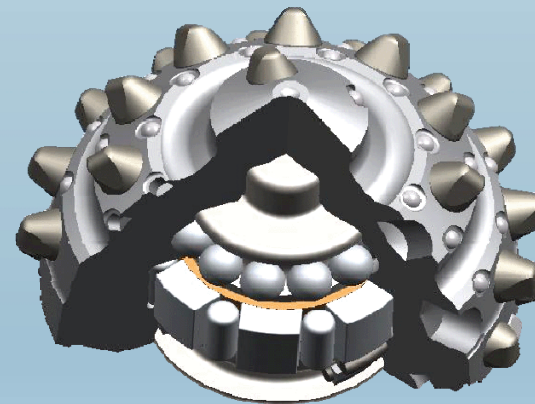
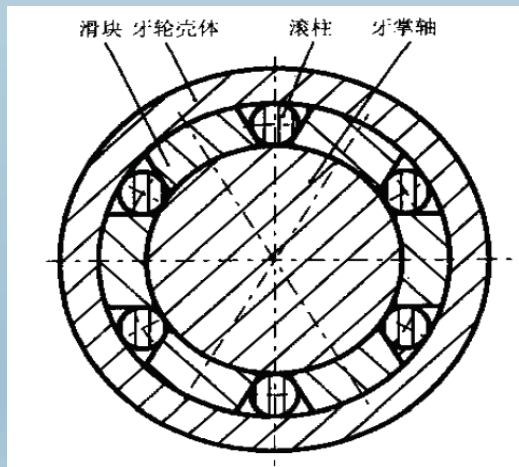
Development of the ultra-high speed bearing

Bearing friction couple technology is one of the critical bottleneck technologies for high speed drilling bit. There are mainly two types of bearing designs currently: Roller bearing and journal bearing. Major advantage of the roller bearing is its high speed performance, its rotary speed can reach above 300r/min, but such bearing has relatively lower load capacity and shorter service life. Compared with roller bearing, journal bearing can sustain higher load but it's easy to be failed in high temperature conditions due to its high frictional coefficient.

Development of the ultra-high speed bearing

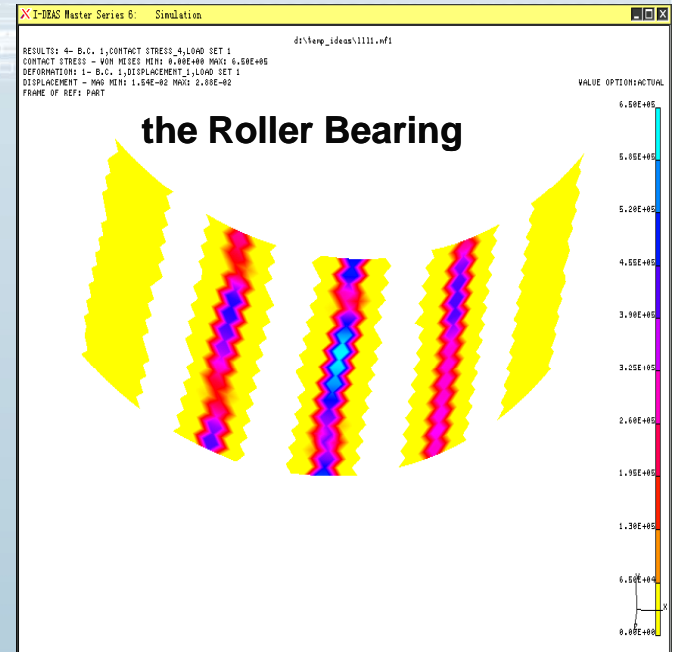
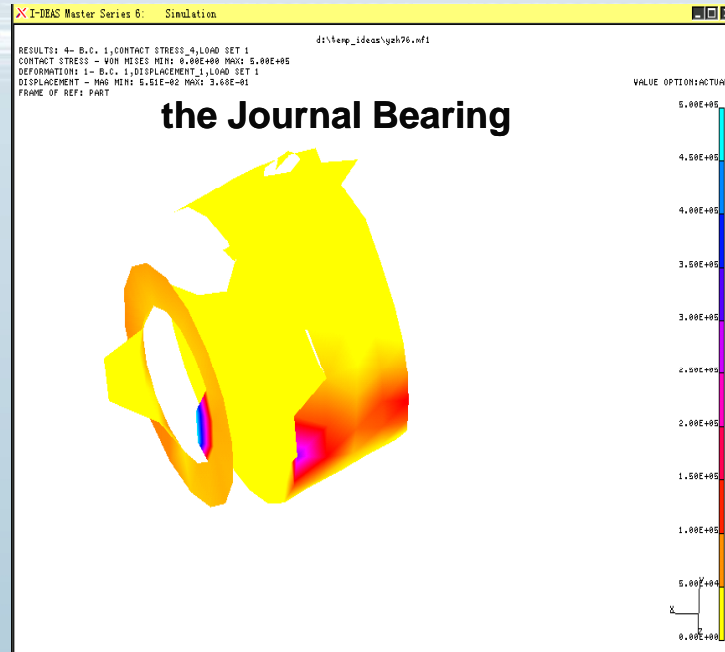
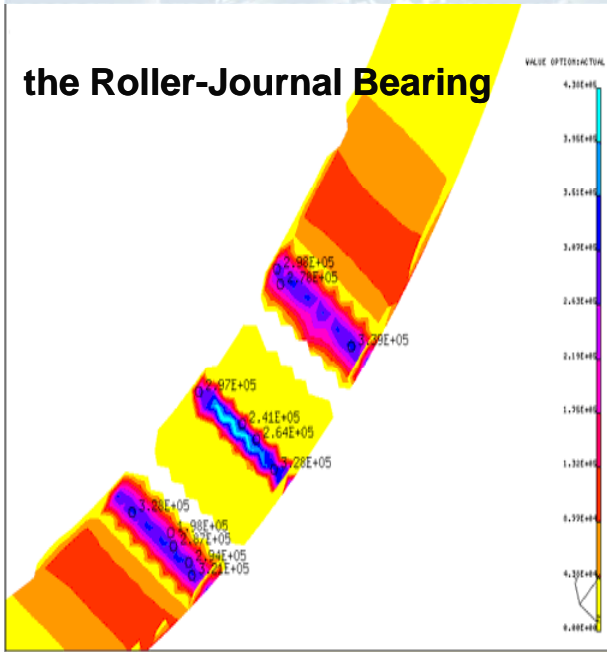
In order to adapt for high speed drilling conditions, Kingdream engineers invented innovative roller-journal composite bearing and this technology had been patented.

In the roller-journal composite bearing, some rollers are substituted with sliding pieces to increase the bearing's loading capacity. The sliding pieces are arranged discontinuously so that frictional heat of the bearing can't be too high. The new bearing design can effectively reduce contact stress between rollers and bearing shaft, and therefore, load capacity and working life of the bearing are both improved while still maintaining the high speed performance of the roller bearing.



Development of the ultra-high speed bearing

In order to verify the feasibility of the application of the Roller-Journal Composite Bearing technology on ultra-high speed roller cone bit, finite element calculation & analysis was done to compare the same size of the roller bearing, journal bearing and Roller-Journal Composite Bearing under same load condition.



Stress Analysis

Unit (Mpa)

	Roller-journal bearing	Changes (%)	Roller bearing	Journal
On roller σ_{max}	515	-44.9	3000	
On roller σ_a	350	-30	1000	
On sliding piece σ_{max}	574	49.5		
On sliding piece σ_a	300	50		
On shaft σ_{max}	438	-21.8	655	300
On shaft σ_a	250	-37.5	430	150

Development of the ultra-high speed bearing

Bearing simulation test was done in lab in order to study the feasibility and rationality of the Roller-Journal Composite Bearing. Reliability of the test is insured since Kingdream owns the world advanced roller cone bit bearing simulation test equipments. The test indicated that the Roller-Journal Composite Bearing features high RPM of the roller bearing and, its capacity is largely improved as compared with the roller bearing and in addition, the new bearing has long working life and better overall performances.



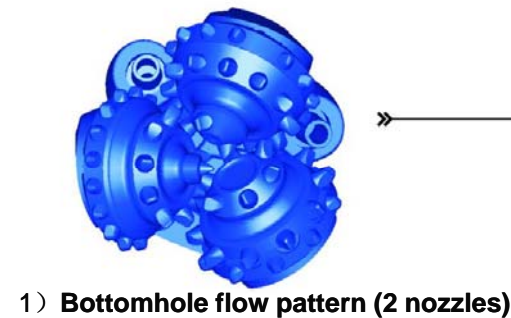
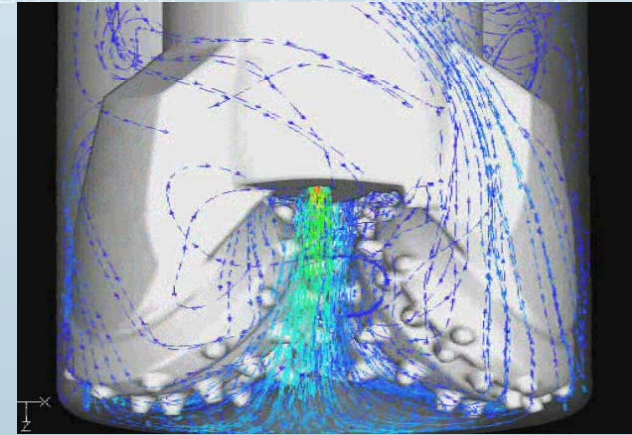
Photo of the sliding pieces on Roller-Journal Composite Bearing (after testing)

Study on bit grease for drilling under ultra-high RPM

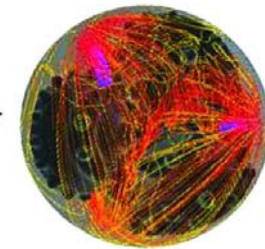
- New synthetic grease for drilling bit was specially developed that suitable for high RPM. This grease can be used in a wider temperature range and the defect of poor dynamic flow ability of original grease in low temperature is overcome. The new grease does not change its lubrication property between high and low temperatures, and features low surface viscosity and very low dynamic torque between high and low temperatures and therefore, the torque started by friction couple can be greatly reduced which leads to increased bearing life. It has been approved that the new grease is suitable for high RPM drilling condition through four-ball test, end face friction test, Timken test, roller cone bit bearing simulation test and field test.

Study on bit hydraulic system for drilling under ultra-high RPM

Under ultra-high RPM, regrinding of the cuttings would occur if the cuttings couldn't be carried up the annular space timely, which will result low ROP. In addition, drilling cuttings can cause wear on cone shell and result bearing failure. Using hydraulic system enhancement design technology, such as double nozzle and low nozzle technology, etc. can avoid such problems. Double nozzle configuration can eliminate resorting area on bottom hole and realize highly efficient drilling.



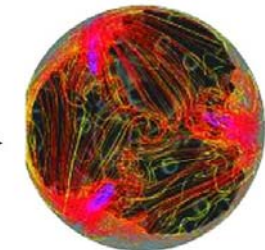
1) Bottomhole flow pattern (2 nozzles)



加长双喷嘴结构井底流场



2) Bottomhole flow pattern (3 nozzles)



三喷嘴结构井底流场

Through detailed study on various technologies related to ultra-high speed drilling applications and in consideration of geological characteristics and drilling processes, new roller cone bit for ultra-high RPM drilling is developed and associated designing, machining and application standards are established. This bit can sustain higher RPM and WOB, completely complies with API Spec. 7-1, and a company standard for ultra-high speed roller cone bit is also set up based on API standard. It is just because of the well integration of API standard and company standard so that the new bit product can enter into the international market fast and successfully.



Application cases of the new bit

Ultra-high speed roller cone bit with Kingdream's intellectual property rights was developed using above-mentioned technologies. This bit has been successfully used in Russian market and gained good reputation in our distributors and end users. The footage drilled by the ultra-high speed roller cone bit in the same formation and under same drilling conditions is 2 to 3 times that of the competitor's bits. When used on down hole power drilling tool, the longest footage drilled by a single 215.9mm ultra-high speed roller cone bit was 1242m, longest pure drilling time was 56.01h and the highest average ROP was 40.62m/h.

Application cases of the new bit

1. Performance of the 437 ultra-high speed bit in Meigeao oilfield in Russia

8 1/2 ZJT437GLEX ultra-high speed roller cone bit was specifically designed for 750~1750m section of the area. The table below is the comparison of competitor's bits vs. Kingdream's bits. Figures in the table show that in the same section and with similar drilling parameters, the average ROP of Kingdream's new bits is close to that of competitor's bits, but the average footage and pure drilling time achieved by Kingdream bits are two times those of the competitor's bits. As to say the failure condition, the bit bearing, inserts and gage holding capability of the ultra-high speed roller cone bit are all better than those of the competitor's bits, especially the bearing performance of the new bit.

	Qty	Average			Median value			Bearing failure (%)	Cutter failure (%)	Gage failure (%)	Others
		Footage	Pure	ROP	Footage	Pure	ROP				
Competitor's	64	438.2	11.1	39.4	443.0	10.5	41.9	39 (pcs)	10 (pcs)	30 (pcs)	3 bits lost cone
								61%	16%	47%	
Kingdream's	11	849	22	40.2	890	23	42	4 (pcs)	1 (pcs)	2 (pcs)	No lost cone
								37%	9%	18%	

Conclusions

- 1. Bit with Roller-Journal Composite Bearing is suitable for drilling medium soft to medium hard formations with high and ultra-high RPM. It is a new type of bit bearing independent of roller and journal bearings. The development of this bearing filled up the blanks both domestically and internationally in the industry and it is significant to the construction of our own intellectual property rights.
- 2. The roller cone bit specifically designed for high and ultra-high RPM drilling applications achieved great success in field application and it is a great significance for establishing standard for designing roller cone bit for ultra-high RPM drilling.
- 3. The development of the ultra-high speed roller cone bit follows Kingdream's standardized new product development procedure and in conformance with API and industrial design specifications and so, the development cycle was shortened and cost was reduced.
- 4. The standardization of design, production and application of the ultra-high speed roller cone bit has made the product entering the international market at a fast pace and therefore the conversion time from technology to economic benefit was largely shortened.



Thank You!
Warmly Welcome Everyone
To Kingdream